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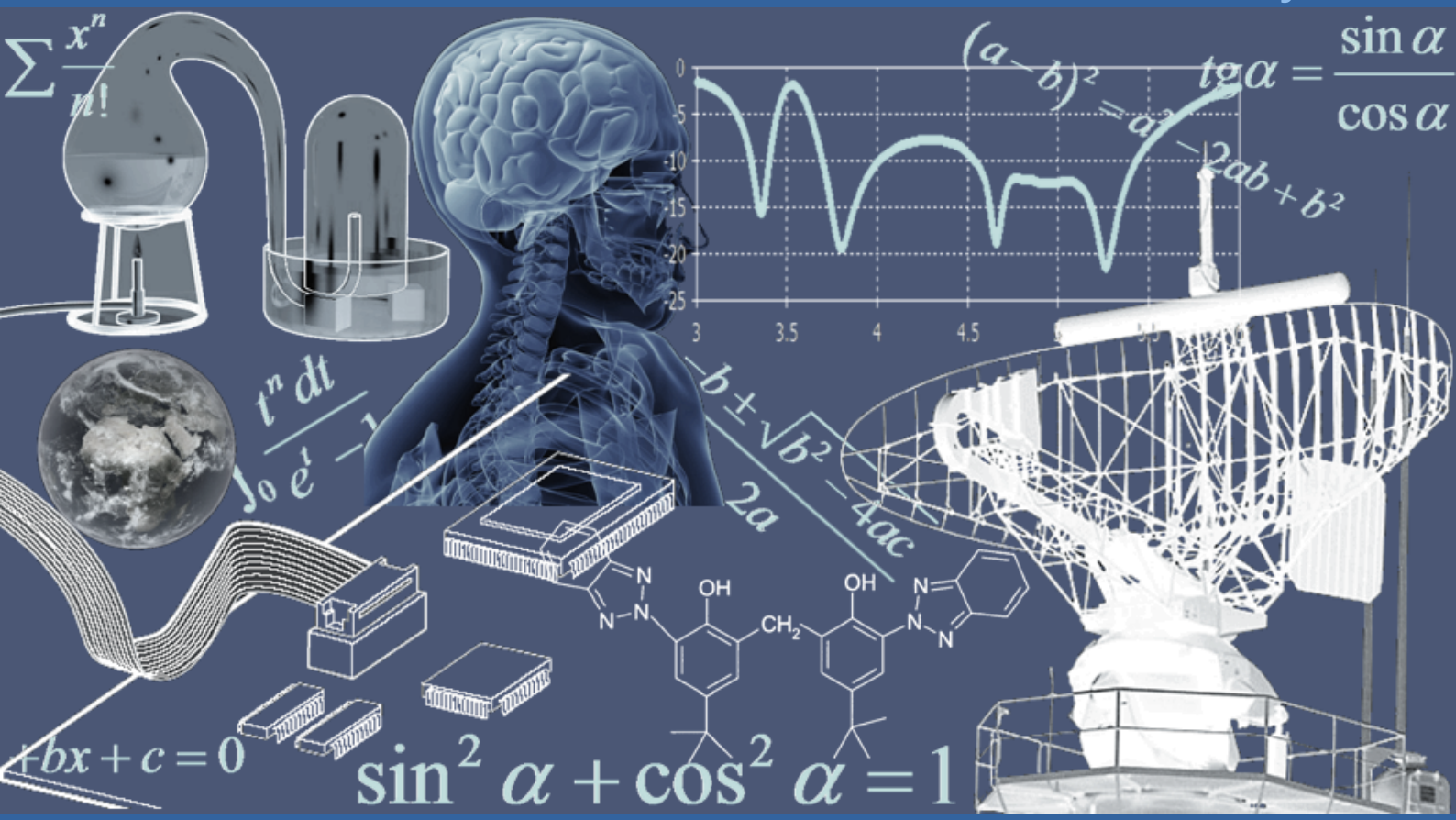

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Flame Synthesis of Carbon Nanorods with / without catalyst

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ABSTRACT: The carbon nanorods (CNR's) were synthesized using flame reactor with diffusion burner. The growth of carbon nanorods in presence and absence of catalyst has been studied. The role of ferrocene as catalyst in the synthesis of carbon nanorods was investigated using a Flame Reactor at different oxygen to fuel ratios. The fuel used over here is acetylene. The fuel i.e., acetylene to oxygen ratio is also optimized to produce the carbon nanorods in presence of cataylst. The carbon nanorods showed a very good result with increasing yield and decreasing diameter with the use of catalyst. The morphology, purity and crystal structural characterization of CNR's was carried out using scanning electron microscopy, transmission electron microscopy and X-ray diffraction. From the analysis it was observed that in the presence of ferrocene, the density of CNR's increased with variable lengths between 10 – 50 micrometers (μm) with an average tube diameter range of 150 – 300 nanometers (nm), when compared to a non-catalytic synthesis which yielded CNR's with lengths and diameter ranging from 10 -180 micrometers (μm) and 3-10 micrometers (μm) respectively. These carbon nanorods can be widely used in various applications such as electronic devices, semi-conducting materials, electrodes, hydrogen storage and composites for its outstanding properties.

KEYWORDS: Flame synthesis, Nanomaterials, Acetylene, Ferrocene.

1 INTRODUCTION

Carbon nanomaterials have attracted great interest from past few decades owing to their promising physical and chemical properties. Till date different carbon nanomaterials have been reported such as carbon nanoparticles [1], nanotubes [2], onions [3], nanowires [4], nanofibers [5] and carbon nanorods [6]. These nano meter carbon material are expected to have relatively large band gap and are expected to behave like a semiconductor. More interestingly carbon nano rods have been largely applied as anodic materials in batteries apart from their applications like fillers [7] and high-performance electrode materials in batteries [8]. Upto now, various methods have been proposed for thier synthesis like ball milling [9, 10] chemical vapor deposition [11], laser ablation, chemical reduction and co-precipitation [12-15]**.** More recently, new synthetic methods like flame synthesis, sol-gel, microwave plasma and low energy cluster beam deposition [16] have been developed.

We have earlier reported the synthesis of carbon nanorods using the flame reactor. Here in this article we report the synthesis of carbon nanorods using a diffusion burner with acetylene as a sole carbon source and oxygen as an oxidant in the presence of catalyst, ferrocene. We have aimed to study the difference between the growth of CNM's with and without catalyst with respect to the (oxidant to fuel) O/F ratio in the range of 0.6 – 1.2 v/v. The samples were characterized using SEM, TEM and XRD.

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2 EXPERMENTAL

The experimental design & procedure for the synthesis of carbon nanorods has been reported [17]. Basically the flame reactor consists of a burner through which measured flows of oxygen and acetylene in various ratios enters the reactor chamber controlled by the calibrated rotameters. On spark ignition soot is produced which is collected over a glass fiber filter paper (GF/A Whatmann). The experiments were carried out using 0.5g of catalyst (ferrocene) in the range of 0.6 to 1.2 v/v. The same experiment was repeated without catalyst to study the difference in with and without catalyst.

3 RESULTS AND DISCUSSIONS

The SEM micrograph of the CNM (Fig. 1a) synthesized at O/F ratio of 0.6v/v in the absence of catalyst yielded microrods with lengths up to 10µm and their diameters ranging around 3µm. Fig. 1b represents the SEM image of two microrods synthesized at 0.8 v/v, these rods were found to be extremely lengthy and measured up to 150 µm each with their diameters up to 5 µm. At O/F ratio of 1.0 v/v (Fig. 1c) and 1.2 v/v (Fig. 1d) showed similar results with some mass of amorphous carbon around. The average diameter of a microrod in Fig. 1c was found to be 8 µm where as the lengths greater than 120 µm. The SEM image at 1.2 v/v (Fig. 1d) showed little lengthy wire like rods with lengths in the ranging 50-180 µm and diameter around 10µm respectively.

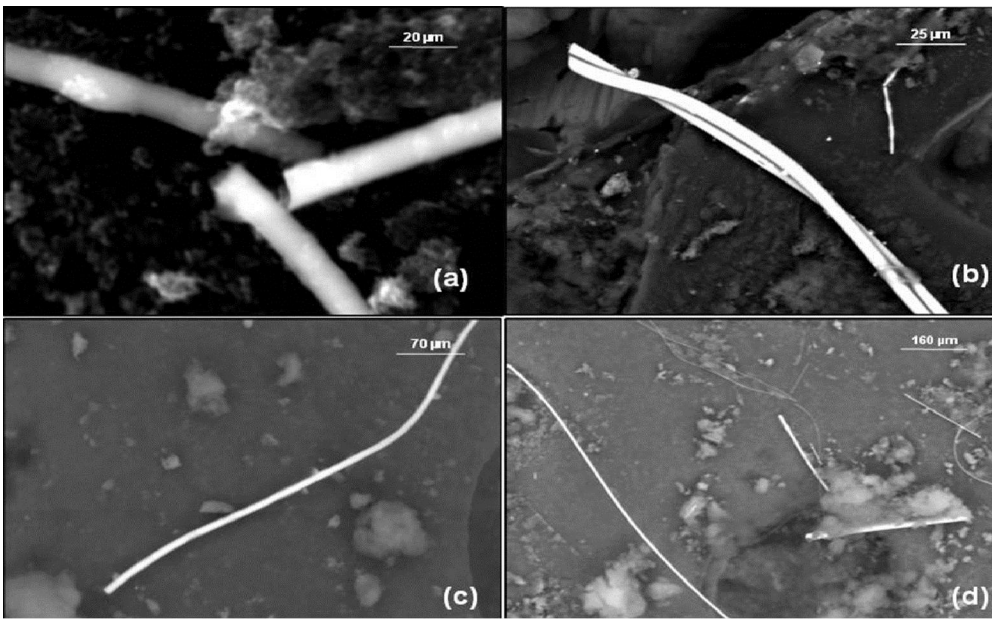

Fig. 1. SEM Images of microrods produced using acetylene and oxygen in the absence of catalyst. (a) Microrods produced at O/F ratio of 0.6 v/v. (b) Microrods produced at O/F ratio of 0.8 v/v. (c) Microrods produced at O/F ratio of 1.0 v/v. (d) Microrods produced at O/F ratio of 1.2 v/v.

Upon introduction of catalyst (ferrocene), growth of nanomaterials was dense in the O/F range of 0.6v/v to 1.2v/v as shown in the SEM images. Fig. 2a shows a SEM image of a nanorod synthesized at 0.6v/v with an average length of 30 – 40 µm and diameter around 210nm. Fig. 2b shows SEM image of densely entangled mass of nanorods at 0.8v/v with an average diameters in the range of 150 nm and lengths stretching up to 50 µm respectively. At 1.0v/v many equi-sized rods joined together to form a rope like structure as shown in Fig. 2c. The average diameter of the individual equi-sized rod was around 300nm, a very few thin rods with the average diameter and lengths of 140nm and 5-10µm respectively were also. Fig. 2d shows less dense nanorods at 1.2v/v. The figure shows two different sized nanorods: The thicker rods measure up to 700nm in diameter whereas the thinner rods measure nearly 200nm. The average length of all the nanorods was found to be 15µm.

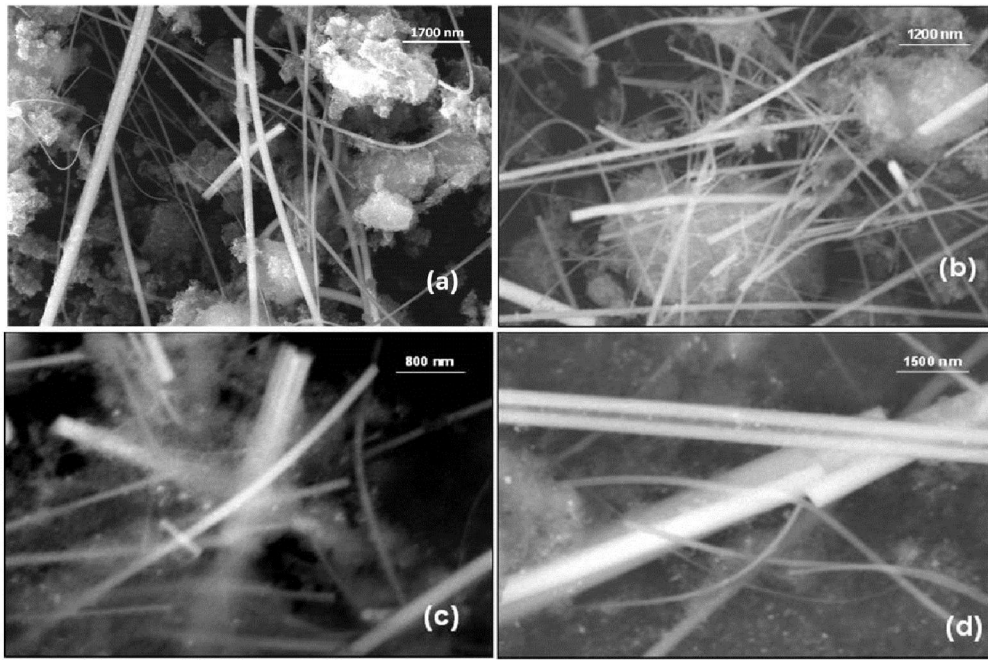

Fig. 2. SEM Images of nanorods produced using acetylene and oxygen in the presence of ferrocene as catalyst. (a) Nanorods produced at O/F ratio of 0.6 v/v. (b) Nanorods produced at O/F ratio of 0.8 v/v. (c) Nanorods produced at O/F ratio of 1.0 v/v. (d) Nanorods produced at O/F ratio of 1.2 v/v.

Thus from the SEM analysis it was found that the synthesis of CNRs catalyzed by the catalyst(ferrocene) had better crystal structures and smaller diameters compared to those synthesized without catalyst [18,19,20]. Furthermore, the CNRs synthesized using catalyst had smoother and cleaner the topologies compared to that synthesized in absence of catalyst. It is well accounted in the literature that the diameters of the nanorods were mainly determined by the size of the catalysts [18, 19, 20]. Higher temperatures enhanced the decomposition of ferrocene to produce fine Fe clusters increasing the possibility for the growth of CNR's with smaller diameters.

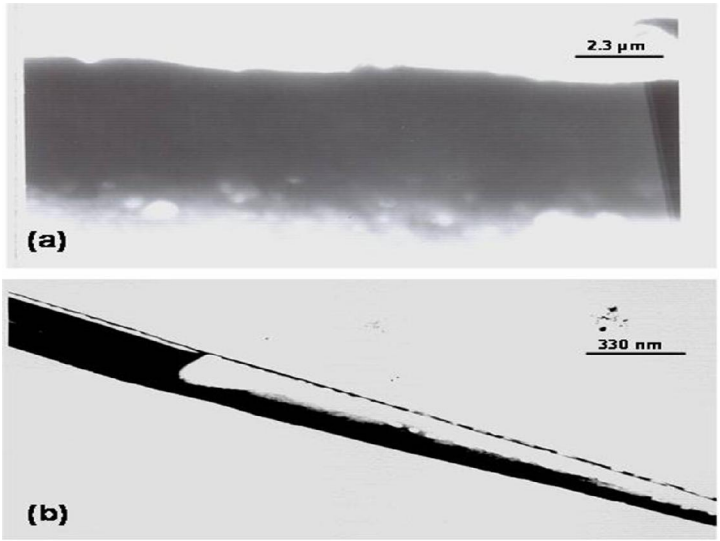

Fig. 3. TEM image of nanorods using (a) In the absence of catalyst (b) In the presence of catalyst.

The TEM image (Fig. 3a) shows the typical microrod of 15µm in length with a diameter around 5µm obtained at O/F 0.8V/V grown without catalyst. In case of catalysed reactions the diameter of the nanorods increase with increasing catalyst concentration [21, 22, 23, 24, 25] as shown in TEM image (Fig. 3b). The O/F of 0.8v/v with catalyst showed the best result as per TEM analysis but the total yield was found to be low. The length of the rods measured nearly 10µm with a variable diameter distribution along its axis. Fig. 3b explains the basal growth of CNR's from the catalyst which is well documented in the literature [21, 22, 23, 24, 25].

XRD (Fig.4a) of microrods produced using acetylene and oxygen without catalyst at an O/F ratio of 0.8 v/v showed one strong peak. Using the PDF-2 database the first peak at 2θ angle of 43.545^{o} was found with (110) orientation of atoms along its plane with peak corresponding to graphite with a rhombohedral type of system and a rhombocentred lattice. The peak broadening also confirms the presence of abundant amorphous state of carbon.

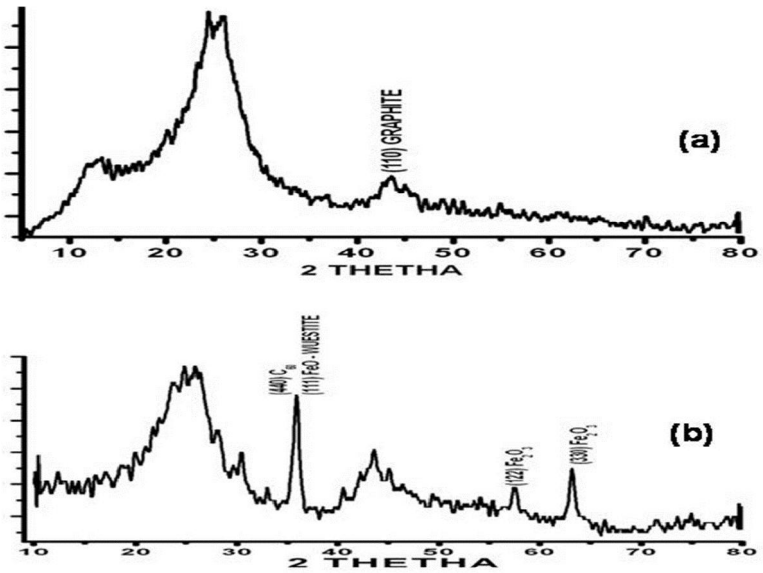

Fig. 4. XRD of carbon material produced using acetylene and oxygen.
(a) O/F of 0.8 v/v in the absence catalyst. (b) O/F of 0.8 v/v in the presence of catalyst.

XRD (Fig. 4b) of nanorods at 0.8 v/v in the presence of catalyst resulted in heterogeneous crystallinity in the sample. The raw scan detected three strong peaks. The first peak at 2θ angle of 35.932^{O} was found with (111) orientation of atoms along its plane with peak corresponding to FeO in the form of wuestite mineral with a cubic type of system and an FCC lattice. The same peak was also detected for the presence of C_{60} with (440) as its orientation of atoms with a cubic system and a Face centered cubic (FCC) lattice. The second peak at 2θ angle of 57.504^{O} was found with (122) orientation of atoms along its plane with peak corresponding to Fe_2O_3 with a rhombohedral type of system and a rhombocentred lattice. The third peak at 2θ angle of 63.226^{O} was found with (330) orientation of atoms along its plane with peak corresponding to Fe_2O_3 with an orthorhombic type of system and a primitive type lattice respectively. The average crystalline size at 2θ = 35.0^{O} of the ferrocene catalyzed samples was calculated as 30 nm which is evident in the SEM images which shows highly dispersed bright spots in the SEM scans of Fig. (2a - 2d) respectively.

4 CONCLUSION

In the present investigation, we have successfully grown a CNR's using catalyst in acetylene – oxygen system with a diffusion type of burner. The CNR's morphology and catalyst concentration were closely examined. The CNRs shows a good result with increasing yield and decreasing diameter using catalyst. CNRs in the form of nanorods of 150 – 400 nm diameters were synthesized in good quantities. These nanorods with decrease in their diameters to the nearest minimum for their use in many applications like hydrogen storage, semi-conducting materials, electrodes, medicine applications and composites.

ACKNOWLEDGEMENT

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REFERENCES

[1] J. Yu, J. Ahn, Q. Zhang, S. F. Yoon, Rusli, Y. J. Li, B. Gan, K. Chew, K. H. Tan, "Catalyzed growth of carbon nanoparticles by microwave plasma chemical vapor deposition and their field emission properties," *J. Appl.Phys*, vol. 91, no. 1, pp. 433–436.

[2] S. Iijima, "Helical microtubules of graphitic carbon", *Nature*, vol. 354, pp. 56–58, 1991.
[3] W. Kratschmer, L. D. Lamb, K. Fostiropoulos, D. R. Huffman, "Solid C_{60}: a new form of carbon," *Nature,* vol. 347, pp. 354–358, 1990.
[4] Y. H. Tang, N. Wang, Y. F. Zhang, C. S. Lee, I. Bello, S. T. Lee, "Synthesis and characterization of amorphous carbon nanowires," *Appl. Phys. Lett.*, vol. 75, no. 19, pp. 2921–2923, 1999.
[5] Y. Chen, S. Patel, Y. G. Ye, S. T. Shaw, L. P. Luo, "Field emission from aligned high-density graphitic nanofibers," *Appl. Phys. Lett.*, vol. 73, no. 15, pp. 2119–2121, 1998.
[6] X. J. Wang, J. Lu, Y. Xie, G. A. Du, Q. X. Guo, S. Y. Zhang, "A Novel Route to Multiwalled Carbon Nanotubes and Carbon Nanorods at Low Temperature," *J. Phys. Chem. B.*, vol. 106, no. 5, pp. 933–937.
[7] A. Laforgue, P. Simon, J. F. Fauvarque, M. Mastragostino, F. Soavi, J. F. Sarrau, P. Lailler, M. Conte, E. Rossi, S. Saguatti, "Activated Carbon/Conducting Polymer Hybrid Supercapacitors," *J. Electrochem. Soc.*, vol. 150, no.5, pp. A645–A651, 2003.
[8] R. Dominko, M. Gaberscek, J. Drofenik, M. Bele, J. Jamnik, "Influence of carbon black distribution on performance of oxide cathodes for Li ion batteries," *Electrochim. Acta,* vol. 48, no. 24, pp. 3709–3716, 2003.
[9] G. F. Goya and H. R. Rechenberg, "Magnetic properties of $ZnFe_2O_4$ synthesized by ball milling," *Journal of Magnetism and Magnetic Materials*, vol. 203, no. 1-3, pp. 141-142, 1999.
[10] D. J. Fatemi, V. G. Harris, V. M. Browning and J. P. Kirkland, "Processing and cation redistribution of MnZn ferrites via high-energy ball milling," *J. Appl. Phys*., vol. 83, no. 11, pp. 6867-6869, 1998.
[11] L. Thien-Nga, K. Hernadi, L. Forro, "Catalytic Growth of Carbon Nanorods on a High-Tc Substrate," *Adv. Mater.*, vol. 13, no. 2, pp. 148–150, 2001.
[12] Sato Toshihiko, Tetsuo Iijima, Masahiro Seki and Nobuo Inagaki, "Magnetic properties of ultrafine ferrite particles," *Journal of Magnetism and Magnetic Materials,* vol. 65, no. 2-3, pp. 252-256, 1987.
[13] Ueda Midori, Shiro Shimada and Michio Inagaki, "Synthesis of crystalline ferrites below 60 °C," *Journal of the European Ceramic Society*, vol. 16, no.6, pp. 685-686.
[14] M. Yokoyama, T. Sato, E. Ohta and T. Sato, "Magnetization of cadmium ferrite prepared by coprecipitation," *J. Appl. Phys*, vol. 80, no.2, pp. 1015-1019, 1996.
[15] Chen Qi and John Zhang, "Size-dependent super paramagnetic properties of $MgFe_2O_4$ spinel ferrite nanocrystallites," *Appl. Phys. Let,* vol. 73, no. 21, pp. 3156-3158, 1998.
[16] Pileni, M.P., *Text Book of Nanostructured Materials, Selected Synthesis Methods, Properties and Applications,* In: Philippe Knauth, Joop, and Schoonman (Eds.), *Chapter 1: Nanomaterials Production by Soft Chemistry*, New York, Kluwer AcademicPublishers, pp. 2, 2004.
[17] Vivek Dhand, J. S. Prasad, M. Venkateswara Rao, K. Naga Mahesh, L. Anupama, V. Himabindu, Anjaneyulu Yerramilli, V. S. Raju, A. A. Sukumar, "Design and Development of Flame Reactor for Carbon Nanorods (CNRs) Production," *Ind J Eng & Mat. Sci,* vol. 14, no. 3, pp. 240-252, 2007.
[18] A. Huczko, "Synthesis of aligned carbon nanotubes," *Applied Physics A*, vol. 74, no. 14, pp. 617-634, 2002.
[19] Charanjeet Singh, S. P. Milo Shaffer, H. Alan Windle, "Production of controlled architectures of aligned carbon nanotubes by an injection chemical vapour deposition method," *Carbon,* vol. 41, pp. 359–368, 2003.
[20] P. Sampedro-Tejedor, Maroto-Valiente, D. M. Nevskaia, V. Múñoz, I. Rodríguez-Ramos, Guerrero-Ruíz, "The effect of growth temperature and iron precursor on the synthesis of high purity carbon nanotubes," *Diamond & Related Materials,* vol. 16, no. 3, pp. 542–549, 2007.
[21] Huaping Liu, Guoan Cheng, Ruiting Zheng, Yong Zhao, Changlin Liang, "Influence of acid treatments of carbon nanotube precursors on Ni/CNT in the synthesis of carbon nanotubes," *Journal of Molecular Catalysis A: Chemical*, vol. 230, no. 1-2, pp. 17–22, 2005.
[22] B. Louisc, G. Gulino, R. Vieira, J. Amadou, T. Dintzer, S. Galvagno, G. Centi, M. J. Ledoux, C. Pham-Huu, "High yield synthesis of multi-walled carbon nanotubes by catalytic decomposition of ethane over iron supported on alumina catalyst," *Catalysis Today*, vol. 102-103, pp. 23–28, 2005.
[23] Shigeo Maruyama, Erik Einarsson, Yoichi Murakami, Tadao Edamura, "Growth process of vertically aligned single-walled carbon nanotubes," *Chemical Physics Letters*, vol. 403, no. 4-6, pp. 320–323, 2005.
[24] Liming Yuan, Tianxiang Li, Kozo Saito, "Growth mechanism of carbon nanotubes in methane diffusion flames," *Carbon,* vol. 41, no. 10, pp. 1889–1896, 2003.
[25] K. Andreas, Schaper, Haoqing Hou, Andreas Greiner, and Fritz Phillipp, "The role of iron carbide in multiwalled carbon nanotube growth," *Journal of Catalysis*, vol. 222, no. 1, pp. 250–254, 2004.

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Caractérisation des coordonnées et de la vitesse de la pointe du stylo à partir des signaux électromyographiques de l'avant bras

[Characterization of pen-tip coordinates and velocity using electromyographic signals of the forearm muscles]

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ABSTRACT: Handwriting is considered as one of the most delicate and complex human activities. This habit requires a certain level of evolution of the language, the control of the graphic space and a certain degree of affective and praxis development. The production of a meaningful and readable writing involves a variety of motor commands generated by the brain and sent to the muscles to define, with an extreme precision, the motion of each joint at a given time. In this paper, two models characterizing the handwriting process are proposed. Using the activities of the forearm muscles, called the ElectroMyoGraphic signals (EMG), the first model is based on the coordinates of the pen-tip moving on (x,y) plan and the second model is defined from the velocity of the pen-tip. The parameters' estimation of both models is determined from the Recursive Least Square algorithm (RLS). The comparison of responses of two proposed structures shows the interest of the velocity to model the complex biological process. Indeed, the model based on the velocity shows best results then the model bases on the coordinates of the pen-tip.

KEYWORDS: ElectroMyoGraphic signals, the coordinates of the pen tip, (x,y) plane, velocity of the pen tip, Recursive Least Square algorithm (RLS).

RESUME: L'écriture à la main est considérée parmi les activités motrices les plus délicates et complexes. Cette habitude motrice nécessite un certain niveau d'évolution du langage, une maîtrise de l'espace graphique et un certain degré de développement moteur, praxique et affectif. La production d'un écrit sensé est lisible fait intervenir une variétés de commandes motrices générées par le cerveau et envoyées aux muscles afin de définir d'une façon extrêmement précise le mouvement de chaque articulation à un instant donné. Dans cet article deux modèles caractérisant le processus d'écriture à la main sont proposés. En utilisant les activités musculaires de l'avant bras, appelées les signaux ElectroMyoGraphiques (EMG), le premier modèle est basé sur les coordonnées de la pointe du stylo en mouvement dans le plan (x,y) et le deuxième est défini à partir de la vitesse de la pointe du stylo. L'estimation des paramètres des deux modèles est déterminée à partir de l'algorithme des Moindres Carrées Récursifs (MCR). La comparaison des réponses des deux structures proposées est également proposée dans ce papier. Cette comparaison nous conduit à conclure l'intérêt de la vitesse de l'écriture manuscrite dans la modélisation de ce processus biologique complexe. En effet le modèle basé sur la vitesse montre de meilleurs résultats par rapport à celui basé sur les coordonnées de la pointe du stylo.

MOTS-CLEFS: Signaux ElectroMyoGraphiques, coordonnées de la pointe du stylo, plan (x,y) , vitesse, estimation des paramètres, Moindres Carrées Récursifs.

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1 INTRODUCTION

La production de traces graphiques est considérée comme une manifestation physique d'un processus cognitif complexe. En effet, le cerveau traite l'information de localisation de la pointe du stylo, envoyée par les yeux. Cette information est analysée et évaluée par un système de contrôle intelligent, afin d'envoyer un ordre aux muscles de l'avant bras pour faire bouger la main vers la nouvelle position désirée. En première analyse, Van Der Gon a élaboré un modèle mathématique caractérisant ce phénomène, [1]. Une version électronique est ensuite proposée par Mc Donald qui a considéré le système de l'écriture manuscrite comme une masse se déplaçant dans un milieu visqueux, [2]. Le mouvement de cette masse est décrit par une équation différentielle linéaire du second ordre. Un modèle régi par un système de deux équations différentielles non linéaires du second ordre a été élaboré par Yasuhara qui a intégré l'effet de la force de frottement entre la pointe du stylo et la surface d'écriture, [3]. Il a ensuite identifié et décomposé un système d'écriture rapide, [4]. A partir de ce modèle Iguider a élaboré deux approches, une pour l'extraction des pulsations de commande, [5], et l'autre pour la reconnaissance de l'écriture arabe cursive, [6].

Edelman et Flash ont élaboré en 1987 un modèle basé sur l'étude des trajectoires de la main, [7]. Une approche de modélisation linéaire obtenue à partir de données expérimentales a été proposée par Sano en 2003, [8].

En utilisant des approches non conventionnelles, des modèles sont proposés pour la caractérisation du processus de l'écriture manuscrite, [9], [10]. Ces modèles sont basés sur les concepts des réseaux de neurones artificiels, de la logique floue, des algorithmes génétiques, etc., [11] et [12].

D'autres modèles utilisant la vitesse ont été présentés dans [13], [14] et [15].

L'écriture est, fondamentalement, une activité et caractéristique individuelle, de la même manière que la voix et le visage d'une personne. Elle reflète l'état psychique et physique du scripteur, [16] et [17].

La vitesse de l'écriture manuscrite d'un même scripteur varie selon son âge, son attitude, son humeur (énervé, pressé, etc), la surface d'écriture, etc. Elle est considérée parmi les propriétés individuelles qui dépendent de plusieurs facteurs à savoir le sexe du scripteur, le niveau culturel, la profession, la manière de tenir le stylo, etc, [17].

Les modèles proposés dans la littérature pour la modélisation du processus à la main, ont contribués à des caractérisations plus ou moins valides d'un nombre limité de formes manuscrites. Pour surmonter ces difficultés, nos travaux de recherches portent sur la modélisation et l'identification ce processus biologique afin de proposer un modèle généralisé caractérisant plusieurs types de traces graphiques générées par un seul ou plusieurs scripteurs. Pour mener à ces études, il est nécessaire de définir une structure mathématique permettant de refléter le mieux possible le comportement réel du processus étudié en prenant en considération les différentes caractéristiques et contraintes en rapport avec ce processus (vitesse, variétés de formes et de personnes, etc).

Dans le cadre de la modélisation du système d'écriture à la main, une approche expérimentale proposée en 2003 par Sano, [8]. Cette approche a permis l'élaboration d'une base d'exemples constituée des coordonnées (x, y) relatives aux déplacements de la pointe du stylo sur le plan de l'écriture, d'un ensemble de lettres arabes et de formes géométriques simples et des enregistrements relatifs aux activités musculaires de deux muscles de l'avant bras intervenants lors de la production des traces graphiques, appelées signaux ElectroMyoGraphiques (EMG). Dans ce cas, les modèles caractérisant l'écriture manuscrite sont déterminés à partir des mesures de type entrée/sortie représentant les seules informations exploitables sur le processus à étudier

A partir des enregistrements expérimentaux, et en utilisant l'algorithme d'identification des Moindres Carrées Récursifs (MCR), nous proposons dans ce papier deux structures mathématiques de caractérisation du processus d'écriture à la main. En effet, la première structure est basée sur les coordonnées de la pointe du stylo. La deuxième structure proposée est définie à partir de la vitesse de la pointe du stylo afin de reproduire différentes formes manuscrites générées par plusieurs scripteurs.

2 MATERIELS

Les déplacements verticaux de la pointe du stylo sont générés par les mouvements de flexion extension des doigts alors que les déplacements horizontaux sont générés par les mouvements d'abduction-adduction du poignet. Les composantes spatiales de la pointe de stylo correspondent aux mouvements des composantes biomécaniques mises en jeu lors de l'écriture, [3].

Les muscles de l'avant bras, intervenant dans l'acte de l'écriture à la main, sont situés directement sous la peau, ce qui permet l'utilisation des électrodes de surface pour enregistrer les signaux EMG. Afin de caractériser ce processus biologique,

Sano a proposé dans [8] une approche expérimentale permettant d'enregistrer en même temps les coordonnées de quelques traces graphiques dans le plan (x,y) et des signaux électromyographiques de l'avant bras, intervenant lors de la production de l'écriture. Ces signaux sont obtenus à partir des électrodes de surface, servant à calculer les activités musculaire deux muscles de l'avant bras, à savoir l'« abductor pollicis longus » et l'« extensor capri ulnaris » .

La figure 1 illustre le montage expérimental et matériel utilisé pour la réalisation de cette approche. Cette approche nécessite un ordinateur permettant d'enregistrer les positions x et y et la pression de la pointe de stylo sur le plan d'écriture.

Ces enregistrements sont obtenus en utilisant une table numérique de la marque « WACOM, KT-0405-RN » comme plan d'écriture, un enregistreur de données, du type « TEAC, AR- C2EMG1 ». La production des traces graphiques est réalisée par plusieurs scripteurs, hommes et femmes, âgés entre 22 et 23 ans. Ces scripteurs confortablement assis, utilisent un crayon optique pour mémoriser dans l'ordinateur les coordonnées des points de la trajectoire d'écriture à une fréquence fixe et les signaux EMG mesurés par des électrodes de surface qui déposées sur l'avant bras du scripteur. La marque des électrodes qui ont servis à cette expérience est « MEDICOTEST, Blue Sensor N-00-S », [8].

La figure 2 indique le positionnement des électrodes sur le bras du scripteur, les électrodes, indiquées par « ch 1 » sont relatives au premier muscle et celles relatives au deuxième muscle sont indiquées par « ch 2 ».

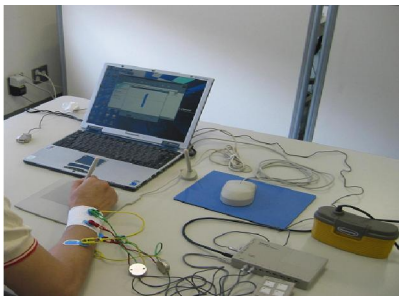


Fig. 1. Montage expérimental

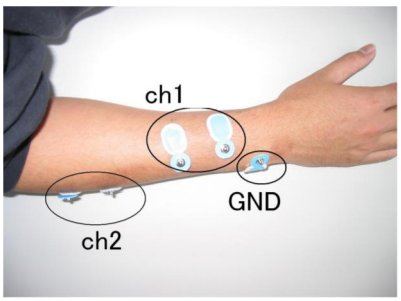


Fig. 2. Positions des électrodes sur le bras du scripteur

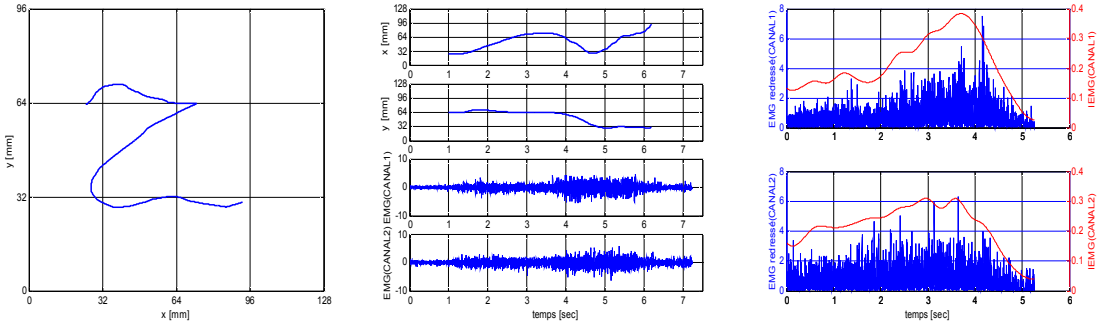
L'étude expérimentale, présentée, est réalisée à l'université de Hiroshima City. Ces scripteurs ont écrit plusieurs lettres arabes, et dessiné huit formes géométriques de base, tableau 1.

Tableau 1. Formes géométriques élémentaires choisies pour l'expérimentation

Numéro	Nomde la forme	Représentation de la forme	Numéro	Nom de la forme	Représentation de la forme
1	Ligne horizontale (1) (gauche/droite/gauche)		5	Cercle (1) (vers la droite)	
2	Ligne horizontale (2) (droite/ gauche / droite)		6	Cercle (2) (vers la gauche)	
3	Ligne verticale (1) (gauche/droite/gauche)		7	Triangle (1) (vers la droite)	
4	Ligne verticale (2) (droite/ gauche / droite)		8	Triangle (2) (vers la gauche)	

Les signaux EMG présentent des phénomènes transitoires ou de segments bruités et d'autres signaux perturbateurs d'origines électroniques ou physiques provenant des diverses sources comme les phénomènes électromagnétiques du secteur et les bruits parasites liés aux électrodes et aux incertitudes des mesures [18]. Ceci nécessite l'introduction des approches de traitement de signaux biomédicaux pour obtenir un signal facile à étudier qui est le signal ElectroMyoGraphique Intégré (IEMG).

Dans la figure 3 sont consignées des exemples des signaux EMG et IEMG enregistrés pour les deux muscles choisis, ainsi que les mesures de déplacements de la pointe du stylo (déplacements suivant x et y) pour différentes lettres et formes choisies, [8].



(a) (b) (c)

Fig. 3. La lettre « HA »
(a) Forme, (b) Déplacements selon x et y, signaux EMG et (c) Signaux IEMG

3 METHODE D'IDENTIFICATION PAR L'ALGORITHME DES MOINDRES CARRES RECURSIFS (MCR)

L'implantation des algorithmes d'identification non récursifs en temps réel est quasiment impossible dans le cas des systèmes ayant une puissance de calcul et une capacité de stockage de données limitées (microprocesseur, DSP, etc.).

L'estimateur des MCR est une solution des problèmes posés dans l'identification non paramétrique. Il offre, à chaque instant, un traitement séquentiel de données expérimentales disponibles, évoluant au fur et à mesure que le système évolue, [19], [20] et[21].

L'algorithme d'identification des moindres carrées récursifs permet d'obtenir les équations (1) jusqu'à (3).

$$\hat{\theta}(k) = \hat{\theta}(k-1) + P(k) \sum_{i=n+1}^{k} y(i)\,\Psi(i) \tag{1}$$

$$P(k) = P(k-1) - \frac{P(k-1)\,\Psi(k)\,\Psi^{T}(k)\,P(k-1)}{1+\Psi^{T}(k)\,P(k-1)\,\Psi(k)} \tag{2}$$

$$\xi(k) = y(k) - \hat{\theta}(k-1)\,\Psi(k) \tag{3}$$

$\hat{\theta}(k)$ est le vecteur des paramètres
ψ est la matrice d'observation
ξ est le vecteur d'erreur de prédiction

La convergence de cet algorithme dépend des conditions portant sur l'erreur de prédiction et sur la variation des paramètres estimés à chaque pas d'itération, [22] et [23].

4 MODELISATION DU PROCESSUS D'ECRITURE A LA MAIN

L'identification consiste en la détermination, à partir de mesures sur les couples entrées/sorties, des paramètres d'un modèle mathématique, de telle sorte qu'il arrive à reproduire partiellement ou totalement le comportement du système réel dans le domaine de fonctionnement pour lequel il a été établi.

Dans notre cas, les seules informations disponibles sur le processus d'écriture à la main, sont les mesures expérimentales, collectées à partir de l'approche présentée dans la partie (2). L'identification expérimentale qui est basée sur l'analyse expérimentale ou sur un ensemble de mesures relevées sur le système au cours de son fonctionnement, est la meilleure méthode utilisée pour l'élaboration d'un modèle mathématique traduisant le comportement du processus étudié.

4.1 MODELE BASE SUR LES COORDONNEES DE LA POINTE DU STYLO

L'identification des processus nécessite un choix pertinent de la structure mathématique. Afin de caractériser le processus d'écriture à la main en générant le déplacement de la pointe du stylo, x et y selon l'axe des abscisses et l'axe des ordonnées, les entrées du modèle proposé sont les signaux IEMG1 et IEMG2 et les sorties, x et y, à des instants retardés.

4.1.1 RESULTATS DE L'IDENTIFICATION DU MODELE PROPOSE, BASE SUR LES COORDONNEES

La structure proposée est linéaire, du quatrième ordre. Les entrées de ce modèle sont les signaux IEMG aux instants k, (k-1), (k-2), (k-3), (k-4) et les positions x et y retardées jusqu'à l'instant (k-4). Les signaux de sorties de ce modèle sont les positions x et y à l'instant k, équations (4).

$$\begin{aligned} x_e(k) &= \sum_{i=1}^{4} \hat{a}_{ix}\, y_e(k-i) + \sum_{i=1}^{4} \hat{b}_{ix}\, x_e(k-i) + \sum_{i=1}^{5} \hat{c}_{ix}\, e_1(k-i+1) + \sum_{i=1}^{5} \hat{d}_{ix}\, e_2(k-i+1) \\ y_e(k) &= \sum_{i=1}^{4} \hat{a}_{iy}\, x_e(k-i) + \sum_{i=1}^{4} \hat{b}_{iy}\, y_e(k-i) + \sum_{i=1}^{5} \hat{c}_{iy}\, e_1(k-i+1) + \sum_{i=1}^{5} \hat{d}_{iy}\, e_2(k-i+1) \end{aligned} \quad (4)$$

avec :

x_e, y_e : la position estimée relative à x et y, respectivement,

$\hat{a}_{ix}$, $\hat{b}_{ix}$, $\hat{c}_{ix}$, $\hat{d}_{ix}$: les paramètres relatifs au modèle caractérisant la position x_e,

$\hat{a}_{iy}$, $\hat{b}_{iy}$, $\hat{c}_{iy}$, $\hat{d}_{iy}$: les paramètres relatifs au modèle caractérisant la position y_e,

k : le temps discret.

L'estimateur des moindres carrées récursifs permet de déterminer les paramètres à estimer d'une manière récursive. En effet, la simple mise en œuvre pratique, le temps de calcul relativement faible, ainsi que la capacité réduite de stockage et de traitement des données, nous amène à proposer cet estimateur pour la caractérisation du processus étudié. Les entées du modèle proposé sont les entrées et les sorties à des instants passés du système étudié, les sorties sont déterminées à des instants futurs, [20].

Le modèle proposé est caractérisé par deux vecteurs paramètres θx et θy relatives aux entrées estimées xe et ye, respectivement, ainsi que des matrices d'observation ψx et ψy, (relatives à xe et ye, respectivement), équations (5) et (6).

$$x_e = \psi_x^T \hat{\theta}_x + \varepsilon_x \quad (5)$$

$$y_e = \psi_y^T \hat{\theta}_y + \varepsilon_y \quad (6)$$

Notons que ε_x et ε_y sont les erreurs entre la réponse réelle et celle générée par le modèle proposé.

L'algorithme MCR, avec un facteur d'oubli fixé à une valeur égale à 0.95, est appliqué au système d'équations (4) traduisant le comportement du processus d'écriture à la main. Nous obtenons différentes réponses de la structure proposée pour différents scripteurs et différentes formes et lettres, figure II. 20.

Les données relatives aux sorties qui ont déjà servi à l'identification sont représentées par un trait pointillé, et la réponse du modèle est représentée par un trait rouge plein.

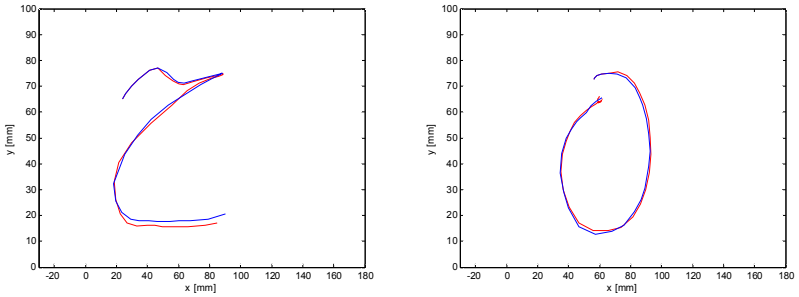


Fig. 4. Comparaison des réponses du modèle proposé et les données expérimentales

Les courbes présentées par la figure 4, montrent une concordance satisfaisante entre les réponses du modèle proposé et les données expérimentales.

Les modèles caractérisant les traces graphiques produites par la même personne ne présentent pas une différence importante entre les paramètres.

La figure 5 illustre l'évolution de quelques paramètres du modèle proposé, ($\hat{a}_{ix}$, $\hat{b}_{ix}$, $\hat{c}_{ix}$, $\hat{d}_{ix}$) et ($\hat{a}_{iy}$, $\hat{b}_{iy}$, $\hat{c}_{iy}$, $\hat{d}_{iy}$) et leur convergence vers une valeur constante. Pour chaque paramètre, la dernière valeur calculée par l'algorithme d'identification est considérée dans l'élaboration des modèles.

Le modèle élaboré est un modèle linéaire du quatrième ordre, à deux entrées et deux sorties. Il génère les traces graphiques à partir des signaux IEMG1 et IEMG2 ainsi que les positions x et y à des instants retardés.

Les allures des paramètres de ce modèle montrent que ces derniers convergent vers des valeurs constantes, ce qui nous amène à proposer des paramètres non variables dans le temps.

4.1.2 VALIDATION ET DISCUSSION

L'identification des processus est achevée par une étape de validation de la structure mathématique proposée. Cette structure n'est valable, en toute rigueur que pour l'expérience à partir de laquelle le modèle a été élaboré. Une vérification du modèle mathématique proposé est nécessaire afin de confirmer la compatibilité de ce dernier avec l'utilisation que l'on en fera.

Cette étape, consiste à proposer des tests qui aident à retenir ou à rejeter la structure élaborée. Lors d'un échec de la validation du modèle proposé, le choix de ce dernier doit être mis en question.

Dans ce sens, une étape de validation est nécessaire pour achever l'identification du processus d'écriture à la main. Cette étape consiste à:

- Vérifier la structure mathématique proposée dans le cas monoscripteur :

C'est-à-dire tester un modèle (1), élaborée pour un scripteur (1) avec des informations sur les entrées/sorties d'un autre exemple de la trace graphique caractérisée par le modèle (1) et écrite par le même scripteur (1).

- Vérifier la structure dans le cas multiscripteurs :

Dans ce cas, nous injectons à un modèle élaboré par un scripteur (1) les données relatives à un scripteur (2) ayant écrit le même type de la forme modélisée.

Des tests permettant de retenir ou de rejeter cette structure proposée pour la caractérisation de ce processus biologique sont présentés dans ce qui suit.

Le tableau 2 présente une différence entre les paramètres relatifs aux modèles représentant différents exemples de la lettre « HA », générés par deux scripteurs.

Une seule personne est caractérisée par une orientation préférentielle bien déterminée, surtout en gardant les mêmes conditions expérimentales (personne confortablement assise, même stylo, même plan d'écriture, etc.). Cependant, nous remarquons que les exemples (2) et (3) relatifs à la lettres « HA» et générés par le scripteur (2) ne sont pas identiques.

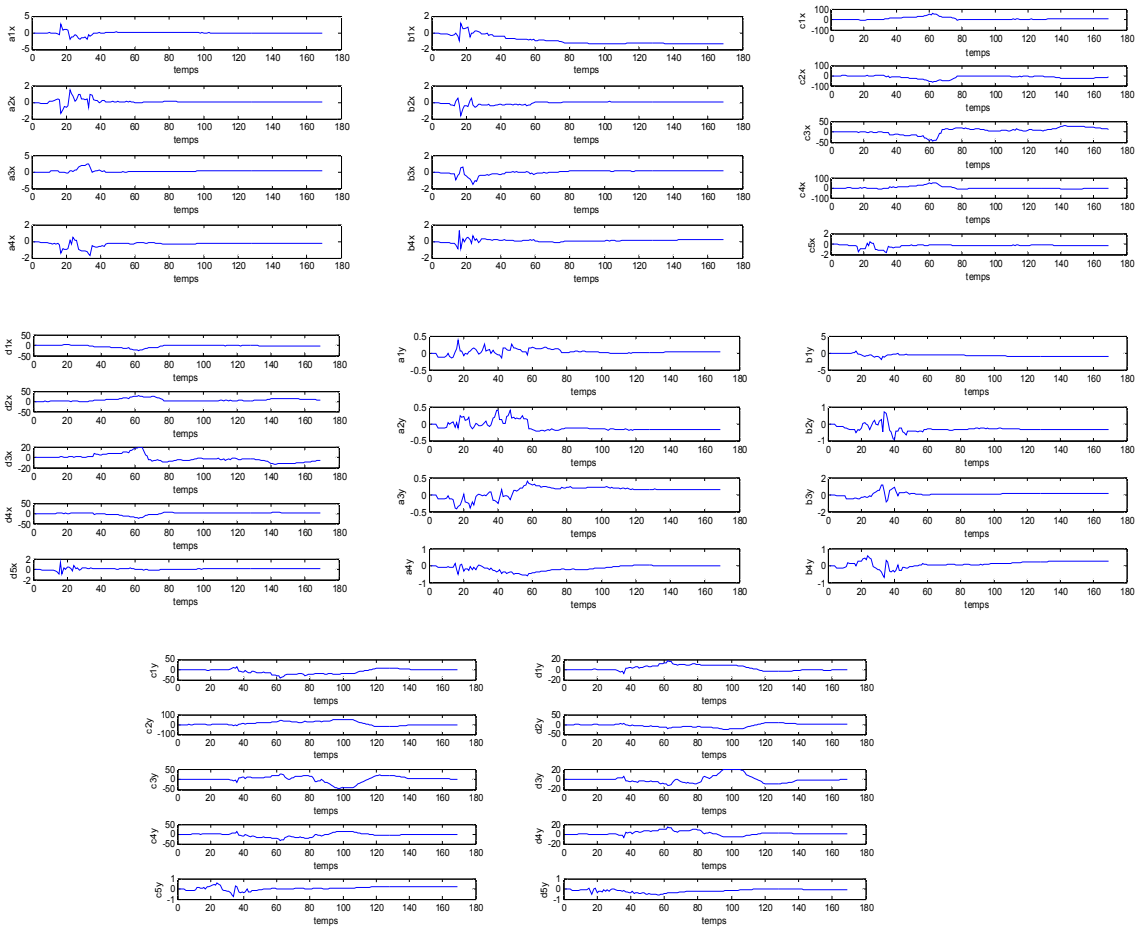
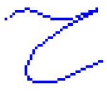
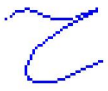


Fig. 5. ***Evolution des paramètres*** **(** $\hat{a}_{ix}$, $\hat{b}_{ix}$, $\hat{c}_{ix}$, $\hat{d}_{ix}$ **)** ***et*** **(** $\hat{a}_{iy}$, $\hat{b}_{iy}$, $\hat{c}_{iy}$, $\hat{d}_{iy}$ **)** ***relatifs à la forme triangle***

Une concordance peu importante est observée entre les paramètres de l'exemple (1), généré par le scripteur (1), et les deux autres écrits par le scripteur (2). Ces deux candidats ont deux orientations préférentielles différentes, les exemples (2) et (3), sont inclinés vers la droite, contrairement au premier exemple qui admet une orientation verticale. Ce qui explique la correspondance peu importante entre les paramètres de deux exemples traduisant les lettres générées par deux candidats différents.

Tableau 2. Paramètres relatifs à différents modèles de la lettre « HA » obtenus par identification pour deux scripteurs

	Paramètres relatifs à la position *x*			Paramètres relatifs à la position y		
Lettre	**HA**					
Exemples	**Scripteur1**	**Scripteur2**		**Scripteur1**	**Scripteur2**	
	exemple1	**exemple2**	**exemple3**	**exemple1**	**exemple2**	**exemple3**
Formes						
a_{1vx}	-1.0693	-0.0535	-0.1354	0.0668	-0.1118	-0.0767
a_{2xv}	0.2679	-0.087	0.4467	-0.0241	0.0509	0.1149
a_{3vx}	-3.1452	0.109	-0.3757	-0.0801	-0.052	-0.2008
a_{4vx}	2.0757	-0.079	0.0509	0.0487	0.0048	0.1578
b_{1vx}	1.1714	-1.534	-1.3088	-1.4273	-1.2751	-1.2396
b_{2vx}	-0.0867	0.4394	0.202	0.2184	0.1557	0.1116
b_{3vx}	-0.3597	-0.3006	-0.4615	0.127	-0.1899	-0.2397
b_{4vx}	1.1837	0.4032	0.5846	0.0775	0.3164	0.3412
c_{1vx}	3.0087	-2.5627	-1.9846	0.1450	0.0076	0.0487
c_{2vx}	2.6063	-0.4163	-0.436	0.0269	0.2032	0.1965
c_{3vx}	1.9364	1.211	1.616	-0.0033	-0.0453	-0.0162
c_{4vx}	-2.2827	-2.6607	-0.4256	-0.1724	-0.3644	-0.1289
d_{1vx}	1.0422	2.3007	0.9808	0.2777	0.7652	0.5086
d_{2vx}	-0.1366	-0.7213	-0.3615	-0.1604	-0.377	-0.6141
d_{3vx}	0.9194	0.7898	0.5489	0.1513	-0.041	0.6329
d_{4vx}	-2.6307	-3.3565	-2.0611	-0.3042	-0.3746	-2.9071

En utilisant le principe de validation qu'on a expliqué, les résultats illustrés par la figure 6 montre une certaine correspondance peu satisfaisante entre la réponse du modèle et les sorties relatives aux données expérimentales, dans le cas d'une validation monoscripteur. Des résultats peu satisfaisants sont également observés dans le cas multiscripteurs, figure 7. En résumé, partant uniquement des enregistrements électromyographiques de l'avant bras et des coordonnées de la pointe du stylo. La modélisation et l'identification de la structure proposée pour la caractérisation du processus d'écriture à la main, basée sur l'algorithme MCR a permis de proposer un modèle mathématique, linéaire et d'ordre quatre

L'analyse et les tests de validation du modèle proposé ont montré:

- une erreur très faible, voire négligeable, entre la réponse réelle et la réponse estimée du modèle élaboré pour des données à partir desquelles l'algorithme a été mis en œuvre,
- un écart plus au moins important dans le cas d'utilisation de nouvelles données pour le même scripteur et pour la même lettre ou forme dessinée,
- une erreur non négligeable dans le cas d'utilisation de nouvelles données pour un autre scripteur et pour la même forme ou lettre dessinée.

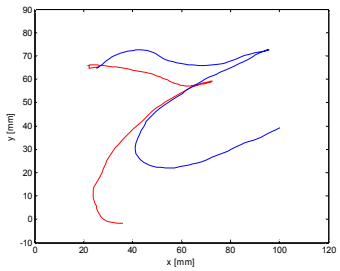


Fig. 6. Validation monoscripteur : Paramètres de l'exemple (2) → modèle de l'exemple (3)

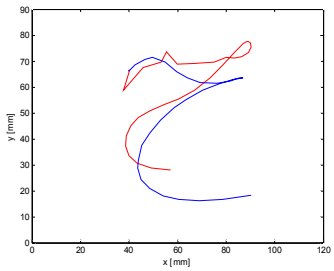


Fig. 7. Validation multiscripteurs :Paramètres de l'exemple (3) → modèle de l'exemple (1)

4.2 MODELE BASE SUR LA VITESSE DE LA POINTE DU STYLO

La synthèse du modèle direct, basé sur le calcul de la vitesse de la pointe du stylo lors de son déplacement dans le plan (x,y), est élaborée à partir deus signaux ElectroMyoGraphiques Intégrés de l'avant bras, IEMG1 et IEMG2. L'équation (7) définit la vitesse de la pointe du stylo.

$$\left\|\mathrm{V(k)}\right\| = \sqrt{\mathrm{V_x(k)^2 + V_y(k)^2}} \tag{7}$$

V_x et V_y sont les vitesses selon les axes des x et y, respectivement.

4.2.1 RESULTATS DE L'IDENTIFICATION DU MODELE PROPOSE, BASE SUR LA VITESSE

Le modèle proposé est exprimé par les équations (8).

$$V_{xe}(k) = \sum_{i=1}^{4} -\left[\hat{a}_{ivx}\, V_{ye}(k-i) + \hat{b}_{ivy}\, V_{xe}(k-i)\right] + \left[\hat{c}_{ivx}\, e_1(k-i+1) + \hat{d}_{ivx}\, e_2(k-i+1)\right]$$

$$V_{ye}(k) = \sum_{i=1}^{4} -\left[\hat{a}_{ivy}\, V_{xe}(k-i) + \hat{b}_{ivy}\, V_{ye}(k-i)\right] + \left[\hat{c}_{ivy}\, e_1(k-i+1) + \hat{d}_{ivy}\, e_2(k-i+1)\right] \tag{8}$$

$\hat{a}_{ivx}$, $\hat{b}_{ivx}$, $\hat{c}_{ivx}$, $\hat{d}_{ivx}$, $\hat{a}_{ivy}$, $\hat{b}_{ivy}$, $\hat{c}_{ivy}$, $\hat{d}_{ivy}$ sont les paramètres relatifs aux vitesses estimées V_{xe} et V_{ye} respectivement.

e_1 et e_2 sont les signaux IEMG1 et IEMG2, respectivement.

L'évolution des paramètres, illustrée par la figure 8, montre que ces paramètres convergents rapidement vers des valeurs constantes.

La figure 9 montre quelques exemples de comparaison entre la trajectoire réelle de la pointe du stylo et celle reconstituée par le modèle direct proposé. Une conformité importante est observée entre ces deux trajectoires pour les mouvements simples, les formes géométriques et les lettres arabes.

La ligne discontinue, bleue, représente les données enregistrées de la base et la ligne continue, rouge, représente la réponse du modèle basé sur le calcul de la vitesse.

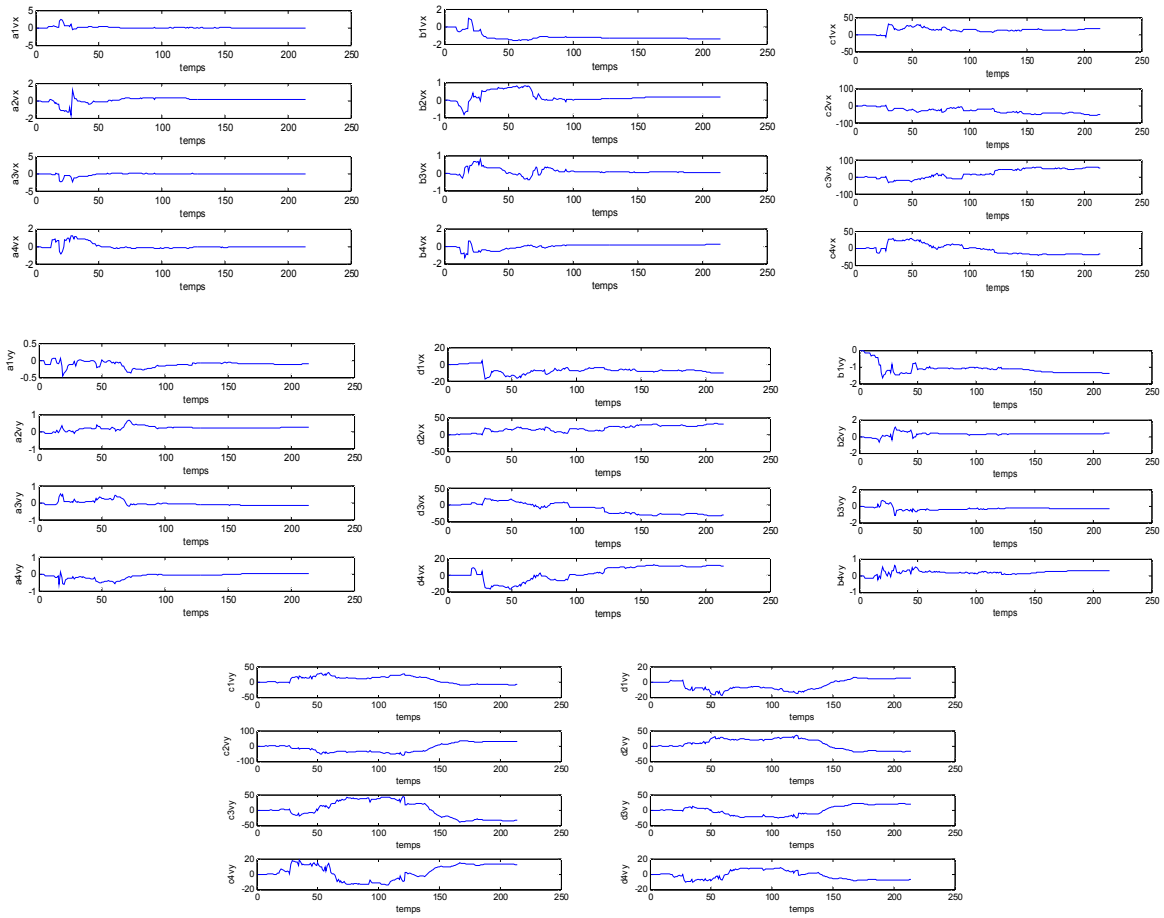


Fig. 8. Evolution des paramètres ($\hat{a}_{ivx}$, $\hat{b}_{ivx}$, $\hat{c}_{ivx}$, $\hat{d}_{ivx}$, $\hat{a}_{ivy}$, $\hat{b}_{ivy}$, $\hat{c}_{ivy}$, $\hat{d}_{ivy}$) relatifs à la lettre « HA »

4.2.2 VALIDATION ET DISCUSSION

Dans le cadre de validation du modèle mathématique proposé, deux types de validation sont présentés dans cette partie. La première est proposée pour le cas monoscripteur et une deuxième pour le cas multiscripteurs.

La validation monoscripteur consiste à intégrer les données d'un modèle caractérisant une lettre ou forme géométrique dans un autre modèle présentant un autre exemple de la trace graphique écrite par la même personne.

La deuxième étape de validation est proposée pour le cas multiscripteurs, elle consiste à appliquer les entrées relatives aux données expérimentales d'une lettre arabe ou d'une forme géométrique de base, à un modèle caractérisant le même type de trace graphique pour un scripteur différents.

Le tableau 3 illustre les paramètres relatifs à la lettre arabe « HA », écrite par deux scripteurs.

Les résultats de validation monoscripteur et multiscripteurs, sont montrés par les figures 10 et 11.

La validation de la structure proposée, dans le cas monoscripteur et multiscripteurs, montre une correspondance entre les trajectoires réelles et celles reconstruite à partir du modèle proposé.

En comparant ces résultats avec ceux obtenus par validation du modèle basée sur les positions, nous remarquons que l'erreur entre la sortie du modèle et celle enregistrée. Cette amélioration pourrait être due à la vitesse de l'écriture manuscrite, considérée, d'une part, comme un moyen de distinction entre les écritures de différentes personnes et d'autre part de différents états psychiques d'une même personne.

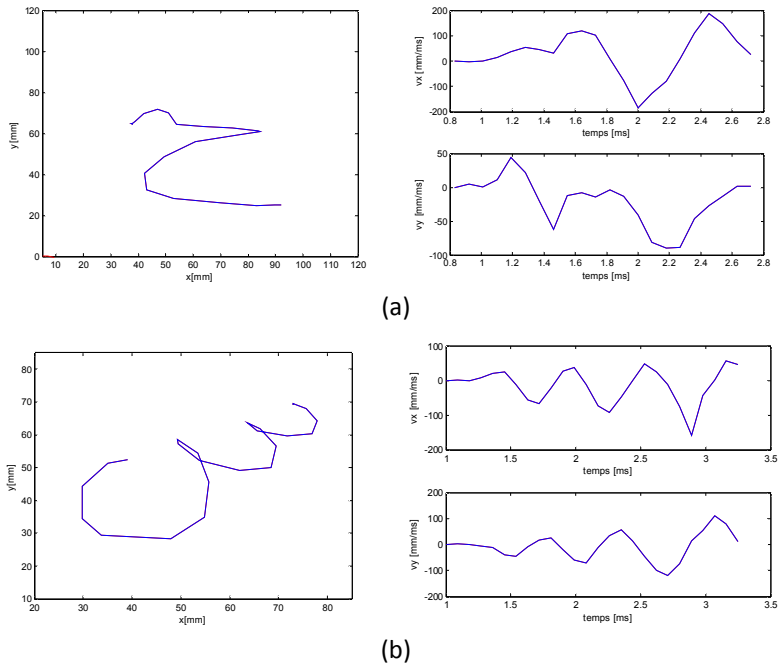


Fig. 9. Réponses du modèle proposé basé sur la vitesse de la pointe du stylo (forme et vitesses selon les axes x et y)

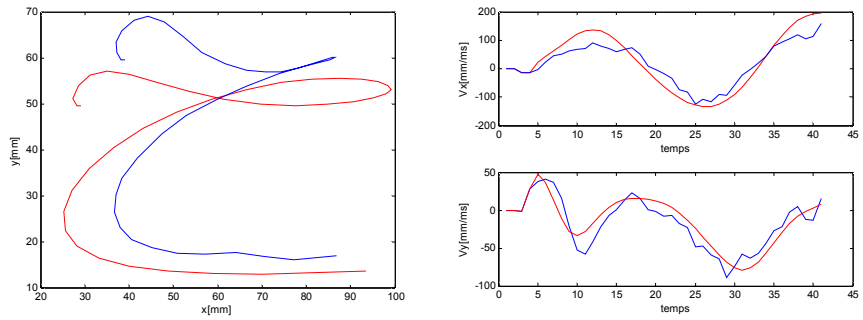


Fig. 10. Résultats de validation dans le cas monoscriteur (forme, vitesses selon les axes x et y)

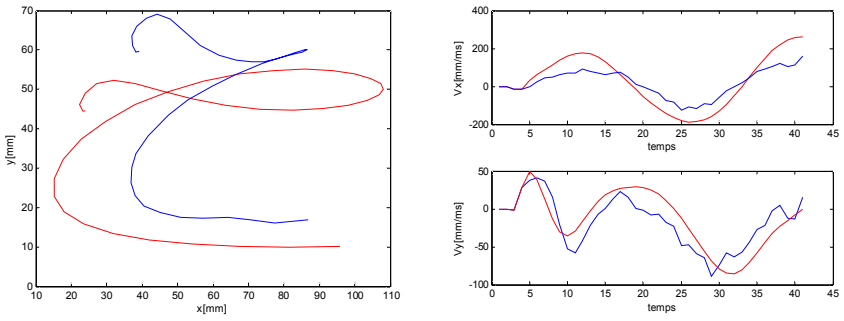
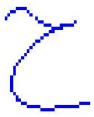
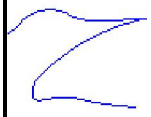
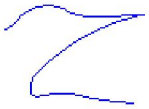


Fig. 11. Résultats de validation dans le cas multiscripteurs (forme, vitesses selon les axes x et y)

Tableau 3. Paramètres relatifs à différents modèles de la lettre « HA » obtenus par identification pour deux scripteurs (modèle direct)

	Paramètres relatifs à la position *x*			Paramètres relatifs à la position y		
Lettre	**HA**					
Exemples	**Scripteur1**	**Scripteur2**		**Scripteur1**	**Scripteur2**	
	exemple1	**exemple2**	**exemple3**	**exemple1**	**exemple2**	**exemple3**
Formes						
a_{1vx}	0.1184	0.0310	0.0615	-0.7490	-1.0811	0.9257
a_{2xv}	-0.3816	0.0255	-0.1192	-0.2997	1.3020	-1.2438
a_{3vx}	0.0721	-0.0633	-0.0554	1.9701	2.0120	1.3596
a_{4vx}	1.0778	0.1612	0.1216	-0.8389	-1.8569	-0.0450
b_{1vx}	1.1534	2.1280	-1.7652	-1.3206	-0.9389	-1.9139
b_{2vx}	-0.9776	2.0594	0.6710	0.5402	-0.3174	0.8692
b_{3vx}	0.2781	-0.6558	0.2085	-0.5141	-0.1619	-0.2143
b_{4vx}	-1.5650	-0.6502	-0.1159	0.4383	0.5832	0.2561
c_{1vx}	-1.0938	-0.7995	0.7932	3.6287	1.8997	2.3732
c_{2vx}	-1.2707	0.9445	2.2539	-11.0354	-4.2695	-5.6656
c_{3vx}	4.6653	1.7699	2.4364	4.3254	3.2910	5.3856
c_{4vx}	-1.1018	0.2716	-1.0172	-1.4171	-1.4450	-1.9553
d_{1vx}	-0.0732	-0.4455	-0.4919	1.3134	6.9266	-1.0667
d_{2vx}	1.0902	0.9567	1.3458	-0.8896	-1.4966	0.4276
d_{3vx}	1.8816	-0.8145	-1.6401	1.3555	0.9244	-4.2803
d_{4vx}	-0.4668	1.8674	0.8371	3.5058	0.5038	1.0552

5 CONCLUSION

L'exploitation de l'algorithme d'identification des moindres carrées récursifs a permis d'estimer les paramètres des structures mathématiques proposées pour la caractérisation du processus d'écriture à la main. Ces modèles sont élaborés en exploitant des enregistrements, obtenus à partir d'une base expérimentale qu'on a présenté. Cette base permet d'enregistrer les activités musculaires de l'avant bras et les coordonnées de la pointe du stylo selon les axes x et y. En effet le premier modèle proposé dans ce chapitre est fondé sur la relation entre ces enregistrements. En utilisant les vitesses de l'écriture, un modèle direct et un autre inverse sont également proposés.

Les résultats de tests et de validations de ces structures sont satisfaisants dans le cas d'un modèle élaboré pour des données à partir desquelles l'algorithme a été mis en œuvre. Un écart est toujours constaté dans le cas d'utilisation de nouvelles données avec les paramètres d'un scripteur différent pour la même lettre ou forme. L'intégration de nouvelles données avec les paramètres d'un scripteur différent pour la même trace graphique montre une erreur acceptable entre la réponse du modèle et celle désirée. Les modèles basés sur les vitesses de la pointe du stylo présentent un ordre inférieur par

rapport à celui fondé sur les coordonnées de la trace graphique manuscrites. Ils présentent également des résultats affinés même pour les graphes les plus compliqués (lettre « SIN », lettre « HA », etc).

L'approche de modélisation et d'identification paramétrique proposée dans ce chapitre caractérisant le processus d'écriture manuscrite s'est relevée concluante. Cependant Il est intéressant d'améliorer les modèles mathématiques proposés afin de représenter plusieurs types de traces graphiques produites par un seul ou plusieurs scripteurs. La solution de ce problème est abordée dans le chapitre suivant, consacré à la représentation multimodéles pour la modélisation du processus d'écriture à la main.

REFERENCES

[1] D. Van Der Gon, J.P Thuring et J. Strackee «A handwriting simulator», Physics in Medical Biology, pp. 407-414, 1962.

[2] J.S. Mac Donald, «Experimental studies of handwriting signals», Ph. D Dissertation, Mass. Inst. Tech., Cambridge, 1964.

[3] M. Yasuhara, «Experimental studies of handwriting process», Rep. Univ. Electro-Comm., vol. 25 no 2, pp. 233-254, Japon, 1975.

[4] M. Yasuhara, «Identification and decomposition of fast handwriting process», IEEE Transanctions on Circ. And Syst., vol. 30, no 11, pp. 828-832, 1983.

[5] Y. Iguider et M. Yasuhara, «Extracting control pulses of handwriting movement, Trans. of the Soc». Inst. and Cent., Eng., vol. 31, no 8, pp. 1175-1184, 1995, (Japon, 1995).

[6] Y. Iguider, M. Yasuhara, «An active recognition pulses of handwriting isolated Arabic characters», Trans, of the Soc. Inst. And Cont., Eng., Vol. 32, N°8, pp. 1267-1276, 1996, (Japon, 1996).

[7] S. Edelman et T. Flash, «A model of handwriting», Biological Cybernetics, Volume 57, pp. 25-36, Springer Verlag, 1987.

[8] S. Manabu, T. Kosaku et Y. Murata, «Modeling of Human Handwriting Motion by Electromyographic Signals on Foream Muscles», CCCT'03, 2003, (Orlando-Florida, 2003).

[9] M. Benrejeb, F. Bouslama, M. Ayadi et M. Sano, «Studying and modelling handwriting process», ACIDCA'2000, Vision and Pattern Recognition, pp. 124-129, 2000, (Monastir, 2000).

[10] M. Benrejeb, A. El Abed-Abdelkrim, S. Bel Hadj Ali et M.Gasmi, «A neuro-fuzzy internal model controller for handwriting process», CESA, 2003, (Lille, 2003).

[11] A. Abdelkrim, « Contribution à la modélisation du processus d'écriture à la main par approches relevant le calcul évolutif», Thèse de Doctorat, ENIT, Tunis, 2005.

[12] M. Benrejeb, M. Sano et A. El Abed-Abdelkrim, « Conventional and non conventional models of the handwriting process: differential, neural and neuro-fuzzy approaches», TIWSS'01, pp. 46-50, 2001, (Tokyo, 2001).

[13] M.A. Alimi, «Contribution au développement d'une théorie de génération de mouvements simples et rapides. Application au manuscript», Thèse de Doctorat, Université de Montréal, 1995, (Canada, 1995).

[14] R. Plamondon, « A kinematics theory of rapid human movements ». Part I : Movement representation and generation, Biological Cybernetics, vol. 72, pp. 295-307, 1995.

[15] R. Plamondon, « A kinematics theory of rapid human movements », Part II: Movement time and control, Biological Cybernetics, vol. 72, pp. 309-320, 1995.

[16] N. S. Bernstein, «The co-ordination and regulation of movements», Pergamon Press, Oxford, 1967

[17] I. Sallagoïty, « Dynamique de coordination spontanée de l'écriture », Thèse de Doctorat, Université Toulouse III - Paul Sabatier, 2004.

[18] F. de Coulon, « In Théorie et traitement des signaux », Presses Polytechniques Romandes, vol. 6, Lausanne,1984.

[19] R. en Abdennour, P. Borne, M. Ksouri et F. M'salhi, « Identification et commande numérique des procédés industriels », Edition Technip, 2001.

[20] I. D. Landau, « Identification et commande des systèmes », Hermès, Paris, 1993.

[21] M.Gerves et T.Kailath, «An innovation approach to least-squares estimation-part VI: Discrete-time innovations representations and recursive estimation». IEEE Transactions on Automatic Control, vol. 18, no 6, pp. 720-727, Décembre, 1973.

[22] P. Borne, G. Dauphin-Tanguy, J-P. Richard, F. Rotella et I. Zambettakis, « Modélisation et identification des processus », Tome 1, Technip, Paris, 1992.

[23] P. Borne, G. Dauphin-Tanguy, J-P. Richard, F. Rotella et I. Zambettakis, « Modélisation et identification des processus », Tome 2, Technip, Paris, 1992.

[24] T. Tutunji, M. Molhim et E. Turki, « Mechatronic systems identification using an impulse response recursive algorithm, Simulation Modelling Practice and Theory », vol. 15, pp 970-988, 2007.

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Analysis of Control Strategies for Diode Clamped Multilevel Inverter

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ABSTRACT: This paper presents the comparison of various Pulse Width Modulation (PWM) strategies for the three phase Diode Clamped Multi Level Inverter (DCMLI). The main contribution of this paper is the proposal of new modulation schemes with Variable Amplitude (VA) and various new schemes adopting the constant switching frequency and also variable switching frequency multicarrier control freedom degree combination concepts are developed and simulated for the chosen three phase DCMLI. The three phase DCMLI, is controlled in this paper with Sinusoidal PWM (SPWM) reference along with triangular carriers and analysis is made among both without carrier overlapping and with Carrier Overlapping (CO) techniques to choose the better strategy by performing simulation using MATLAB-SIMULINK. The variation of Total Harmonic Distortion (THD) and fundamental RMS output voltage is observed for various modulation indices. It is observed that among the various equal amplitude PWM strategies, COPWM-C provides less THD and higher RMS voltage. It is recognized that among the various variable amplitude PWM strategies, VACOPWM-C provides less THD and VACOPWM-B provides higher RMS voltage. By comparing the equal amplitude PWM strategies with the variable amplitude PWM strategies it is inferred that VACOPWM-C provides less THD and VACOPWM-B provides higher RMS voltage. It is also inferred that carrier overlapping techniques provides better results compared to the without carrier overlapping techniques.

KEYWORDS: SPWM, DCMLI, THD, COPWM.

1 INTRODUCTION

Multi Level Inverter (MLI) is a power electronic system that produces output voltage from several levels of DC input voltages. The attractive feature of this technology is mainly in the range of medium to high voltage application and offers a number of advantages when compared to the conventional two-level inverter. Ceglia et al [1] described a new multilevel inverter topology. Tehrani et al [2] made a detailed review on novel multilevel inverter model. Caballero et al [3] performed a study on new asymmetrical hybrid multilevel inverter. Ahmed et al [4] made a survey on new multilevel inverter topology with reduced number of switches. Sun et al [5] evaluated performance of multilevel inverter capable of power factor control with DC link switches. Boller et al [6] presented a survey on optimal pulse width modulation of a dual three level inverter system operated from a single DC link. Spencer et al [7] developed the study of multi sampled multilevel inverters to improve control performance. Najafi and Yatim [8] made a detailed review of design and implementation of a new multilevel inverter topology. Abdalla et al [9] carried out survey on multilevel DC link inverter and control algorithm to overcome the PV partial shading. Kangarlu and Babaei performed a survey on generalized cascaded multilevel inverter using series connection of sub multilevel inverters.

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2 MULTI LEVEL INVERTER

Multilevel inverters are used in power conversion system due to improved voltage and current waveforms. It is recently emerged as very important alternatives in high power medium voltage applications because of their advantage over the conventional one and their capability to reduce the undesirable harmonics. So that performance and efficiency of the system is improved. The concept of multilevel inverter is introduced with an aim to reduce switching losses and to obtain the output voltage with multiple steps to achieve the improved power quality and higher voltage capability. Multilevel inverters are used in high voltage AC motor drive, distributive generation, high voltage direct transmission as well as SVC applications.

The main concept of this inverter is to use diodes to limit the voltage stress on power devices. A DCMLI typically consists of (m-1) capacitors on the DC bus where m is the total number of positive, negative and zero levels in the output voltage. The order of numbering of the switches is Sa1, Sa2, Sa3, Sa4, Sa1', Sa2', Sa3' and Sa4'. The DC bus consists of four capacitors C1, C2, C3 and C4 acting as voltage divider. For a DC bus voltage Vdc, the voltage across each capacitor is Vdc/4 and voltage stress on each device is limited to Vdc/4 through clamping diode. The middle point of the four capacitors 'n' can be defined as the neutral point. The principle of diode clamping to DC link voltages can be extended to any number of voltage levels. Since the voltages across the semiconductor switches are limited by conduction of the diodes connected to the various DC levels, the inverter is called DCMLI. The switches are arranged into 4 pairs (Sa1,Sa1'), (Sa2,Sa2'), (Sa3,Sa3') and (Sa4,Sa4'). If one switch of the pair is turned ON, the complementary switch of the same pair must be OFF. The output phase voltage Van, Vbn, Vcn have five states: Vdc/2, Vdc/4, 0, - Vdc/4 and - Vdc/2. Four switches are triggered at any point of time to select the desired level in the five level DCMLI. Fig.1 shows a conventional three phase five level DCMLI.

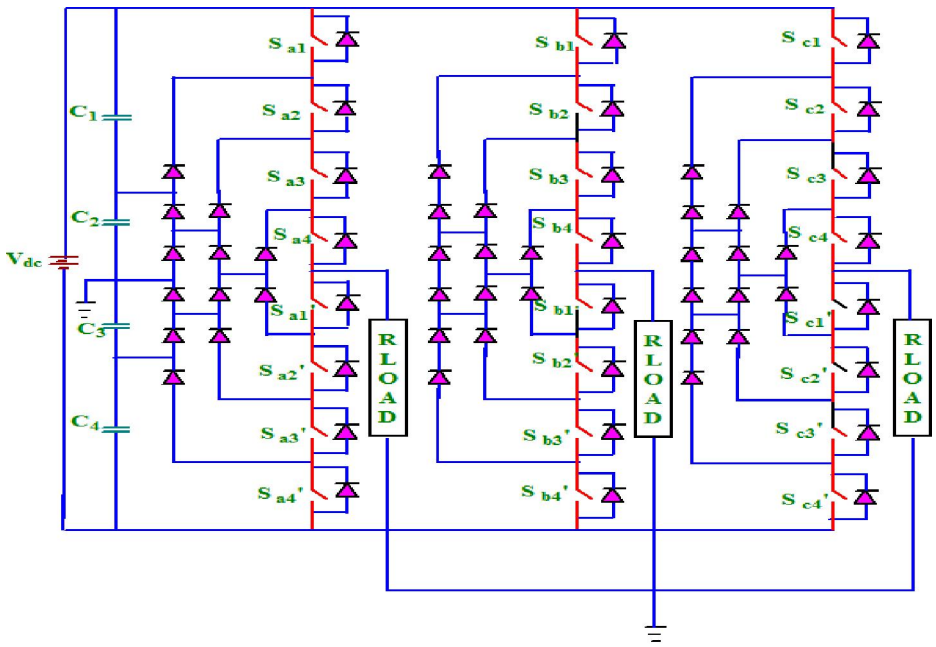

Fig. 1. Three phase five level DCMLI

3 MODULATION STRATEGIES

The most popular method of controlling the output voltage is by incorporating PWM control within the inverters. In this paper sixteen different modulation stragies are introduced in order to increase the output voltage and also to reduce the THD in which the fixed DC is converted into continuous AC signal efficiently by controlling the on and off time of PWM signal. It is generally recognized that, increasing the switching frequency of the PWM pattern results in reducing lower frequency harmonics. This paper includes reference waveform as sinusoidal and m-1 triangular carriers. The sixteen different modulation strategies are simulated in this work and the comparisons are made among them to chose the better technique which will be efficient and provides the output with improved power quality. The gate signals for chosen five level Diode Clamped Multilevel Inverter are simulated using MATLAB-SIMULINK. The gate signal generator model developed is tested for various values of modulation index m_a and for various PWM strategies. The simulation results presented in this work are compared and evaluated.

3.1 PHASE DISPOSITION PWM STRATEGY (PDPWM)

In this method all carriers have the same frequency, same amplitude and same phase but they are just different in DC offset to occupy contiguous bands. Since all carriers are selected with the same phase, this method is known as PD strategy. Carrier arrangement for this strategy is shown in Fig. 2.

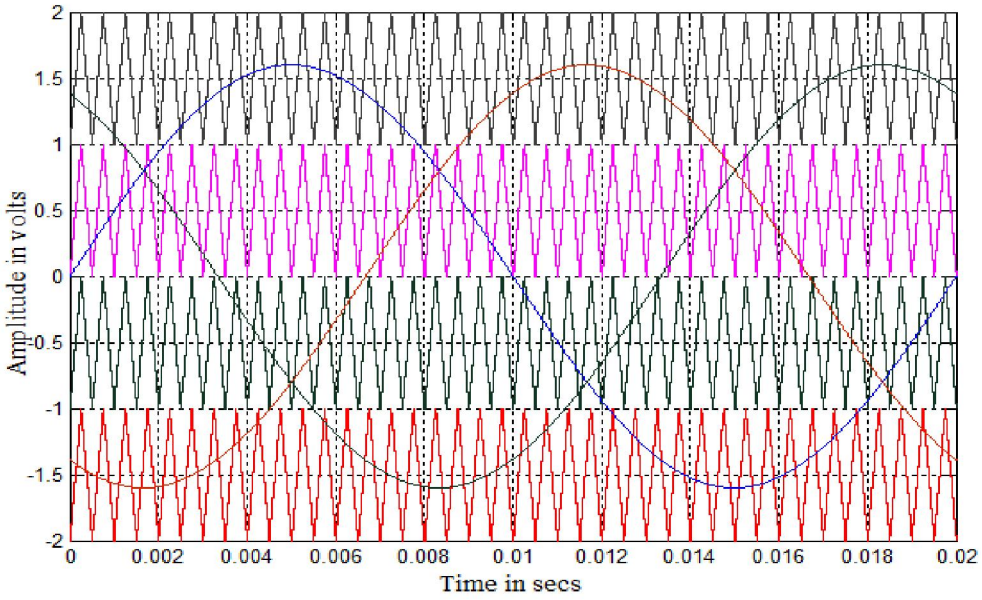

Fig. 2. Modulating and carrier waveforms for PDPWM strategy (m_a = 0.8 and m_f = 40)

3.2 VARIABLE AMPLITUDE PHASE DISPOSITION PWM STRATEGY (VAPDPWM)

This method is same as PDPWM method except that intermediate carriers are having variable amplitude compared to upper and lower carriers. Carrier arrangement for this scheme is shown in Fig. 3.

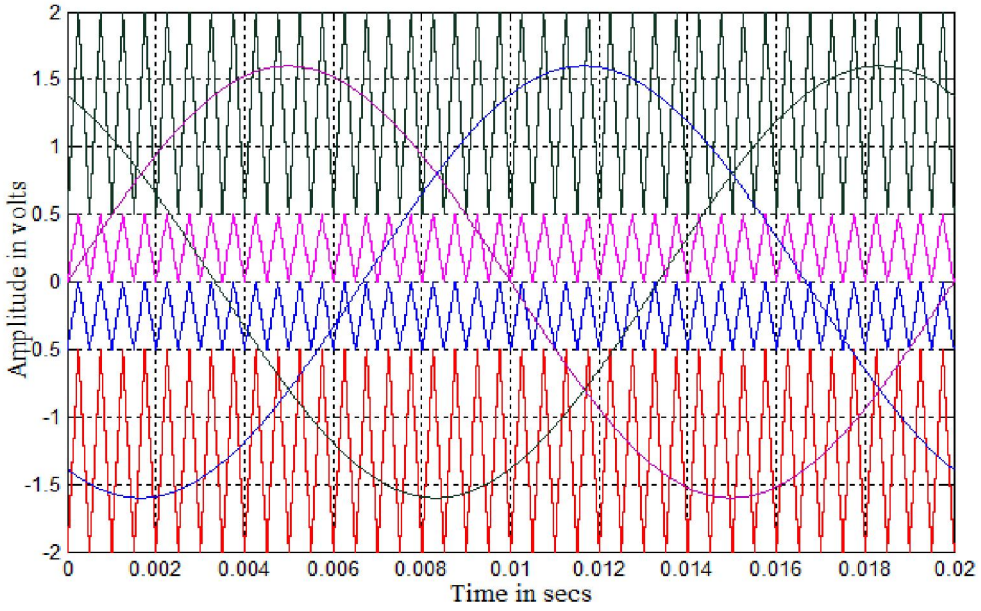

Fig. 3. Modulating and carrier waveforms for VAPDPWM strategy (m_a = 0.8 and m_f = 40)

3.3 PHASE OPPOSITION DISPOSITION PWM STRATEGY (PODPWM)

Four carriers, generated for five level inverter, is divided into two groups according to the positive and negative average levels. This scheme is similar to the PDPWM strategy but the two groups are opposite in phase with each other, so it is named as Phase Opposition Disposition PWM (PODPWM) technique. Carrier arrangement for this strategy is shown in Fig. 4.

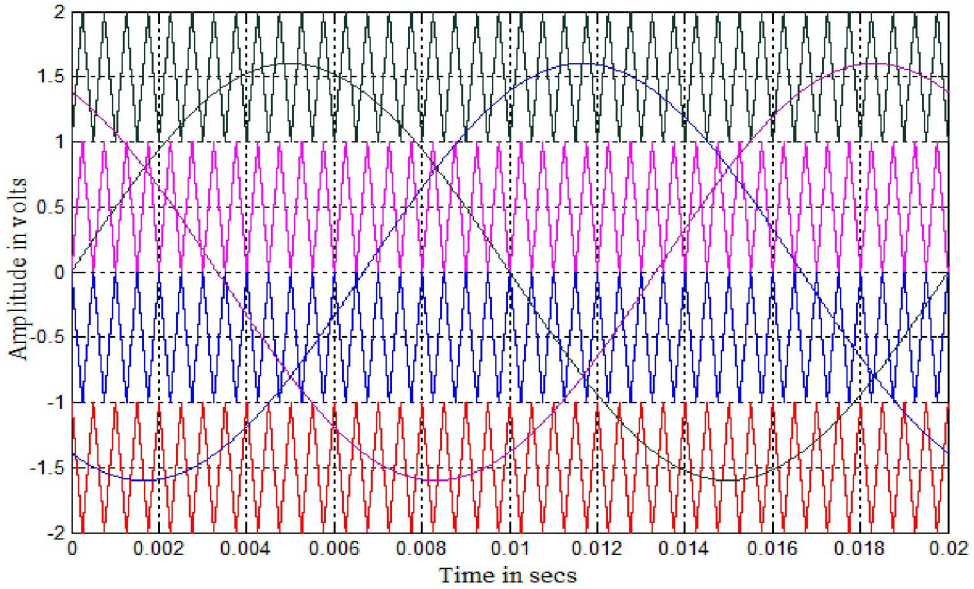

Fig. 4. Modulating and carrier waveforms for PODPWM strategy (m_a = 0.8 and m_f = 40)

3.4 VARIABLE AMPLITUDE PHASE OPPOSITION DISPOSITION PWM STRATEGY (VAPODPWM)

In this method four carriers, generated for five level inverter, is divided into two groups according to the positive and negative average levels. All carriers have the same frequency and varying amplitude, so it is named as Variable Amplitude Phase Opposition Disposition PWM strategy (VAPODPWM). Since all carriers are selected with the same phase, this method is similar to PODPWM strategy except with varying amplitude. It provides lower total harmonic distortion and relatively higher fundamental RMS voltage, while comparing to PDPWM technique. Carrier arrangement for this strategy is shown in Fig. 5.

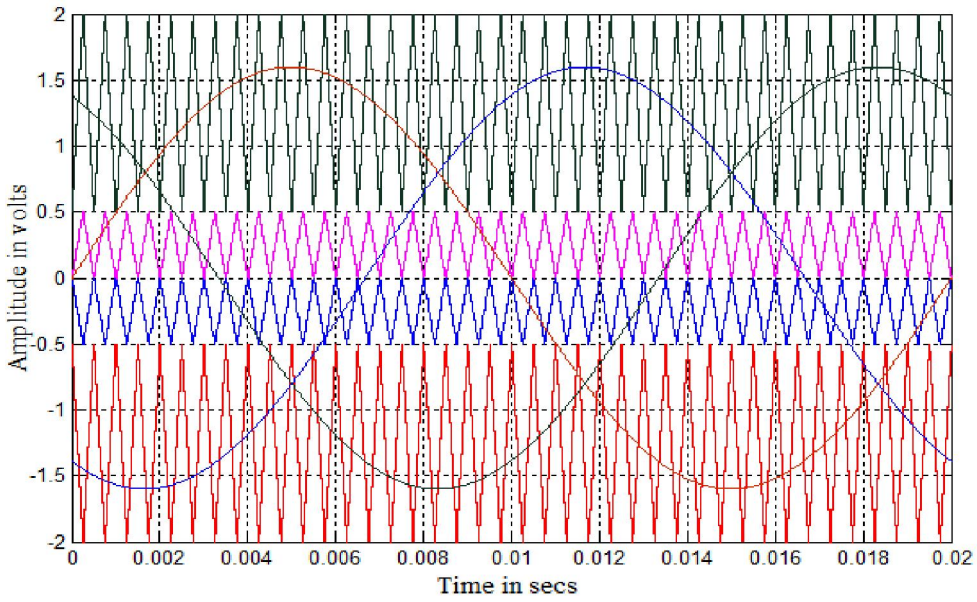

Fig. 5. Modulating and carrier waveforms for VAPODPWM strategy (m_a = 0.8 and m_f = 40)

3.5 ALTERNATE PHASE OPPOSITION DISPOSITION PWM STRATEGY (APODPWM)

In APOD strategy each carrier is phase shifted by 180 degrees from its adjacent one. In this strategy, carriers are seem to be invert their phase in turns from previous one and the same procedure is repeated below the zero average levels, hence it is named as Alternate Phase Opposition Disposition PWM (APODPWM) strategy. Carrier arrangement for this strategy is shown in Fig. 6.

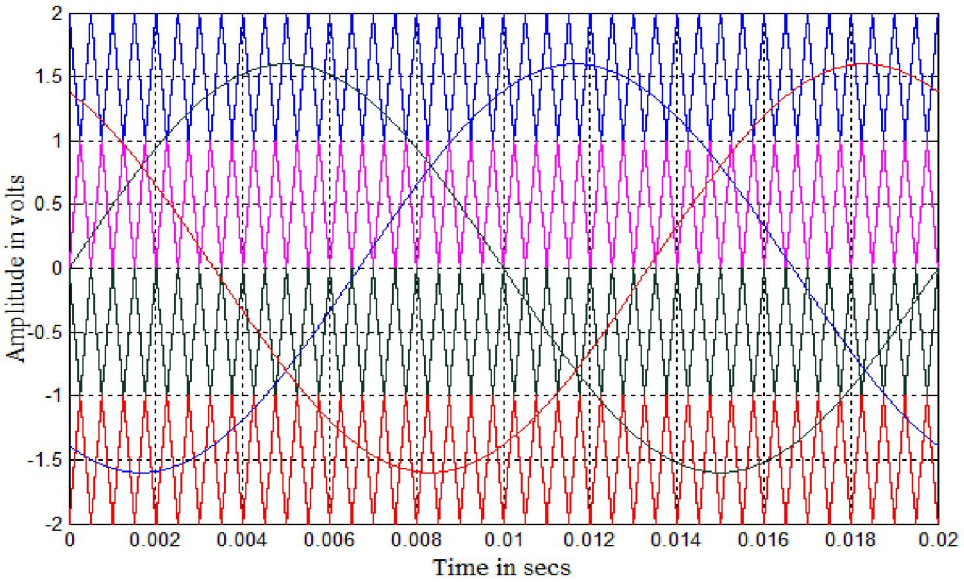

Fig. 6. Modulating and carrier waveforms for APODPWM strategy (m_a = 0.8 and m_f = 40)

3.6 VARIABLE AMPLITUDE ALTERNATE PHASE OPPOSITION DISPOSITION PWM STRATEGY (VAAPODPWM)

The VAAPODPWM is same as APODPWM method except that intermediate carriers are having variable amplitude compared to upper and lower carriers. In this strategy, carriers are seem to be invert their phase in turns from previous one and the same procedure is repeated below the zero average levels, hence it is named as Variable Amplitude Alternate Phase Opposition Disposition PWM (VAAPODPWM) strategy. Carrier arrangement for this strategy is shown in Fig. 7.

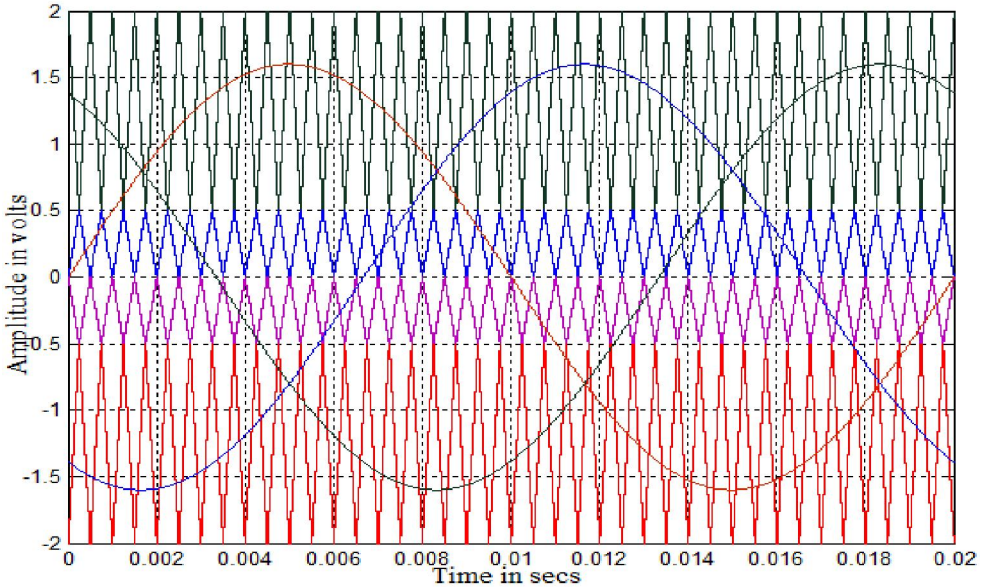

Fig. 7. Modulating and carrier waveforms for VAAPODPWM strategy (m_a = 0.8 and m_f = 40)

3.7 VARIABLE FREQUENCY PWM STRATEGY (VFPWM)

The number of switching for upper and lower devices of chosen MLI is much more than that of intermediate switches. In order to equalize the number of switching for all the switches, variable frequency PWM strategy is used, in which the carrier frequency of the intermediate switches is properly increased to balance the number of switching for all the switches. Carrier arrangement for this strategy is displayed in Fig. 8.

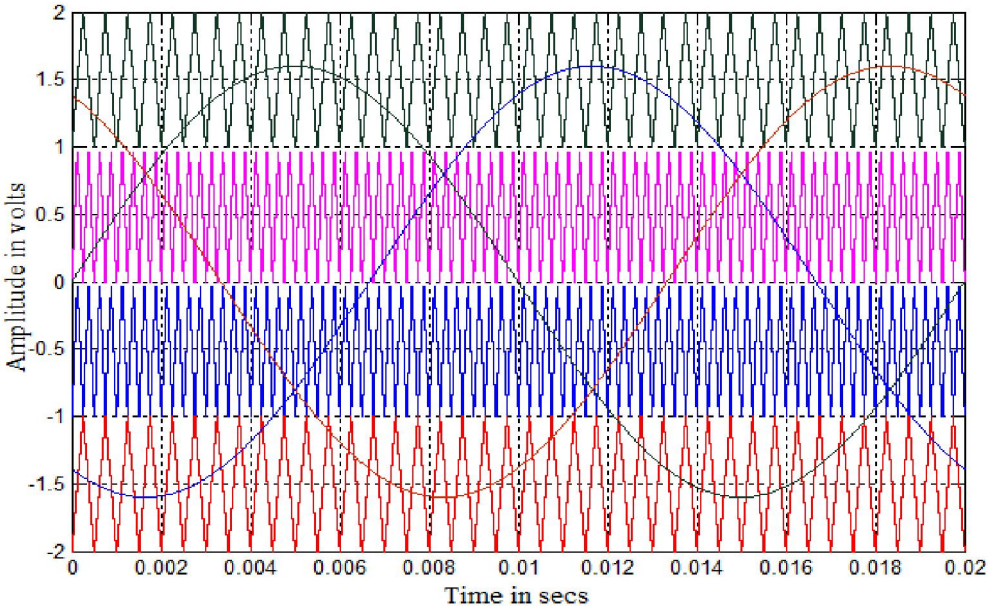

Fig. 8. Modulating and carrier waveforms for VFPWM strategy (m_a = 0.8 and m_f = 40 for upper switches and m_a = 0.8 and m_f = 80 for intermediate switches)

3.8 VARIABLE AMPLITUDE VARIABLE FREQUENCY PWM STRATEGY (VAVFPWM)

This VAVFPWM is same as VFPWM method except that intermediate carriers are having variable amplitude compared to upper and lower carriers. Carrier arrangement for this strategy is shown in Fig. 9.

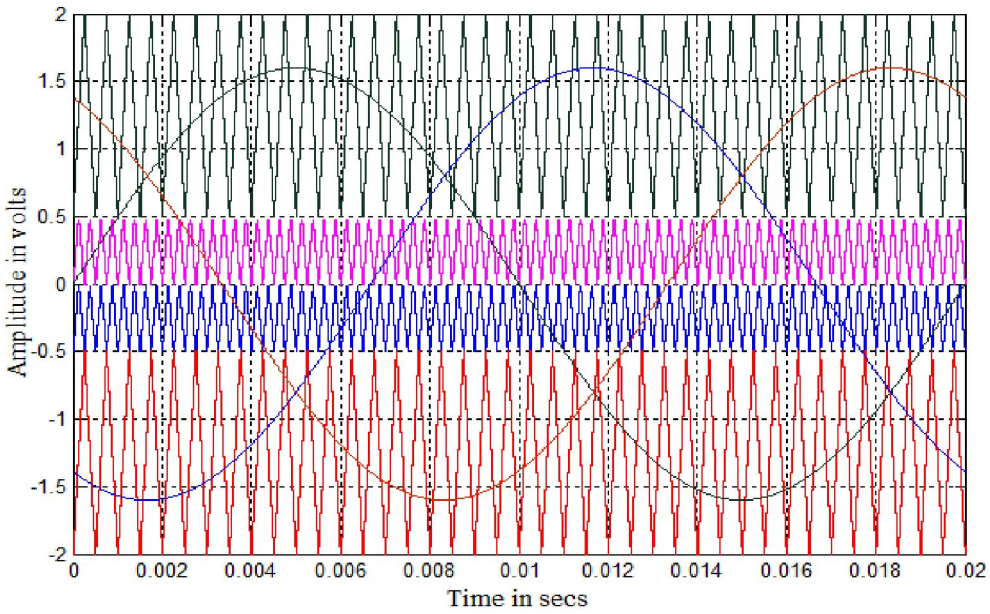

Fig. 9. Modulating and carrier waveforms for VAVFPWM strategy (m_a = 0.8 and m_f = 40 for upper switches and m_a = 0.8 and m_f = 80 for intermediate switches)

3.9 CARRIER OVERLAPPING PWM-A STRATEGY (COPWM-A)

In this method all carriers have the same frequency, same amplitude and same phase. Carriers needed for m level inverters is m-1, here we present four triangular overlapping carriers with one sine reference for five level inverter. All carriers, selected above and below the zero reference are in same phase and amplitude of each carrier chosen as 1.6 and overlapping amplitude will be $0.8(A_c/2)$, where A_c is overlapping amplitude of the carrier. Carrier arrangement for this strategy is shown in Fig. 10.

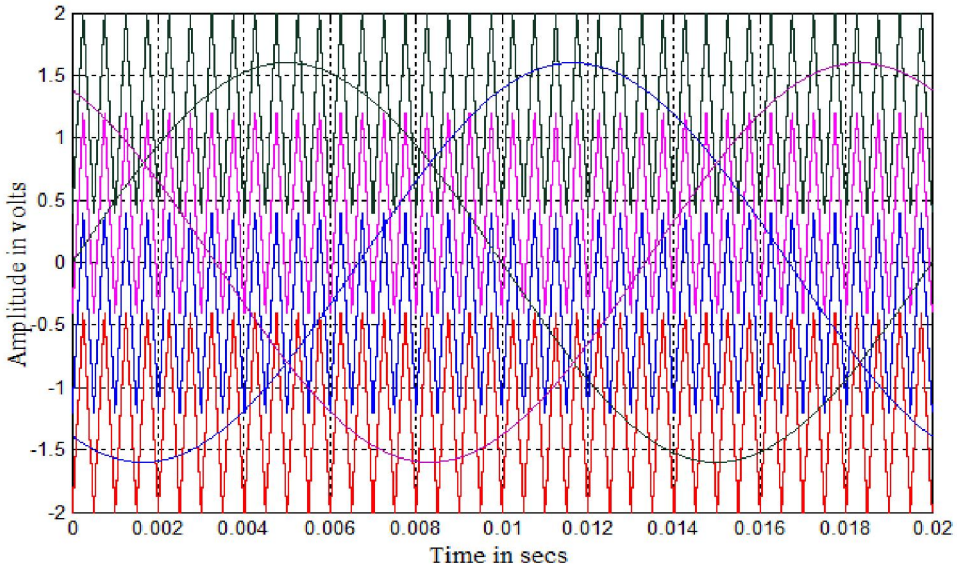

Fig. 10. Modulating and carrier waveforms for COPWM-A strategy (m_a = 0.8 and m_f = 40)

3.10 VARIABLE AMPLITUDE CARRIER OVERLAPPING PWM-A STRATEGY (VACOPWM-A)

In this method all carriers have the same frequency, same phase and varying amplitude, so it is named as Variable Amplitude Carrier Overlapping Pulse Width Modulation A strategy (VACOPWM-A). Since all carriers are selected with the same phase, this method is similar to COPWM-A strategy except with varying amplitude and overlapping amplitude is 0.8. It provides lower total harmonic distortion and relatively higher fundamental RMS voltage, while comparing to COPWM-A technique. Carrier arrangement for this strategy is shown in Fig. 11.

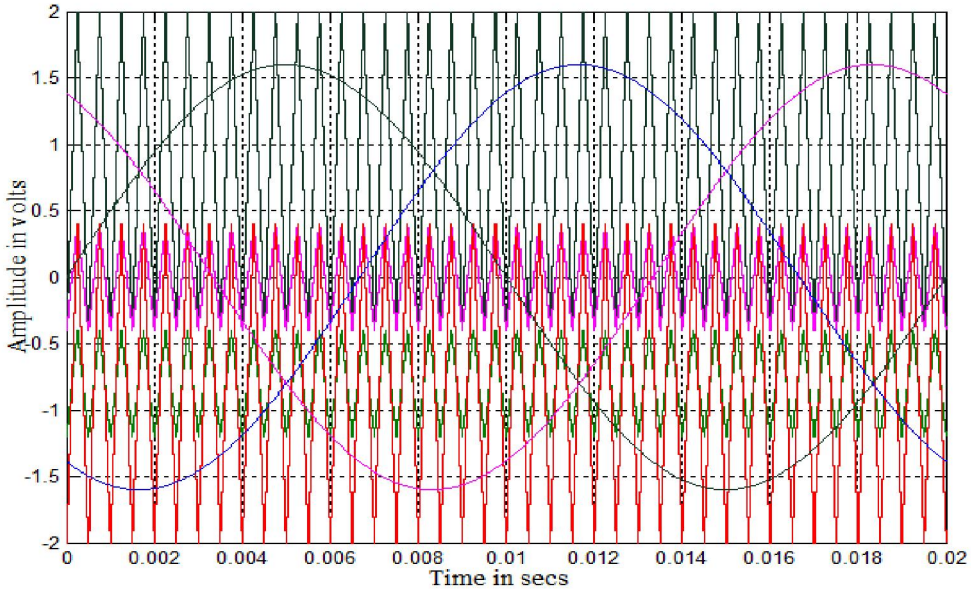

Fig. 11. Modulating and carrier waveforms for VACOPWM-A strategy (m_a = 0.8 and m_f = 40)

3.11 CARRIER OVERLAPPING PWM-B STRATEGY (COPWM-B)

Four carriers generated for five level inverter, is divided into two groups according to the positive and negative average levels. This scheme is similar to the COPWM-A strategy but the two groups are opposite in phase with each other with overlapping amplitude of 0.8, so it is named as Carrier Overlapping Pulse Width Modulation B (COPWM-B) technique. Carrier arrangement for this strategy is shown in Fig. 12.

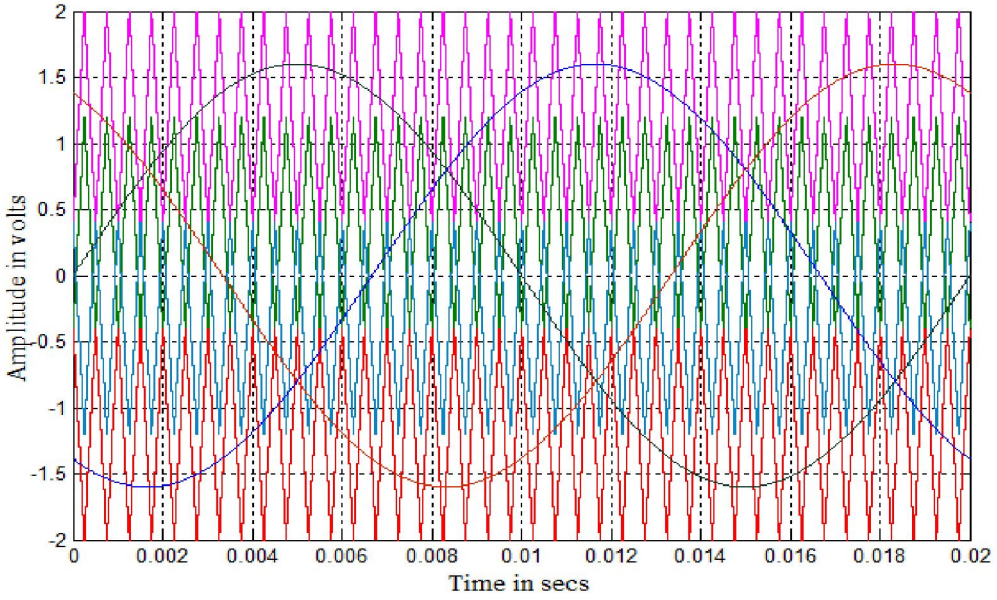

Fig. 12. Modulating and carrier waveforms for COPWM-B strategy (m_a = 0.8 and m_f = 40)

3.12 VARIABLE AMPLITUDE CARRIER OVERLAPPING PWM-B STRATEGY (VACOPWM-B)

In this scheme carriers are divided into two average levels according to the positive and negative groups, above and below the zero reference line with varying amplitude such that the two groups are opposite in phase with each other with an overlapping amplitude of 0.8. So, it is named as Variable Amplitude Carrier Overlapping Pulse Width Modulation B (VACOPPWM-B) strategy. Carrier arrangement for this strategy is shown in Fig. 13.

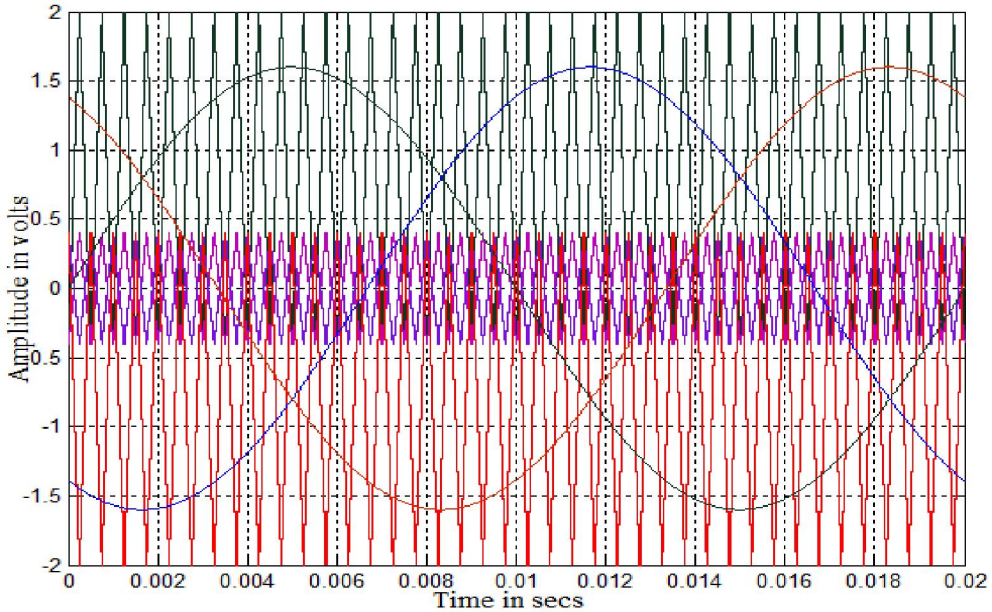

Fig. 13. Modulating and carrier waveforms for VACOPWM-B strategy (m_a = 0.8 and m_f = 40)

3.13 CARRIER OVERLAPPING PWM-C STRATEGY (COPWM-C)

In this strategy, carriers are seem to be invert their phase in turns from previous one and the same procedure is repeated below the zero average levels, with overlapping amplitude of 0.8, hence it is named as Carrier Overlapping Pulse Width Modulation C (COPWM-C)strategy. Carrier arrangement for this strategy is shown in Fig. 14.

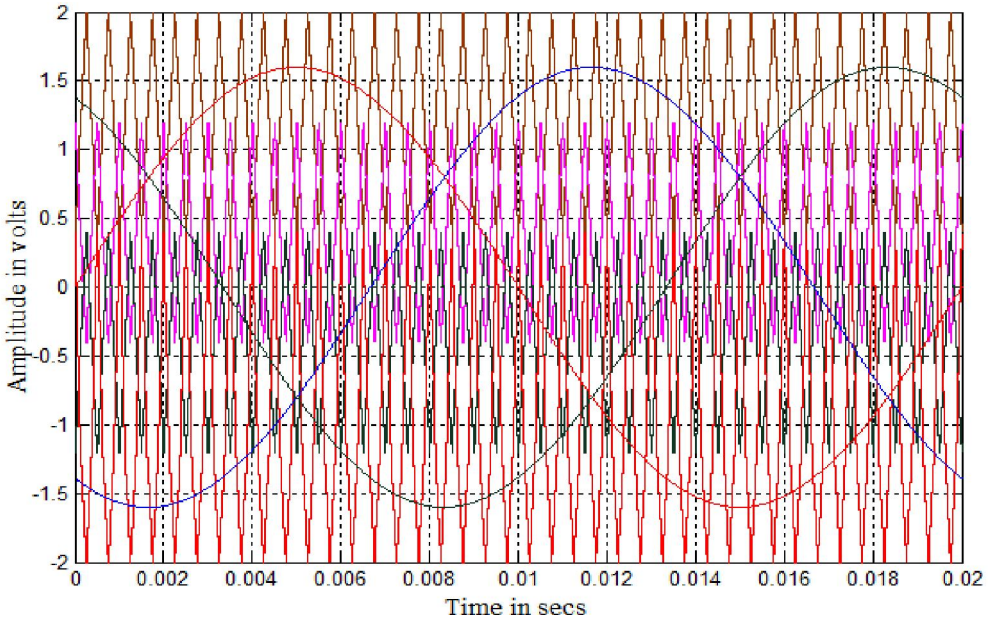

Fig. 14. Modulating and carrier waveforms for COPWM-C strategy (m_a = 0.8 and m_f = 40)

3.14 VARIABLE AMPLITUDE CARRIER OVERLAPPING PWM-C STRATEGY (VACOPWM-C)

In this pattern, carriers invert their phase from the previous one with same frequency and varying amplitude with overlapping amplitude of 0.8. So it named as Variable Amplitude Carrier Overlapping Pulse Width Modulation C (COPWM-C) strategy. Carrier arrangement for this strategy is shown in Fig. 15.

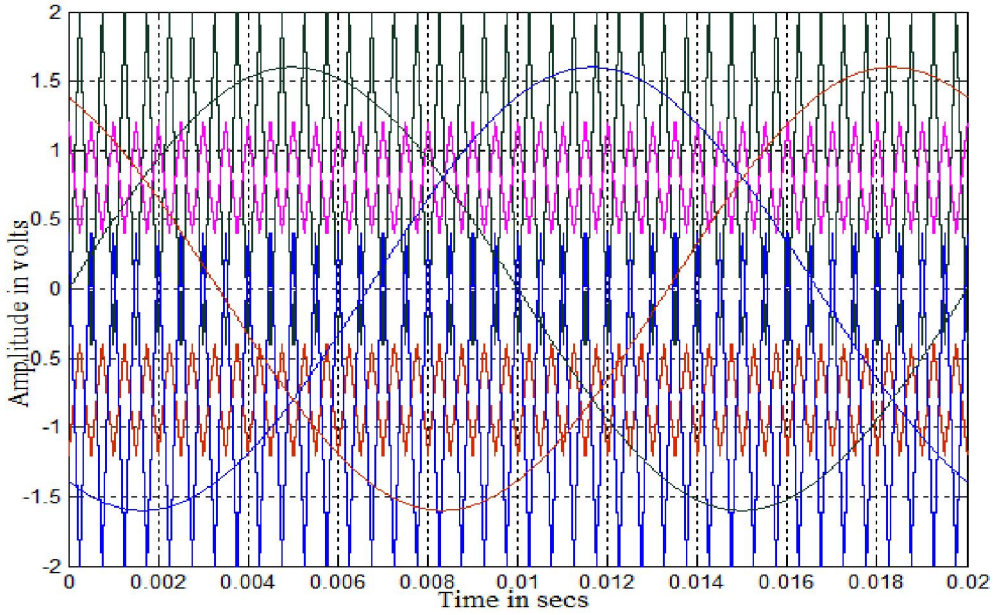

Fig. 15. Modulating and carrier waveforms for VACOPWM-C strategy (m_a = 0.8 and m_f = 40)

3.15 CARRIER OVERLAPPING PWM-D STRATEGY (COPWM-D)

This pattern is similar to COPWM-C scheme, such that the frequency of the intermediate carriers is increased for balancing the switching pattern for all switches and carriers are seem to be crossing the zero reference line with overlapping amplitude of 0.8. Carrier arrangement for this strategy is shown in Fig. 16.

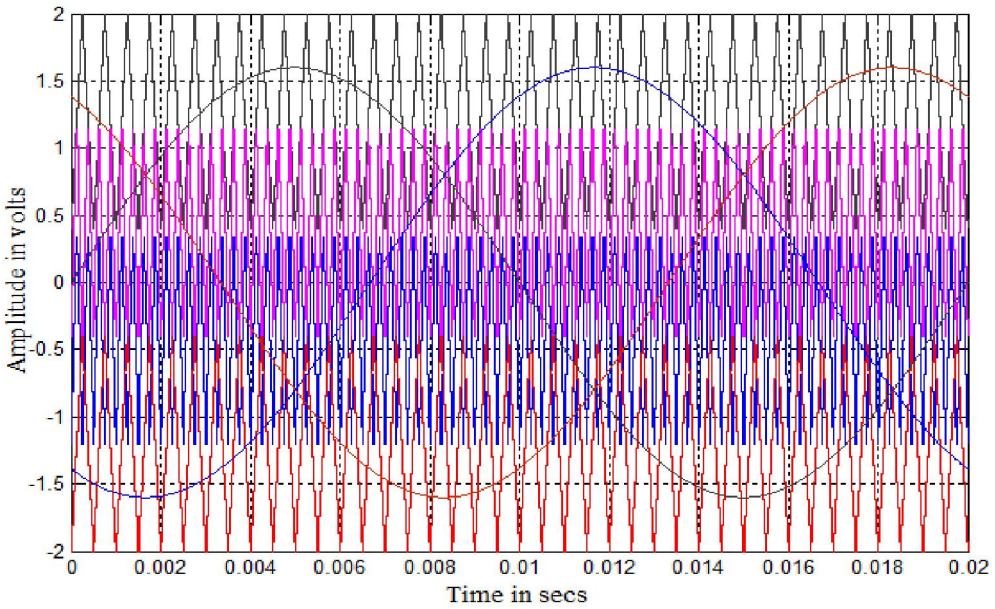

Fig. 16. Modulating and carrier waveforms for COPWM-D strategy (m_a = 0.8 and m_f = 40 for upper switches and m_a = 0.8 and m_f = 80 for intermediate switches)

3.16 VARIABLE AMPLITUDE CARRIER OVERLAPPING PWM-D STRATEGY (VACOPWM-D)

In order to balance the switching pattern for all switches, VACOPWM-D is introduced with overlapping amplitude of 0.8 and by increasing frequency of the intermediate carriers. Carrier arrangement for this strategy is shown in Fig. 17.

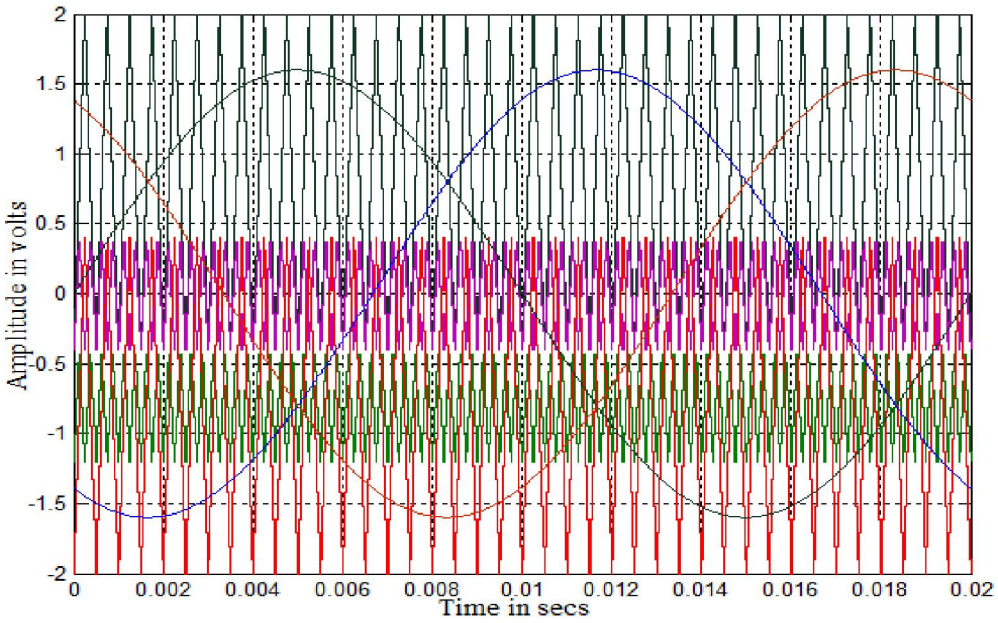

Fig. 17. Modulating and carrier waveforms for COPWM-D strategy (m_a = 0.8 and m_f = 40 for upper switches and m_a = 0.8 and m_f = 80 for intermediate switches)

4 SIMULATION RESULTS

Simulation studies are performed by using MATLAB-SIMULINK to verify the proposed PWM strategies for chosen three phase diode clamped five level inverter for various values of m_a ranging from 0.6 – 1 and corresponding %THD values are measured using FFT block and they are shown in Table 1&2. Table 3&4 shows the V_{RMS} of inverter output for the same modulation indices. Table 5&6. Shows the crest factor for different modulation indices which are measured using peak voltage and RMS voltage from FFT plots. Table 7&8. Shows form factor values which are calculated using RMS voltage and DC component from FFT plots. Table 9&10. Shows distortion factor for different modulation indices. From the analysis, it is inferred that PDPWM Strategy produces 30th, 32nd, 36th, 38th, and 40th harmonic energy. VAPD produces 3rd, 5th, 7th, 20th, 22nd, 24th, 32nd, 34th, 36th, 38th and 40th harmonic energy. POD Strategy produces 33rd,35th and 39th harmonic energy. VAPOD produces 3rd, 5th, 7th, 25th, 27th, 29th, 31st, 33rd, 37th and 39th harmonic energy. APOD produces 35th, 37th, and 39th harmonic energy. VAAPOD produces 3rd, 5th, 29th, 31st, 33rd, 35thand 39th harmonic energy. VF produces 34th, 38thand 40th harmonic energy. VAVF produces 3rd, 5th,7th,36th,38th,and 40th harmonic energy. COPWM-A produces 3rd, 38th and 40th harmonic energy. VACOPWM-A produces 3rd, 4th, 38th and 40th harmonic energy. COPWM-B produces 3rd, 35th, 37thand 39th harmonic energy. It is observed that the VACOPWM-B strategy produces significant 4th, 6th, 8th, 10th, 34th, 36th, 39th harmonic energy. It is observed that the COPWM-C strategy produces significant 2nd, 3rd, 4th, 5th, 33rd, 36th, 37th,38th, 39th and 40th harmonic energy. It is observed that the VACOPWM-C strategy produces significant 3rd, 5th, 7th, 16th, 20th, 29th, 31th, 33rd, 35th and 39th harmonic energy. COPWM-D produces 3rd, 36th, 38th and 40th harmonic energy. VACOPWM-D produces 2nd, 3rd, 4th, 5th and 39th harmonic energy. Figs.18-20 show the simulated output voltages of chosen DCMLI and the corresponding FFT plots are shown in Figs. 21-23 but only for one sample value of m_a = 0.8 and m_f = 40.

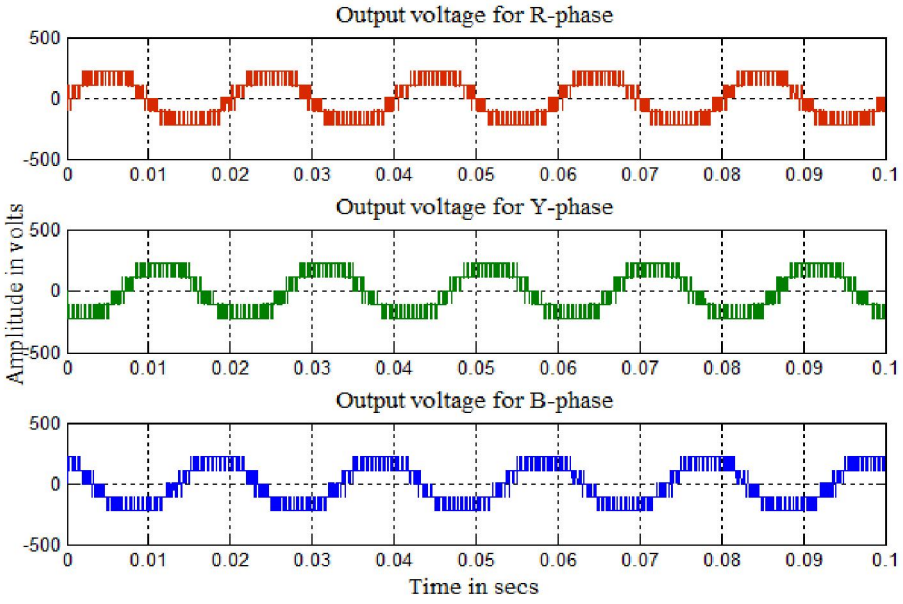

Fig. 18. Simulated output voltage generated by COPWM-C technique for R-load

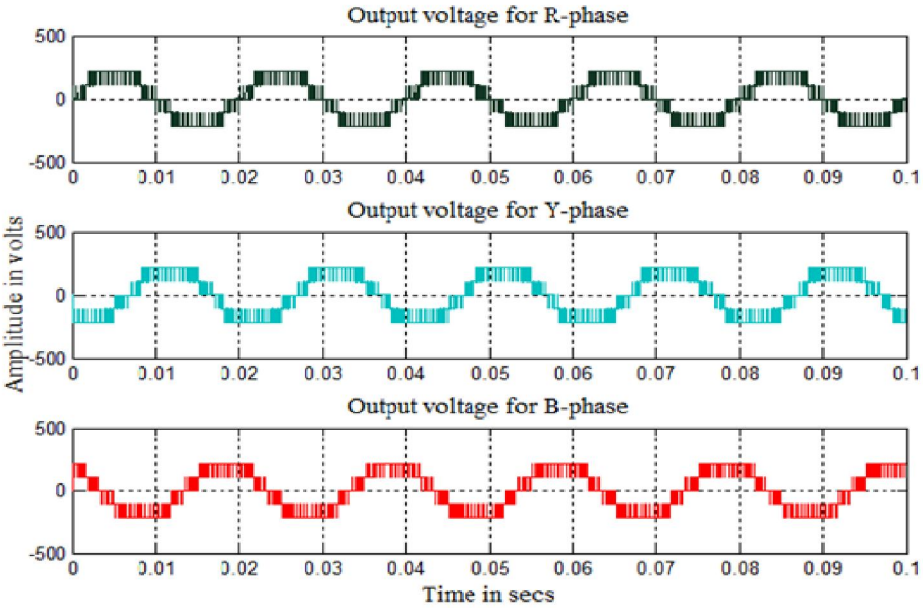

Fig. 19. Simulated output voltage generated by VACOPWM-C technique for R-load

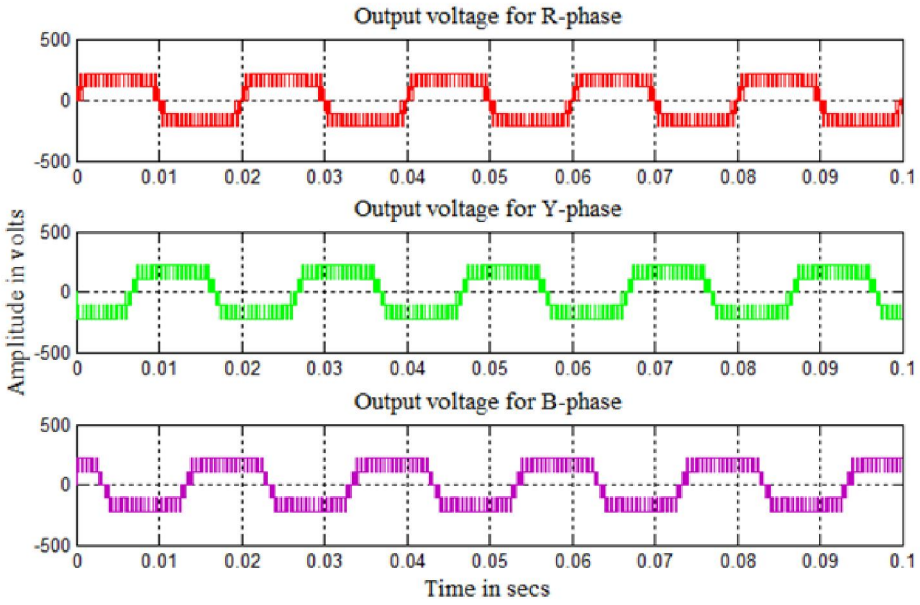

Fig. 20. Simulated output voltage generated by VACOPWM-B technique for R-load

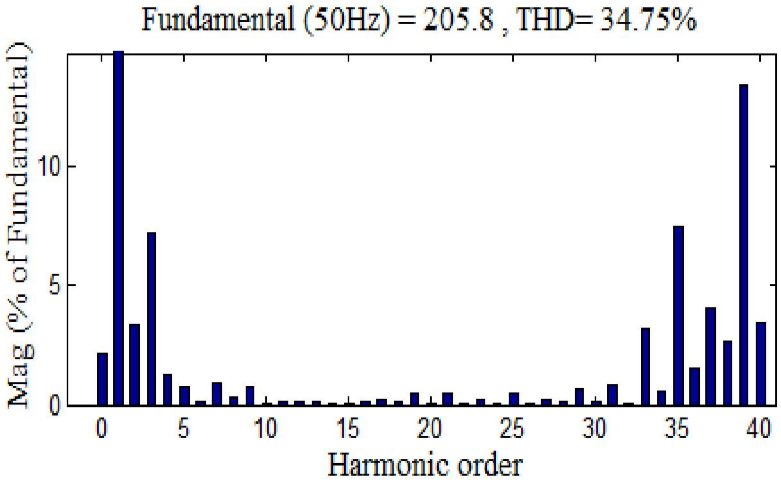

Fig. 21. FFT spectrum for COPWM –C technique

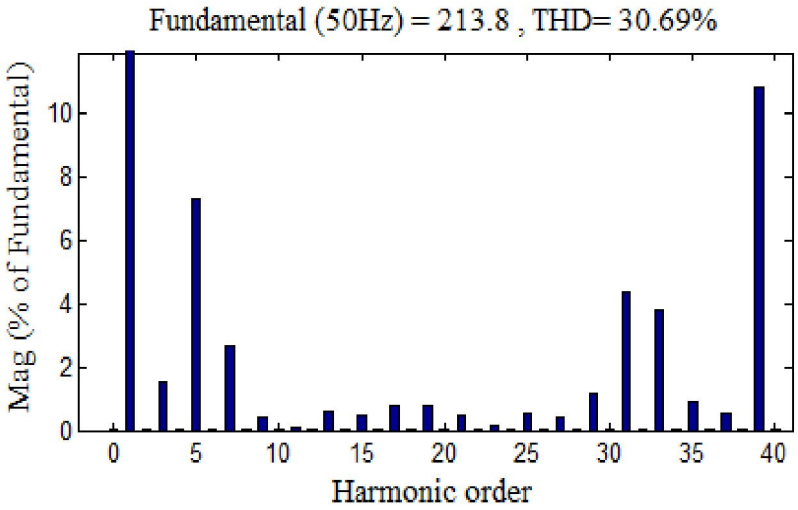

Fig. 22. FFT spectrum for VACOPWM –C technique

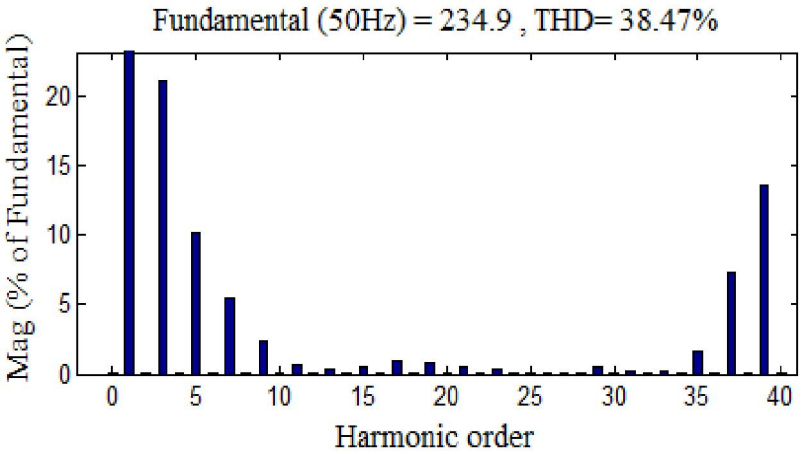

Fig. 23. FFT spectrum for VACOPWM –B technique

Table 1. %THD for Different Modulation Indices for Conventional PWM Strategy

m_a	PD	VAPD	POD	VAPOD	APOD	VAAPOD	VF	VAVF
1	27.05	27.87	26.95	27.70	26.54	27.43	27.09	27.97
0.9	33.63	32.01	33.51	31.99	33.22	31.57	33.48	32.19
0.8	38.39	35.57	38.15	35.17	38.16	35.57	38.34	35.57
0.7	42.09	38.29	41.90	38.01	41.99	37.88	42.51	38.88
0.6	44.48	39.85	44.54	39.59	44.57	39.76	44.54	39.94

Table 2. %THD for Different Modulation Indices with COPWM Strategy

m_a	COPWM-A	VA COPWM-A	COPWM-B	VA COPWM-B	COPWM-C	VA COPWM-C	COPWM-D	VA COPWM-D
1	33.57	37.46	31.78	33.71	26.54	24.61	31.94	33.94
0.9	38.51	41.58	36.82	36.51	30.67	27.67	36.81	37.78
0.8	43.73	45.34	41.91	38.47	34.75	30.69	42.08	40.90
0.7	50.28	49.88	47.85	40.95	37.64	34.15	47.29	44.67
0.6	58.88	57.66	56.28	42.21	40.75	39.34	55.57	50.14

Table 3. V_{RMS} for Different Modulation Indices for Conventional PWM Strategy

m_a	PD	VAPD	POD	VAPOD	APOD	VAAPOD	VF	VAVF
1	155.3	169	155.3	169.2	155.4	168.9	155.3	169
0.9	139.9	158.3	139.8	158.1	140.1	158.4	139.9	158.4
0.8	124.3	147.8	124.5	147.5	121.4	147.9	124.4	147.8
0.7	108.5	137	108.4	137.2	108.5	136.9	108.3	137.2
0.6	92.95	126.2	92.75	126.2	92.9	126.2	93.16	126.2

Table 4. V_{RMS} for Different Modulation Indices with COPWM Strategy

m_a	COPWM-A	VA COPWM-A	COPWM-B	VA COPWM-B	COPWM-C	VA COPWM-C	COPWM-D	VA COPWM-D
1	166.5	175	165.4	179.3	167	170.6	166.3	174.7
0.9	155.8	167	154.6	172.5	156.7	161	155.6	166.9
0.8	144.3	158.9	142.6	166.1	145.5	151.2	144.2	158.8
0.7	130.9	149.7	129.1	159.3	132.7	139.2	130.8	149.1
0.6	116.8	137.5	114.7	151.9	119.5	121.2	116.2	137

Table 5. Crest Factor for Different Modulation Indices for Conventional PWM Strategy

m_a	PD	VAPD	POD	VAPOD	APOD	VAAPOD	VF	VAVF
1	1.4140	1.4142	1.4140	1.4143	1.4144	1.4144	1.4140	1.4142
0.9	1.4138	1.4144	1.4148	1.4142	1.4139	1.4141	1.4138	1.4147
0.8	1.4143	1.4147	1.4144	1.4142	1.4139	1.4137	1.4139	1.4147
0.7	1.4147	1.4145	1.4142	1.4139	1.4147	1.4141	1.4136	1.4139
0.6	1.41473	1.4144	1.4145	1.4136	1.4144	1.4144	1.4136	1.4144

Table 6. Crest Factor for Different Modulation Indices with COPWM Strategy

m_a	COPWM-A	VA COPWM-A	COPWM-B	VA COPWM-B	COPWM-C	VA COPWM-C	COPWM-D	VA COPWM-D
1	1.4138	1.4142	1.4147	1.4143	1.4143	1.4144	1.4143	1.4144
0.9	1.4139	1.4137	1.4146	1.4144	1.4141	1.4142	1.4145	1.4144
0.8	1.4137	1.4140	1.4137	1.4142	1.4144	1.4140	1.4140	1.4143
0.7	1.4140	1.4141	1.4136	1.4155	1.4137	1.4137	1.4143	1.4138
0.6	1.4146	1.414	1.4137	1.4141	1.4138	1.4146	1.4144	1.4142

Table 7. Form Factor for Different Modulation Indices for Conventional PWM Strategy

m_a	PD	VAPD	POD	VAPOD	APOD	VAAPOD	VF	VAVF
1	2588.3	16900	15530	16920	15540	16890	1725.5	4225
0.9	1554.4	565.3	13980	15810	14010	15840	1554.4	7920
0.8	1381.1	328.44	INF	14750	INF	14790	1244	1055.7
0.7	417.3	913.3	INF	13720	INF	13690	984.5	6860
0.6	442.6	788.7	INF	12620	INF	12620	1863.2	1402.2

Table 8. Form Factor for Different Modulation Indices with COPWM Strategy

m_a	COPWM-A	VA COPWM-A	COPWM-B	VA COPWM-B	COPWM-C	VA COPWM-C	COPWM-D	VA COPWM-D
1	5550	29.711	295.35	17930	126.51	17060	5543.3	28.780
0.9	1731.1	22.939	214.72	17250	101.09	16100	2593.3	23.673
0.8	14430	18.563	156.70	16610	67.05	15120	14420	18.882
0.7	13090	14.449	91.560	15930	46.23	13920	467.14	13.831
0.6	16685	9.8004	87.557	15190	33.194	INF	528.18	9.6140

Table 9. Distortion Factor for Different Modulation Indices for Conventional PWM Strategy

m_a	PD	VAPD	POD	VAPOD	APOD	VAAPOD	VF	VAVF
1	0.0353	1.333	0.0400	1.3632	0.0222	1.3302	0.0732	1.3429
0.9	0.0472	1.3655	0.0677	1.3772	0.0319	1.3246	0.0352	1.3903
0.8	0.0368	1.4407	0.0556	1.3773	0.055	1.4328	0.085	1.4307
0.7	0.0942	1.486	0.0296	1.5906	0.0224	1.4697	0.0647	1.5145
0.6	0.0425	1.473	0.0366	1.4619	0.0288	1.4815	0.0857	1.4819

Table 10. Distortion Factor for Different Modulation Indices with COPWM Strategy

m_a	COPWM-A	VA COPWM-A	COPWM-B	VA COPWM-B	COPWM-C	VA COPWM-C	COPWM-D	VA COPWM-D
1	0.838	3.022	0.768	2.276	1.109	0.941	0.823	3.038
0.9	0.741	3.382	0.681	2.336	5.589	0.628	0.730	3.266
0.8	0.569	3.576	0.485	2.384	1.154	0.344	0.542	3.488
0.7	0.247	3.976	0.209	2.436	1.076	0.419	0.226	3.832
0.6	0.052	3.977	0.085	2.352	1.073	1.082	0.137	3.938

5 CONCLUSION

In this paper various new schemes of Pulse Width Modulation Strategies are developed and simulated for chosen three phase DCMLI. Performance indices like %THD, V_{RMS} (indicating the amount of DC bus utilization), Crest Factor (CF) and Form Factor (FF) related to power quality issues have been evaluated, presented and analyzed. The variation of Total Harmonic Distortion (THD) in the inverter output voltage is observed for various modulation indices. It is observed that among the various equal amplitude PWM strategies, COPWM-C provides less THD and higher RMS voltage. It is recognized that among the various variable amplitude PWM strategies, VACOPWM-C provides less THD and VACOPWM-B provides higher RMS voltage. By comparing the equal amplitude PWM strategies with the variable amplitude PWM strategies it is inferred that VACOPWM-C provides less THD and VACOPWM-B provides higher RMS voltage. The result indicate that appropriate PWM strategies have to be employed depending on the performance measure required in a particular application of MLI based on the criteria of output voltage quality (Peak value of the fundamental, THD and dominant harmonic components).

REFERENCES

[1] Gerardo Ceglia, Vicente Grau, Victor Guzman, Carlos Sanchez, Fernando Ibanez, Julio Walter, Antonio Millan and Maria I. Gimenez, "A New Multilevel Inverter Topology", Process. IEEE conf Rec. 0-7803-8777-5/04, pp.212-218.

[2] K. Arab Tehrani, H. Andriatsioharana, I. Rasoanarivo and F. M. Sargos, "A Novel Multilevel Inverter Model", Process. IEEE conf Rec. 978-1-4244-1668-4/08, pp.1688-1693.

[3] Domingo Ruiz-Caballero, Luis Martinez, Reynaldo Ramos and Samir A. Mussa, "New Asymmetrical Hybrid Multilevel Voltage Inverter", Process. IEEE conf Rec. 978-1-4244-3370-4/09, pp.354-361.

[4] Rokan Ali Ahmed, S.Mekhilef and Hew Wooi Ping, "New Multilevel Inverter Topology With Reduced Number of Switches", Process. IEEE conf Rec. 978-1-4244-6890-4/2010, pp.1862-1867.

[5] Ho-Dong Sun, Honnyong Cha, Heung-Geun Kim, Tae-Won Chun and Eui-Cheol Nho, "Multi-level Inverter Capable of Power Factor Control with DC Link Switches", IEEE:978-1-4577-1216-6/12, pp.1639-1643.

[6] Till Boller, Joachim Holtz, and Akshay K. Rathore, "Optimal Pulsewidth Modulation of a Dual Three-Level Inverter System Operated From a Single DC Link", IEEE Transactions on Industry Applications, VOL. 48, NO. 5, Sep. 2012, pp.1610-1615.

[7] Xiaotian Zhang and Joseph W. Spencer, "Study of Multisampled Multilevel Inverters to Improve Control Performance", IEEE Transactions on Power Electronics, Vol. 27, no. 11, Nov.2012, pp.4409-4416.

[8] Ehsan Najafi, and Abdul Halim Mohamed Yatim, "Design and Implementation of a New Multilevel Inverter Topology", IEEE Transactions on Industrial Electronics, Vol. 59, no. 11, 2012, pp. 4148-4154

[9] I. Abdalla, J. Corda, and L. Zhang, "Multilevel DC-Link Inverter and Control Algorithm to Overcome the PV Partial Shading", IEEE Transactions on Power Electronics, Vol. 28, no. 1, Jan. 2013, pp.14-18.

[10] Mohammad Farhadi Kangarlu, and Ebrahim Babaei, "A Generalized Cascaded Multilevel Inverter Using Series Connection of Submultilevel Inverters", IEEE Transactions on Power Electronics, Vol. 28, no.2, Feb. 2013, pp.625-636.

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Key factors for impelling an innovative social culture

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ABSTRACT: The aim of this paper is to identify the key factors that permit the gradual development of an innovative social culture which, in turn, influences the innovation process. After decades of theory development and empirical research into innovation, researchers still know surprisingly little about how the innovation process works. In this paper the capabilities, values and relationships that people, organizations and territories need to work on and develop to achieve innovation-oriented behaviour are identified. Thus, it is conducted qualitative research focused on a literature review, a workshop with 35 participants and 32 in-depth interviews with experts in different fields seeking to achieve a consensus on what values, capabilities and relationships enable people, organizations and territories to develop a propensity to become more innovative. As a result it is proposed a theoretical model which seeks to orient organizations, institutions and politicians about the factors to which they should pay attention to create and expand an innovative culture in people and/or organizations in a specific territory. That model also seeks to serve as a platform on which researchers can base future empirical analysis and approximate the level of innovative social culture in different territories. This study provides with a more dynamic, more complete view of the innovation process. However, this is only the first step in the identification of key factors for driving an innovative social culture and, therefore, encouraging innovation.

KEYWORDS: Innovative social culture, capabilities, values, relationships, theoretical model.

1 INTRODUCTION

It is commonly accepted that innovation plays a strategic role in economic development and competitiveness [1]-[3]. In the innovation age the necessary technology, equipment and R&D investments do not suffice to configure an innovation ecosystem [1], [4]-[6].

In fact, the literature on the knowledge economy is currently being enhanced by multidisciplinary contributions with a more socially (and less exclusively economically) oriented vision focused on science and innovation practices and policies [7]-[8]. The concept of business *innovation* has changed and taken on a more global [9]-[10], open approach [1], [4], [5] in which freshly-minted terms such as crowdsourcing and co-creation [11], [12], [6] denote that players outside an organization are now acknowledged as having a key role in the process of generating ideas and developing and improving products and services or new processes. In consequence, the in-house competences and resources of an organisation are no longer sufficient on their own to respond to dynamic market requirements, and collaboration and networks are becoming more and more necessary if organizations are to be competitive [13]-[15].

So genuine business participation in the knowledge economy depends not only on the internal R&D resources assigned by a company, but also on the capability of the surrounding economic, technological, social and cultural setting and the overall level of human capital of a particular region or country for supporting organizations that seek to make sustainable efforts in innovation [16], [17], [2].

Recognizing that innovation is a dynamic, iterative process which involves individuals, organizations and territories, previous studies have provided little or no practical guidance on how to identify the key factors for impelling an innovative

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social culture. For this reason, the present paper sets out to identify and define the key factors for creating and driving an *innovative social culture* in a specific territory and among its people and organizations, focused on both theoretical and practical aspects.

Accordingly, the paper is structured as follows. Section 2 presents the literature background and discusses the lack of studies jointly considering the main agents of the innovation process. Section 3 introduces the method of research and data collection. Section 4 presents the theoretical model for impelling an innovative social culture, defining the key factors that people, organizations and territories need to develop to become more innovative agents. Section 5 draws conclusions and makes some final remarks.

2 TOWARDS AN INTEGRATIVE APPROACH TO THE INNOVATION PROCESS CONSIDERING THE KEY AGENTS JOINTLY: A LITERATURE REVIEW

An important limitation of previous studies is that they focus the innovation process mainly on organizations (firms) and on the way in which knowledge and information flows within and between organizations for innovation [15], ignoring the role that people, collectively or individually, and territory could play in the success of the innovation process. The social participation and quality of governance of a specific territory seem to exert considerable influence on innovative activity [2], but these factors have received little attention in the relevant literature, perhaps due to the fact that they are considered as social-level concepts rather than organization-level concepts. In this regard, most studies tend to overlook these groups and the social aspects of the innovation process [15], despite its relevance and influence [2].

Most research highlights the role of individuals and more specifically the importance of informal and interpersonal networking for the development and dissemination of innovation [18], but there is a lack of studies focused on individuals and on their particular features as drivers of innovation. Most of the studies of the roles of individuals in the innovation process that have been found come from the fields of psychology and sociology. Few of them deal with individuals in regard to the innovation process from an economic, management or organizational viewpoint (see: [19], [20], [2]. More and more studies are now being produced about flows of information and knowledge between lead users and organizations for innovation, but most of them fail to identify what features of the individuals involved in the innovation process mainly make them become more innovative. Therefore, politicians or managers who attempt to improve innovative capabilities and skills in citizens and workers to create innovation do not have enough information to make the right decisions.

Other streams of innovation research have focused on territorial (national or regional) systems of innovation, but there haven't been found studies on all three agents jointly. Nor are the main values or skills that organizations, people and territories must develop in order to become more innovative are not covered jointly in any study. In other words, there is a lack of studies that examine the big picture of innovation, i.e. that consider all the strategic agents involved in the innovation process and their key features for success in that process. This paper attempts here to shed some light on these aspects. To start with, some arguments related to the need to include the aforementioned agents in the innovation process in the globalizing economy are provided.

According to [21] successful innovation is the completion of a three-stage process: idea generation, acceptance and implementation. Ideas can only be generated by individuals, since only people posses the capability to think and create new ideas individually or within a group. These ideas are usually modified and shaped by other individuals, by the culture and routines of organizations, and by the environment or characteristics of the territory where they emerge before being accepted or rejected. Once a new idea is accepted, the necessary resources and personnel must be gathered and put into place to implement it [22], [15].

Therefore, innovation requires more than just creative skills and new ideas [23]. It needs to bring about new products, services or new organizational, marketing or production processes. Since organizations have the inputs, managerial capabilities and talents necessary to put new ideas into practice, they become part of the innovation process. Individuals and organizations are active agents of the innovation process. However they usually share a common territory, which can impel or inhibit the development of innovation, so that territory becomes the third key agent in the process.

In some studies territory is identified as a local or regional environment/system which impels innovation [24], [25]. Territory can be defined as a geographical area (region, state, nation) which shares common characteristics, such as a common history, language, culture, a certain institutional structure (education system, communication system, etc.) and public institutions that make decisions regarding that geographical area. A territorial innovation theory has emerged recently that emphasizes the significance of the regional level in economic development in addition to, and sometimes over and above, the national level. Thus, over the past twenty years researchers and policy makers have been paying more and more

attention to regions as designated sites of innovation and competitiveness in the globalizing economy. The popularity of this argument is due to various empirical studies of regional success stories, such as examples of successful regional clustering in most developed and developing economies [26], [27], the exemplary industrial system of Silicon Valley [28], the rapid economic growth of networked SMEs in industrial districts in the 'Third Italy' [29], etc. These studies all draw on the common rationale that territorial agglomeration provides the best context for an innovation-based globalizing economy because of localized learning processes and 'sticky' knowledge grounded in social interaction [30], [31].

There is no doubt that territory can play a strategic role in the way in which firms deal and collaborate with one another, in the way in which science and technology and R&D systems are organized [24], and in the way in which people and organizations learn, face change, innovate and assume risks. In general, territories evolve along different paths, through combinations of political, cultural and economic forces [24]. Those paths can be defined actively by innovation-supporting policies and more passively through the way in which individuals and organizations share, combine and implement knowledge and information. Therefore, some territories can have more innovative cultures than others. Institutional agents can encourage individuals and organizations to become innovators by developing appropriate means and policies, and people and organizations can demand that politicians and public institutions create structures and territorial environments to encourage the sharing of significant, specialised knowledge so as to create innovation (universities; technology centres and research institutes; clusters; industrial districts; living labs, etc.).

3 METHODOLOGY

The complexity of the issues involved necessitates a systematic review exploring all aspects of the existing literature and empirical evidence. The study seeks to provide such a review and thus enhance understanding of the values, capabilities and relationships of people, organizations and territory in regard to creating innovation, i.e. to encourage an innovative social culture.

The research conducted is based on a literature review and on the responses of experts in different fields. First, a half-day workshop was organized to collect suggestions from a nurture group of representative people from different fields and disciplines (politicians, managers, anthropologists, entrepreneurs, sociologists, marketers, university lecturers, artists, directors of innovation organizations, clusters, research institutes, etc.). The 35 participants were grouped into 7 roundtables, which were conducted separately by two members of the research team, one of whom was also the moderator. Each researcher asked the participants in each roundtable general questions regarding the improvement of innovative culture in people, organizations and territory, in order to check the first approach to a theoretical model for impelling an innovative social culture. The participants spent about one hour discussing each agent (people, organizations and territory) and their possible determinant factors. After each hour, one member of each roundtable moved to a different one to share the main conclusions of his/her roundtable concerning the agent that they had been discussing. Afterwards, each roundtable had half an hour to share their main conclusions with the participants from the rest of the roundtables so that they could arrive at an agreement as to what the key factors of innovative culture were for people, organizations and territory. All the discussions were recorded and subsequently transcribed and analyzed in depth. The main suggestions and contributions of the participants were incorporated into the proposed theoretical model.

Our model was then enriched by another subsequent qualitative study, in which 32 different experts underwent individual in-depth interviews, in order to test the model. Their responses were recorded and analyzed so that conclusions could be drawn. A structured questionnaire was also put to these 32 experts in order to measure the importance that they attributed to the different dimensions identified for each agent. In general, the responses of these experts regarding the key factors to be considered for developing an innovative social culture coincided with those included in the model.

The research methodology used can be regarded as mainly qualitative in nature: in such methods interviews with experts are frequently used for exploratory and theory building research. Based on the analysis drawn up, a set of factors for fostering innovation were identified that involved embedding people, organizations and territory in an innovative social culture. This encourages the development of certain capabilities, values and relationships in the various participants in the innovation process. The results of previous studies identified during the literature review are also used in the model to reinforce and support the experts' arguments and considerations.

4 Approach to a Theoretical Model for Impelling Innovative Social Culture: Definition and Proposal of Key Factors

The term *innovative social culture* is defined in this work as the set of capabilities, values and relationships possessed by people, organizations and their home region or territory which, jointly and in a coordinated fashion, provide a basis for and legitimizes innovative actions in society.

Specifically, this paper presents a proposal for a theoretical and operational model to identify factors from capabilities, values and relations that are key in enabling people, organizations and territories to respond successfully in the innovation process through the development of an innovative social culture (see Figure 1). To determine how these three analysis units (people, organization and territory) can be measured to define a specific innovative social culture, it is first necessary to conceptualize their structural dimensions, i.e. capabilities, values and relationships:

1. ***Capabilities*** are defined as the abilities, skills and aptitudes possessed by people, organizations and territories.

2. ***Values*** are defined as cultural norms and attitudes that characterize people, organizations and territories.

3. ***Relationships*** refers to the degree of networking between people, organizations and territories, enabling them to establish exchange relationships, networks, cooperation agreements, diversity, multidisciplinary meetings, etc.

Innovation is a multi-level, multidimensional process which represents both individual and collective achievements [15] and requires economic, cultural and institutional changes, where the way in which relationships are managed is crucial. Consequently, for an innovative social culture to be developed several aspects need to be taken into account (see Figure 1).

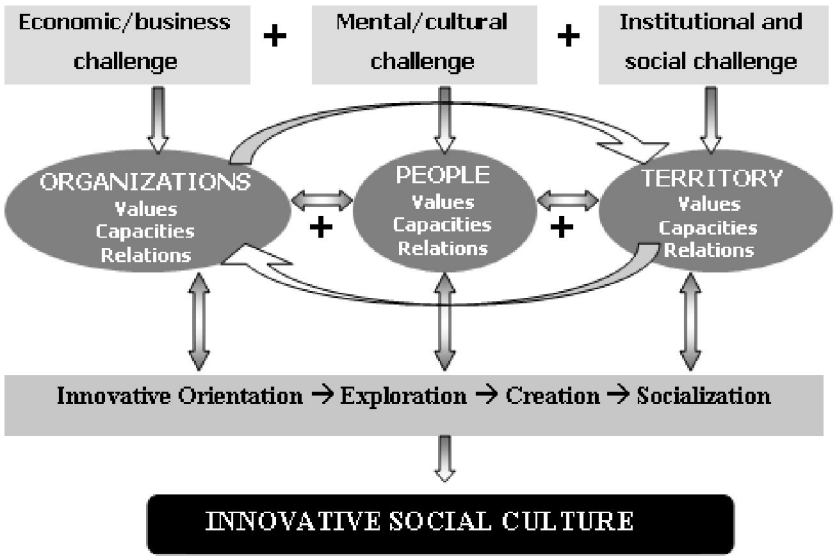

Fig. 1. Approach to a theoretical model for developing an innovative social culture

On the one hand, the development of an innovative environment is normally associated with permanent, complex institutional changes, which usually require long periods of time to mature [24].

On the other hand, the establishment or improvement of networks among the three key agents (within and between each type of participant) is essential to facilitate information sharing, which is expected to encourage innovation [2], [3]. Any network basically consists of nodes (participants) and relationships [32]. In an organizational context a network can be defined as an appropriate structure for encouraging members of an organization to learn and, correspondingly, develop innovative practices [18]. Relatively little research has focused explicitly on the dynamic links between networks and the development and utilization of knowledge during innovation processes [18], [14]. In fact, innovation networks first appeared in the relevant literature in the late 1980s, although the concept did not start to be analyzed extensively until the 2000s [14]. More recently the innovation network concept has been extended by [1] concept of *open innovation,* which is characterized

by cooperation for innovation within broad vertical and horizontal networks (with customers, suppliers, competitors, start-ups, etc.).

As mentioned above, the review of the relevant literature does not provide to identify any prior explanatory model or even a framework for analyzing innovative social culture. This paper proposes a process defined by the following four phases connected to the innovation process in order to study and develop an innovative social culture:

1. Orientation: This is understood as a preliminary stage, which predisposes people and/or organizations to adopt a positive attitude towards continuous improvement, lifelong learning, the desire to better oneself and pro-activeness in the face of change.

2. Exploration: This is a questioning phase, in which people and organizations should analyze the environment, capture information and identify opportunities to be exploited or weaknesses to be remedied.

3. Creation: This is the broadest and most complex phase of the process. It starts with the generation of ideas to solve the problems identified in the exploration phase. Then the most viable ideas are selected. Finally, the selected ideas are designed, modelled (conceptualization and prototype development) and tested to check whether they actually solve the problem identified (experimentation).

4. Socialization: This phase involves the implementation and deployment of the innovation and the progressive adoption of the innovation, starting with the first adopters and extending to the vast majority of people, organizations and potential customers. Socialization usually refers to the launching of the innovation on the market and its acceptance by the vast majority.

Table 1 shows the key factors of the proposal for a theoretical and operational explanatory model for developing an innovative social culture in a given environment or territory (region, nation, etc.). The proposed model contains the structural dimensions (capabilities, values and relationships), the three agents (people, organizations and territory/government) and the drivers for each different phase of the innovation process for the development of the innovative social culture.

Table 1. Model of Innovative Social Culture (MISC): Key factors in people, organizations and territories

Dimension / *Innovation phase*	CAPABILITIES	VALUES	RELATIONSHIPS
	PEOPLE (P)		
ORIENTATION	C1. CAPABILITY FOR CRITICAL THINKING	V1. PROACTIVENESS AND CONTINUOUS IMPROVEMENT	R1. EXCHANGE
EXPLORATION	C2. CURIOSITY AND LIFELONG LEARNING	V2. PERMEABILITY	R2. ACCEPTING DIFFERENCE
CREATION	C3.ENTREPRENURIAL SPIRIT AND CREATIVE TENSION	V3. PERSEVERANCE AND RESPONSIBLE ASSUMPTION OF RISK	R3. COLLABORATION
SOCIALIZATION	C4.FLEXIBILITY	V4. COMMITMENT	R4. NETWORKING
	ORGANIZATION (O)		
ORIENTATION	C5. LEADERSHIP	V5. PROACTIVENESS AND AMBITION	R5. CONNECTIVITY
EXPLORATION	C6. ENVIRONMENT WATCHING AND ABSORPTIVE CAPACITY	V6.- OPENNESS	R6. CAPILLARITY AND DIVERSITY
CREATION	C7. CREATIVITY AND EFFECTIVENESS	V7. REASONED ACCEPTANCE OF RISKS	R7. COLLABORATION AND DIVERSITY
SOCIALIZATION	C8. RECOGNIZING THE MOMENT	V8. DIFFERENTIATION AND AUTHENTICITY	R8. CREDIBILITY AND TRUST
	TERRITORY (T)		
ORIENTATION	C9. TRAINING AND ENTREPRENEURSHIP	V9. RIGHT ATTITUDE TO CHANGE	R9. INTEGRATION
EXPLORATION	C10. KNOWLEDGE OF TERRITORY	V10. OPENNESS AND OPPORTUNITY	R10. NETWORK CREATION AND INTERACTION
CREATION	C11. CREATIVE CLASSES AND MULTIDISCIPLINARY KNOWLEDGE	V11. REASONABLE TOLERANCE TO UNCERTAINTY AND FAILURE	R11. ATTRACTION, MOBILITY AND HOLDING ON TO TALENT
SOCIALIZATION	C12. LEARNING AND SHARING	V12. SOCIAL CAPITAL AND CITIZENRY	R12. ACCESSIBILITY AND COHESION

Therefore, the proposed theoretical Model of Innovative Social Culture (MISC) can be defined as:

MISC = ƒ {P(C1, C2, C3, C4, V1, V2, V3, V4, R1, R2, R3, R4) O(C5, C6, C7, C8, V5, V6, V7, V8, R5, R6, R7, R8) T(C9, C10, C11, C12, V9, V10, V11, V12, R9, R10, R11, R12)}

Below it is briefly explained each factor of the theoretical model for each agent (people, organizations and territory) and dimension (capabilities, values and relationships) analyzed in each phase of the innovation process (orientation, exploration, creation and socialization):

Capabilities: People

- **C1. Capability for critical thinking**: the ability systematically to question everything that is usually taken for granted. Far removed from complacency or laziness, people should consider themselves responsible for and the protagonists of change, whether in their firms or in their role as citizens in society.
- **C2. Curiosity and lifelong learning**: permanent or lifelong learning is defined by the European Commission as "all learning activity undertaken throughout life, with the aim of improving knowledge, skills and competence, within a personal, civic, social and/or employment-related perspective" [33]. It is a broad concept that refers to curiosity, vocation and enthusiasm for learning as something innate to personal and professional development. Therefore, this concept includes formal, non-formal and informal learning activities. Although learning is crucial for innovation, it is equally important to be able to unlearn because things learned can become outdated. Thus, unlearning also becomes a key driver of innovation [34].
- **C3. Entrepreneurial spirit and creative tension**: "entrepreneurial spirit" should be understood as "the ability of a person to transform ideas into acts. It is associated with creativity, innovation and the acceptance of risks, as well as with the ability to plan and manage projects to achieve objectives" [35]. Ensuring that this spirit takes root entails promoting attitudes of self-confidence, personal initiative and the ability to take decisions and accept responsibilities. Creativity alludes to the capacity and ability of individuals to develop novel and useful ideas in any domain [19], [36]. Intrinsic motivation is a key driver of creativity and, in turn, of innovation [37].
- **C4. Flexibility**: associated with the capability to adapt to change, and the possibility of making systematic (and trauma-free) modifications to an original idea.

Values: People

- **V1. Proactiveness and continuous improvement**: proactiveness refers to a prior attitude predisposing a person to the analysis and questioning of reality and the acceptance of new challenges, anticipating change and conceiving it as an opportunity to be taken advantage of. Continuous improvement should be understood as a philosophy or attitude of responsibility (never by imposition or obligation) that entails things being done as soon as an opportunity for improvement is spotted.
- **V2. Permeability**: this implies keeping a flexible, open attitude to suggestions and connections made in any situation. During the exploration phase, this permeability must endow the individual with the ability to "let go of what has been learnt" when necessary, not to focus on the specific, on what he/she already knows, but rather to try to see relationships and connections between apparently separate issues; this is a preliminary step towards inventing something new from the combination of elements that nobody had thought before of pairing [38].
- **V3. Perseverance and the responsible assumption of risk**: perseverance is important keeping in mind that the development of the innovation circuit is usually long, difficult and costly. It is, however, in this phase of creation that several attempts will very likely be required before you come across the key to success. It is intimately connected with "the acceptance and tolerance of failure" as part of the personal and/or group learning process. Finally, it should be emphasized that making the leap to the process of creation (sustained innovation) requires innovative, hardworking people who accept risks "in a reasoned and intelligent way".
- **V4. Commitment**: to the extent that people are more committed as users, workers or citizens, when they abandon the passive roles that they have traditionally been assumed to have, the two-way bottom-up-top-down process of innovation will be enhanced.

Relationships: People

- **R1. Exchange**: there is no doubt that a person's proclivity towards innovation has a lot to do with his or her ability to strike up exchange relationships with the surrounding environment. For [39] "innovation is born out of effort, constancy, method, dedication, a certain amount of patience and, above all, exchange".
- **R2. Accepting difference and diversity**: exchanging and searching in the exploration phase should not be limited to "relationships between peers". Homogeneity produces homogeneous responses, which are insufficient when it comes to tackling variations in the system's environment. Homogeneity needs to be replaced by a personal drive in favour of diversity (experiential, cultural, training, etc.) as a source of innovating [40].
- **R3. Collaboration and trust**: the idea that any achievements are maximized individually must be eliminated [41]. Exchanging experiences develops attitudes and patterns of behaviour that help people to understand and approve the need to cooperate and to learn from others. However, cooperation will only be effective if it is backed by confidence and trust between the parties seeking to set up cooperation to share ideas, resources or to reduce risks.
- **R4. Networking**: For the purpose of this study a network is defined as an individual or firm´s set of relationships with other individuals and/or organizations. People's participation in networks of all kinds helps individuals to disseminate their individual creations and promote group learning through areas of cooperation and joint participation. The more involvement individuals have in social forums and cross-industry networks the more likely is that they will have access to critical knowledge and that the firms in which they are employed will adopt new innovations [18]. Currently, working in networks is not only critical for accessing knowledge but also for promoting social interaction, generating trust and reciprocity that is conductive to knowledge transfer [18].

Capabilities: Organizations

- **C5. Leadership**: clear leadership provides major capacity for coaxing and bringing out systematic innovation processes within organizations [42], [43].
- **C6. Environment watching and absorptive capacity**: environmental watching means using organized systems designed to pick up on external knowledge: technological monitoring, advanced information systems (ERP and CRM systems), open communication mechanisms and channels (websites, corporate blogs, wikis, etc.) and other early warning systems. Absorptive capacity refers to the ability to evaluate, utilize and exploit external knowledge, considering that this ability is largely a function of the level of prior related knowledge [44]. That prior knowledge includes basic skills but may also include knowledge of the most recent technological or scientific developments in a specific area. Reference [44] stresses that firms' own commitment to learning activities is crucial in recognizing and appreciating the value of new information, assimilating it and exploiting its economic potential through commercialization. They also argue that the development of absorptive capacity and, consequently, innovative performance are path-dependent [44]. Thus, the lack of investment in an area of expertise early on might foreclose the future development of a technical skill in that field.
- **C7. Creativity and effectiveness**: the creation phase requires organizations that, besides keeping a vigilant eye on the environment, think, act and generate new, creative ideas. Organizational creativity is defined as "the creation of a valuable, useful new product, service, idea, procedure, or process by individuals working together in a complex social system" [19]. Even so, most businesses that launch innovative initiatives tend to spend most of their energy on the actual generation of creative ideas, forgetting that execution is equally important [45]. Effectiveness appeals to the need to bring together the best of individual or group inspiration and talent with an organization's ability to build something valuable with it [46], [47].
- **C8. Recognizing the moment**: a company's ability to spot the right time to place or socialize the innovation on the market, be it a product/service or an organizational innovation where the market is the company in itself.

Values: Organizations

- **V5. Proactiveness and ambition**: proactiveness and ambition are preliminary values which imply that the organization and the people in it maintain an attitude and orientation towards action and intra-entrepreneurship, turning new ideas into tangible, value-providing results.
- **V6. Openness**: this is defined as a receptive attitude to knowledge and practices developed outside the organization, including ones arriving from organizations and people linked or associated in some way with the organization's activity, and from other players in more remote business areas.

- **V7. Reasoned acceptance of risks**: innovation culture requires organizations to acknowledge the need to accept certain reasoned risks [19]. It is really important for an organization to be aware that failure is not intrinsically negative, because if one knows how to structure and manage it properly (learning protocols in adversity, assumption of responsibilities, avoiding social or economic penalizations, etc.) failure can be the key to future success. Failure is, in fact, a prerequisite for innovation. Reference [41] discusses how companies can reduce their fear of miscues. They argue for the presence of failure-tolerant leaders who, through their words and actions, help employees overcome their anxieties about making mistakes and, in the process, create a culture of intelligent risk-taking that leads to sustained innovation. Therefore, firms need to encourage norms that support creative and exploratory efforts including support for risk taking and tolerance of mistakes [48].
- **V8. Differentiation and authenticity**: clients are becoming increasingly demanding, and they want products and services that convey unusual, personalized experiences. Authenticity and honesty are especially valued here.

Relations: Organizations

- **R5. Connectivity or networking**: currently work on competitiveness emphasizes the importance of business networking for innovation [18]. The most systematic integration possible with clients and suppliers ensures a network of relationships and ensures that the firm is connected up to key knowledge [49], [18], [50]. Networks are thus seen as institutional structures appropriate for encouraging organization members to learn and, correspondingly, develop innovative practices. Yet, despite this observation, relatively little research has focused explicitly on the dynamic links between networks and the development and utilization of knowledge during innovation [18]. The principal benefits of networking include risk sharing; obtaining access to new markets and technologies; speeding products to market; pooling complementary skills; safeguarding property rights when complete or contingent contracts are not possible, and acting as a key vehicle for obtaining access to external knowledge [18]. Those firms which do not co-operate and which do not formally or informally exchange knowledge possess much lower levels of competence in innovation [51], [18]. In fact, network relationships with suppliers, customers and intermediaries such as professional and trade associations are important factors affecting innovation performance and productivity.
- **R6. Capillarity and cooperation**: capillarity is defined in this environment as the ability of organizations to ensure information flows between their members, on all levels and in all directions, with the purpose of innovating [52]. Formalized cooperation relationships with R&D players, public authorities, providers, clients and even competitors are just a few representative examples of a new business culture which some have already baptized as coop-petition [53]. The evidence from the literature review illustrates that those organizations which do not cooperate and which do not formally or informally exchange knowledge limit their knowledge base on a long-term basis [18] and ultimately their ability to enter into exchange relationships and innovate.
- **R7. Collaboration and Diversity**: collaboration implies a further qualitative leap in a firm's cooperation relationships, as it entails setting common objectives *and* creating a group identity and responsibility that facilitates joint efforts towards shared goals in innovation. In a climate of collaboration, diversity and heterogeneity (experiential, cultural, training, etc.) are key values in the effective development of the innovation process [40], [54].
- **R8. Credibility and trust**: trust between the parties is probably one of the most important factors when it comes to tackling cooperation and collaboration processes in innovation effectively and successfully. However, trust will only be possible to the extent that the organization is first capable of making an impression of credibility on the internal and external players with whom it interacts [55].

Territory: Innovation support policies, supra-local governance capability and cohesiveness could impel the innovative social culture of a territory [24] but they are not the only important factors to be taken into account. In the following paragraphs some capabilities, values and relationships for a territory that might be crucial in driving an innovative social culture are presented.

Capacities: Territory

- **C9. Training and entrepreneurship:** an integral approach is needed to enlarging and continually improving human capital, impacting decisively on the need to improve ongoing training levels, developing a genuine "learning culture" [10]. Adaptation to new technologies depends on the training system's capacity, but also on the motivation of people to face change [24], [56]. Recovering and visualizing "the entrepreneur" is vital as he or she is a source of innovation, creating both wealth and jobs [57].

- **C10. Knowledge of territory**: knowing one's own territory and environment is another key factor for exploration. Such knowledge ensures that institutions get the information that they need to structure and encourage a solid regional innovation system suited to the specific feasibility conditions of each territory.
- **C11. Creative classes and multidisciplinary knowledge**: developing talents and creative capital is a major feature of the economic, social, and cultural sustainability of advanced societies. It means creating groups of people who take a creative approach to complex problems. In such situations, they come up with solutions thanks to the innovative application of prior, often multidisciplinary knowledge [58].
- **C12. Learning and sharing**: according to [56] formal research is not a characteristic distinguishing progressive from non-progressive firms or territories, but the willingness to learn and share information is. Learning is a strategic element in any innovative process, but learning often has important specific, local characteristics that can be improved through certain institutional changes and properly oriented policies [24]. Learning requires means (i.e. public investment in education, financial and legal means), incentives and the capability for people and organizations to acquire the new knowledge, which often implies territorial state intervention to keep knowledge and technological options open [24]. Therefore, if governments wish to exert influence to improve innovation capacity, they must develop policies which support the learning process. Moreover, it must be taken into account that learning is sometimes accompanied by cultural and institutional changes and changes in rules and habits, which usually require a long time to mature. The territory should be able to create a framework favourable to innovation by structuring areas and channels of encounter in which science, private firms, R&D players and citizens can get together at business and territorial levels [24], [49], [50].

Values: Territory

- **V9. Right attitude to change**: it is not enough to have a suitable institutional framework and rules that work in favour of an innovative social culture if the territory is not open to new currents and tendencies that favour the emergence of innovation processes at territorial level. The traditional culture of a territory can be transformed by orienting the education and training system towards innovation and technology [24]. Therefore, institutional managers must promote the right attitude to change among people through the education system.
- **V10. Openness and opportunity**: openness is a specific attitude that a territory can use to envisage its activities relating to organizations and the people in them at least as far as innovation is concerned. Opportunity refers to the idea of recognizing and taking advantage of occasions as they arise from a proactive perspective.
- **V11. Reasonable tolerance to uncertainty and failure**: in a creative, innovative territory, institutions and society as a whole must try to protect and support organizations and people subjected to high levels of uncertainty when deciding to undertake processes of creating new ideas or business. In the second place, there is no innovation without the danger of failure. Social tolerance of "failure" in a territory is, therefore, essential. Since mistakes are commonly a major source of learning, the benefits of getting things wrong and reacting must be accepted [52].
- **V12. Social capital and citizenry**: social capital may be defined as a set of social assets such as networks, standards and trust, which can facilitate coordination and cooperation for the mutual benefit of individuals, organizations, communities and societies [59]. Social capital can favour the dissemination and transfer of knowledge between players in the innovation system, with trust being the ingredient that needs to be promoted here [60], [2], together with the strength and rootedness of the links created, helping to socialize the results of innovation. Institutions should encourage processes of citizen empowerment, generating a culture of participation, cooperation [24] and consensus, where people abandon their passive roles to act as active, committed citizens [61]. According to a study by [62] countries with strong R&D and human resources and high innovation output exhibit higher innovation adoption rates. The same authors highlight a specific geographical pattern of EU countries regarding performance in adoption, innovation and cooperation. Their work supports the idea that innovation adoption requires absorption capability and social capital.

Relations: Territory

- **R9. Integration**: the cohesion of a territory with its local environment and its integration with its regional, national and global environment so as to profile its orientation towards innovation is now an unquestionable given, particularly in view of the growing openness of markets, goods, services, information and people. Territories need to identify and integrate the key players in the innovation process, and develop facilitating mechanisms for pooling knowledge, group learning and its effective coordination. Integrating the key factors for driving innovation process networks is now becoming crucial. A territory must deploy activities in a holistically integrated fashion (facilitating

cultural change to openness, infrastructures, process, government, strategy, etc.), and must integrate and link implicated agents (organizations and people, customers, workers, suppliers, competitors, professional and trade associations, etc.) in the innovation process.

- **R10. Network creation and interaction**: innovation networks promote creativity, stimulate the capability for invention and act as a catalyst for innovation [63], [11], [13]. In this sense, regional or territorial systems of innovation can play an important role in the dissemination of innovations in terms of the way in which they shape networking activity [18]. Therefore, networks, their characteristics and scope are essential to developing an innovative society [9]. Networks are a vital component for building new bridges in and through the increasingly globalized economy, favouring the development of long-lasting interactions between players (organizations, individuals) and territories [18], [63]. Interaction is clearly a social process since it involves feedback at different points in the innovation process (knowledge development, dissemination and deployment) [24]. To facilitate interaction and relationships to encourage an innovative social culture, public institutions in a territory must include key organisational elements and linkages between them. These linkages can be specified in terms of flows of knowledge and information, flows of funds, networks, etc.
- **R11. Attraction/mobility and holding on to talent**: a territory has to be capable of generating dynamics of interaction between businesses and people, bodies and institutions, to promote the creation of networks of cooperation that enable them to work together in search of solutions to common problems. The ability to attract and hold on to talented people with an innovative, entrepreneurial profile depends to a great extent on the atmosphere in which they live and work [58].
- **R12. Accessibility and cohesion**: cohesion can be defined as the result of the forces in the territory acting on its members to keep them grouped [3]. Making networking a socialized value for the whole territory requires a high level of cohesion and integration: high enough to permit access to all assets, services, information and people (talents) available on home ground and in other territories.

5 CONCLUSIONS AND REMARKS

Research on innovation definition cuts across multiple levels of analysis. Theorists have tended to avoid multilevel research because of the conceptual problems inherent in aggregating data across different levels of analysis. Each of the various disciplines that have contributed to innovative behaviour has its own dominant theoretical approach. Basic disciplines contributing to the macro and micro approaches to innovation behaviour are at source concerned either for the societal level of analysis (sociology), or the individual level of analysis (psychology) [19]. Therefore, the further establishment of a system of innovation in an organizational or management context necessitates the development of theories and analytical methods that cut across these basic disciplines, including ways of dealing with the problems of aggregation inherent in multilevel research.

For knowledge-based organizations and societies to be constructed there is a need for a social change, in which the values of innovation and entrepreneurship are benchmarks, generating a culture open to changes and capable of producing change itself. A key task is to explore the role of social culture in its bid to encourage innovative attitudes and skills held and wielded by people, organizations and territories, and to investigate potential systems and mechanisms that would facilitate the development of cultural changes of this kind.

In this paper the capabilities, values and relationships that people, organizations and territories need to work on and develop to achieve innovation-oriented behaviour are identified. Next, the accelerators and restraints that encourage or hinder the deployment and development of the key factors selected should be identified and further explored, and qualitative research methodologies for diagnosing the current situation and setting about improving it by proposing specific measures to that end should be developed.

Innovation and, in turn, innovative social culture, must necessarily concern themselves with people, organizations and territory. If they are to fit appropriately into the theoretical model developed here, the measures used in innovation research cannot afford to ignore any of these domains. Dealing with these research problems in depth is beyond the scope of this article. Although this challenge is recognized, it would be unfortunate if scholars and researchers failed to consider the key agents of the innovation process in complex social systems. In the above sections innovation is examined from a variety of perspectives (individual, organizational and territorial scopes).

One thing becomes very clear: after decades of theory development and empirical research into innovation, researchers still know surprisingly little about how the innovation process works. From the standpoint of basic research, for example,

definitive statements can be made regarding the key factors for successful innovation in organizations, people or territories, the processes by which it manifests itself or how it is enhanced or inhibited. On the applied side, little is known about how public institutions or organizations can successfully promote and manage innovation in individuals and in organizations themselves. Much of this is due to failure to consider problems when crossing levels of analysis.

A major factor in these shortcomings is the fragmented approach that many scholars have taken regarding the study of innovation. In particular, the dominant approach has been to study innovation from a single perspective and without regard for many of the subtle nuances likely to be associated with such a complex process. The failure to look at the big picture, for example, leads almost inevitably to an incomplete perspective on innovation.

Various research streams have tended to focus narrowly on only one of these components (people, organizations or territory). The theoretical model of innovative social culture has the potential to integrate diverse research streams while at the same time indicating future research lines, for instance, determining the impact of the different factors in the innovative culture. What is more, scholars should not ignore the fact that although they may focus on one only agent, their research may eventually have important implications for other agents in the innovation process. For example, current research supports the view that networking significantly boosts innovation output and the competitiveness of firms in a wide range of industries. Moreover, close-knit networks have a positive impact on long-term innovation. Likewise firms that do not cooperate have access to a limited knowledge base over the longer term [18].

Some broad policy implications can be derived from this. Governments should focus considerable attention on developing strategies for assisting the development of networking infrastructures. Policies promoting management networking, such as seed funding for business associations, venture networks and industry conventions should, in principal, promote dissemination. Such networks vary widely in focus but dissemination of practices may occur most effectively where networks are cross-functional, engaging actors from a wide range of contexts. Where close collaboration already exists, incentive policies can promote the continuance of long-term relationships. For example, R&D tax incentives for collaborative projects may promote the emergence of longer-term network relationships.

Finally, this study provides with a more dynamic, more complete view of the innovation process. However, this is only the first step in the identification of key factors for driving an innovative social culture and, therefore, encouraging innovation. In spite of its limitation, the model provides for the first time a systematic framework for investigating how and to what extent each factor influences the promotion of an innovative social culture, and therefore the process of innovation.

We believe that this study opens up several strands of scientific research in the field of the economics and management of innovation. For instance, the development of indicators to measure the level of innovative social culture of a territory; testing the degree of correlation between the level of innovative social culture and the degree of innovation; determining the innovative profile of a territory, providing evidence of its impact on the different modalities of innovation, or on productivity, social welfare, employment, etc., might all be fields of further research worth pursuing.

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REFERENCES

[1] H. Chesbrough, *Open innovation: the new imperative for creating and profiting from technology*. Harvard Business School Press, Boston, MA, 2003.

[2] A. Kaasa, "Effects of the different dimensions of social capital in innovative activity: evidence from Europe at the regional level," *Technovation*, vol. 29, pp. 218-233, 2009.

[3] H. C. Huang, H. Y. Shih, and Y. C. Wu, "Contagion effects of national innovative capacity: comparing structural equivalence and cohesion models," *Technological Forecasting & Social Change*, vol. 78, pp. 244-255, 2011.

[4] H. Chesbrough, *Open business models: how to thrive in the new innovation landscape.* Harvard Business School Press, Boston, MA, 2006.

[5] E. Von Hippel, *Democratizing innovation*. The MIT Press, London, 2005.

[6] C. K. Prahalad, and M. S. Krishnan, *The new age of innovation. Driving co-created value through global networks*. McGraw Hill, New York, 2008.

[7] L. Metcalfe, and K. Smith, "Policy learning and innovation theory: an interactive and co-evolving process," *Research Policy*, vol. 31, n° 8/9, pp. 1467-1479, 2002.

[8] R. Capello, and A. Faggian, "Collective learning and relational capital in local innovation processes," *Regional Studies*, vol. 29, pp. 75-87, 2005.

[9] J. Kao, "Tapping the world's innovation hot spots," *Harvard Business Review*, vol. 87, n° 3, pp. 109-114, 2009.

[10] OECD, *Education at glance 2009: OECD indicators*. OECD, Paris, 2010.

[11] C. K. Prahalad, and V. Ramaswamy, "Co-creation Experiences: the next practice in value creation," *Journal of Interactive Marketing*, vol. 18, n° 3, pp. 5-14, 2004a.

[12] C. K. Prahalad, and V. Ramaswamy, *The future of competition: co-creating unique value with customer*. Harvard Business School Press, Boston, MA, 2004b.

[13] L. Berasategui, J. Arana, and E. Castellano, *Networked innovation in innovation networks: a home appliances case study*, In: L. M. Camarinha-Matos (Ed.), *PRO-VE 2009, International Federation for Information Processing*, IFIP AICT 307, pp. 3-12, 2009.

[14] L. Berasategui, J. Arana, and E. Castellano, "A comprehensive framework for collaborative networked innovation," *Production Planning and Control iFirst*, pp. 1-13, 2010.

[15] T. Bland, B. Bruk, D. Kim, and K. Taylor Lee, "Enhancing public sector innovation: examining the network-innovation relationship," *The Innovation Journal: The Public Sector Innovation Journal*, vol. 15, n° 3, pp. 1-17, 2010.

[16] G. Hofstede, Culture's consequences. *Comparing values, behaviours, institutions and organizations across nations*. Sage Publications, London, 2001.

[17] A. James, "Demystifying the role of culture in innovative regional economies," *Regional Studies*, vol. 39, n° 9, pp. 1197-1216, 2005.

[18] L. Pittaway, M. Robertson, K. Munir, D. Denyer, and A. D. Neely, "Networking and innovation: a systematic review of the evidence," *International Journal of Management Reviews*, vol. 5-6, n° 3-4, pp. 137-168, 2004.

[19] R. W. Woodman, J. E. Sawyer, and R. W. Griffin, "Toward a theory of organizational creativity," *Academy of Management Review*, vol. 18, n° 2, pp. 293-321, 1993.

[20] P. Ahmed, "Culture and climate for innovation," *European Journal of Innovation Management*, vol. 1, n° 1, pp. 30–43, 1998.

[21] H. A. Shepard, "Innovation- resisting and innovation-producing organizations," *The Journal of Business*, vol. 40, n° 4, pp. 470-477, 1967.

[22] S. B. Hannah, "The correlates of innovation: lessons from best practice," *Public Productivity & Management Review*, vol. 19, n° 2, pp. 216-228, 1995.

[23] A. H. Van der Ven, and H. Angle, *An introduction to the Minnesota innovation research program*, In: A. H. Van der Ven, H. Angle, and M. S. Pole (Eds.), *Research on the management of innovation: the Minnesota studies*, Oxford University Press, New York, pp. 3–31, 2000.

[24] P. Cooke, M. Gómez-Uranga, and G. Etxebarria, *Regional innovation systems. Institutional and organisational dimensions*, In: C. Edquist, and M. McKelvey (Eds.), *Systems of innovation: growth, competitiveness and employment*, Edward Elgar, Cheltenham, 2000.

[25] D. Doloreux, "What we should know about regional systems of innovation," *Technology in Society*, vol. 24, pp. 243-263, 2002.

[26] M. E. Porter, *The Competitive Advantage of Nations*. Billing and Sons Ltd., Worchester, 1990.

[27] M. E. Porter, *Locations, clusters and company strategy*, In: G. L. Clark, M. P. Feldman, and M. S. Gertler (Eds.), *The Oxford handbook of economic geography*, Oxford University Press, Oxford, pp. 253-274, 2000.

[28] A. Saxenian, *Regional advantage: culture and competition in Silicon Valley and route 128*. Harvard University Press, Cambridge, MA, 1994.

[29] B. T. Asheim, *Industrial districts: the contributions of Marshall and beyond*, In: G. L. Clark, M. P. Feldman, and M. S. Gertler (Eds.), *The Oxford handbook of innovation*, Oxford University Press, Oxford, pp. 413-431, 2000.

[30] B. T. Asheim, and A. Isaksen, "Regional innovation systems: the integration of local 'sticky' and global 'ubiquitous' knowledge," *Journal of Technology Transfer*, vol. 17, pp. 77-86, 2002.

[31] B. T. Asheim, and M. S. Gertler, *The geography of innovation: regional innovation systems*, In: J. Fagerberg, D. Mowery, and R. Nelson (Eds.), *The Oxford handbook of innovation*, Oxford University Press, Oxford, pp. 291-317, 2005.

[32] L. Gelsing, *Innovation and the development of industrial networking*, In: B. A. Lundvall (Ed.), *National system of innovations*, Anthem Press, pp. 119–132, London, 2010.

[33] Commission of the European Communities, *Communication from the European Commission: making a European area of lifelong learning a reality*, Brussels, 21.11.2001, COM, 678-final, 2001.

[34] N. Crouch, The leadership challenge. *Inspiring effective innovation. AIM/CMI Management Research Forum: Leadership for Innovation*. DTI, London, October 2004.

[35] Commission of the European Communities, *Recommendation of the European Parliament and of the Council on key competences for lifelong learning*, Brussels, 10.11.2005, COM , 548-final, 2005/0221(COD) , 2005.

[36] T. M. Amabile, R. Conti, H. Coon, J. Lazenby, and M. Herron, "Assessing the work environment for creativity," *Academy of Management Journal*, vol. 39, n° 5, pp. 1154-1184, 1996.
[37] T. M. Amabile, *Within you, without you: The social psychology of creativity and beyond*, In: M.A. Runco and R. S. Albert (Eds.), *Theories of creativity*, Sage, Newbury Park, pp. 61-91, 1990.
[38] D. H. Pink, *A whole new mind. Riverhead Books*, New York, 2008.
[39] R. Carballo, *Innovación y gestión del conocimiento*. Díaz de Santos, Madrid, 2006**.**
[40] F. Johansson, *The Medici Effect: what elephants and epidemics can teach us about innovation*. Harvard Business School Press, Boston, MA, 2004.
[41] R. Farson, and R. Keyes, "The failure-tolerant leader," *Harvard Business Review*, vol. 80, n° 8, pp. 64-72, 2002.
[42] B. Leavy, "A leader's guide to creating an innovation culture," *Strategic Leadership*, vol. 33, n° 4, pp. 38-45, 2005.
[43] J. P. J. De Jong, and D. N. Den Hartog, "How readers influence employees' innovative behavior," *European Journal of Innovation Management*, vol. 10, n° 1, pp. 41-64, 2007.
[44] G. M. Cohen, and D. A. Levinthal, "Absorptive capacity: a new perspective on learning and innovation," *Administrative Science Quarterly*, vol. 35, pp. 128-152, 1990.
[45] V. Govindarajan, and C. Trimble, "Achieving breakthrough growth: from idea to execution," *Ivey Business Journal Online*, vol. 1, pp. 1-7, January/February 2006.
[46] M. D. Mumford, "Where have we been, where are we going? Taking stock in creativity research," *Creativity Research Journal*, vol. 15, n° 2/3, pp. 107-120, 2003.
[47] M. Basadur, "Leading others to think innovatively together: creative leadership," *Leadership Quarterly*, vol. 15, n° 1, pp. 103-121, 2004.
[48] C. O'Reilly, and M. L. Tushman, *Using culture for strategic advantage: promoting innovation through social control*, In: M. L. Tushman, and P. Anderson (Eds.), *Managing strategic innovation and change*, Oxford University Press, Oxford, 1997.
[49] S. Zahra, and G. George, "Absortive capacity: a review, reconceptualization, and extension," *Academy of Management Review*, vol. 27, n° 2, pp. 185-203, 2002.
[50] A. Rodríguez-Castellanos, M. Hagemeister, and S. Ranguelov, "Absorptive capacity for R&D: The identification of different firm profiles," *European Planning Studies*, vol. 18, n° 8, pp. 1267-1283, 2010.
[51] T. Ritter, and H. Gemünden, "Network competence: its impact on innovation success and its antecedents," *Journal of Business Research*, vol. 56, n° 9, pp. 745-755, 2003.
[52] A. Cornella, and A. Flores, *La alquimia de la innovación*. Deusto, Barcelona, 2007.
[53] A. M. Brandenburger, and B. J. Nalebuff, *Co-opetition: a revolution mindset that combines competition and cooperation: the game theory strategy that's changing the game of business*. Doubleday, New York, 1998.
[54] L. Fleming, "Breakthroughs and the "long tail" of innovation," *MIT Sloan Management Review*, vol. 49, n° 1, 69-74, 2007.
[55] P. Blackshaw, *Running a business in today's consumer-driven world*. Doubleday, New York, 2008.
[56] G. Sweeney, "National innovation policy or a regional innovation culture", *Working Papers in European Industrial Policy 1*, EUNIP, 1995.
[57] N. Bosma, and J. Levie, *Global entrepreneurship monitor: 2009 executive report*. Babson Park, MA, US: Babson College, Santiago, Chile: Universidad del Desarrollo and Reykjavík, Iceland: Háskólinn Reykjavík University, London, UK: Global Entrepreneurship Research Association, 2010.
[58] R. Florida, *The rise of the creative class: and how it's transforming work, leisure, community and everyday life*. Basic Books, New York, 2002.
[59] R. D. Putnam, "Bowling alone: America's declining social capital," *Journal of Democracy*, vol. 6, pp. 65-78, 1995.
[60] B. Uzzi, "The sources and consequences of embeddedness for economic performance of organizations: the network effect," *American Sociological Review*, vol. 61, n° 4, pp. 674-698, 1996.
[61] C. Landry, *The art of city making*. Earthscan, London, 2006.
[62] C. Autant-Bernard, S. Chalaye, F. Manca, R. Moreno, and J. Suriñach, "Measuring the adoption of innovation. A typology of EU countries based on the Innovation Survey," *Innovation: The European Journal of Social Science Research*, vol. 23, n° 3, pp. 199-222, 2010.
[63] J. Hagedoorn, "Inter-firm R&D partnerships: an overview of major trends and patterns since 1960," *Research Policy*, vol. 31, pp. 477-492, 2002.
[64] D. Tapcott, and A. D. Williams, *Wikinomics: how mass collaboration changes everything*. Penguin Group, New York, 2007.

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A Meta – analysis of e- learning effectiveness antecedent

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ABSTRACT: The academic research on e-learning effectiveness becomes one of the current themes. In this perspective, many efforts have been made to give more comprehension to learning effectiveness determinants. In fact, researchers focus frequently on the variables that maximize the reaction, learning and behaviour changes of trainees. Despite these efforts that aim at giving more comprehension to learning effectiveness determinants, researchers have not reached a consensus on the "nomological network" of learning results, ruling distinctness over how to explain them and queries as how could they make training experience more effective and interesting in education and corporation area as well. These divergent perspectives suggest that a conceptual and quantitative review of nomological network of learning outcomes antecedents is justified and necessary.

The present study addresses the limitation of understanding regarding learning outcomes antecedents by reviewing the empirical results of literature. In this case, a review and Meta –analytic summarizes of studies assessing learning outcomes such as declarative knowledge, skill acquisition, its antecedents, and its relationships with learning transfer are presented. First, the present report provides a narrative review of conceptual framework, focusing only on variables that are linked to learning outcomes and the relationship between learning outcomes and learning transfer. Second, Meta –analysis conducts to derive the average effect size value (r_{avg}), average fisher's Z (z_{avg}) and to address the degree of homogeneity of each relationship. The findings are discussed in terms of their theoretical implication and the limitations of this study are shown.

KEYWORDS: Trainee characteristics, training effectiveness, meta-analysis.

1 INTRODUCTION

Learning researchers focus frequently on the variables that maximize the reaction, learning and behaviour changes of trainees [8]. Recently, the academic research and reviews has increased. The scientific conferences publish e-learning studies to understand the impact of learning across different types of delivery on the employees' performance on the one hand and the competitiveness of organization on the other hand. Baldwin and Ford (1988) define learning effectiveness as the quantity of knowledge, skills and behaviour learned in a training session and their effective application by trainees on their job. Empirical research on learning effectiveness focuses on the predictor of learning performance and examining their relationships with transfer performance (e.g. [24], [43] – [52]). Learning refers to the learners' skills and knowledge acquired during training experience [84]. Transfer refers to the learners' change of their behaviour on the job because of training experience [84].

Despite these efforts that aim at giving more comprehension to learning effectiveness determinants, Researchers have not reached a consensus on the "nomological network" [70] of learning results, ruling distinctness over how to explain them and queries as how could they make training experience more effective and interesting in education and corporation area as well. For example, some researchers have stated that training motivation, self efficacy, learning delivery, anxiety are unrelated to learning outcomes (e.g. [17], [68], [52] – [18]).Others have asserted that training motivation, self efficacy,

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learning delivery, anxiety influence learning outcomes (e.g. [38], [76], [41], [74], [33]- [16]). And others have suggested that learning strategy and feedback influence learning outcomes (e.g. [15] – [48]) .These divergent perspectives suggest that a conceptual and quantitative review of nomological network of learning outcomes antecedents is justified and necessary.

The present study addresses the limitation of understanding regarding learning outcomes antecedents by reviewing the empirical results of literature. First, the present report provides a narrative review of conceptual framework, focusing only on variables that are linked to learning outcomes and the relationship between learning outcomes and learning transfer. Second, Meta –analysis conducts to derive the average effect size value (r_{avg}), average fisher's Z (z_{avg}) and to address the degree of homogeneity of each relationship.

The study considers four research questions regarding learning effectiveness. (1) To what degree do trainee characteristics predict learning outcomes? (2) To what degree do situational characteristics predict learning outcomes? (3) To what degree is learning outcomes related to learning transfer? (4) Do moderators influence these relationships?

2 META –ANALYSIS OBJECTIVES

Meta- analysis can serve a variety of purpose. Thus, meta- analysis permits to synthesise quantitative results from several researches to observe effect sizes through those papers on the phenomenon under review [63]. Meta analysis offers a way to gain a large understanding of related studies reports, in order to generalize results. Hence, Meta- analysis overcomes the weaknesses of a single research across combining numerical researches results from a few or many studies [63]. Thus, Meta analysis goes beyond traditional research in that they focus on the direction and magnitude of the effects across researches [67].

3 CONCEPTUAL FRAMEWORK

The training and learning literature generally recognize that learning outcomes can be influenced by both individual and contextual characteristics (e.g. [43] – [52]). According to this, the present review examines only the variables that are linked directly to learning outcomes (performance), and the relationship between learning outcomes and transfer. The present study includes variables examined across several studies in a training, learning and online learning context. Only those factors are included in a quantitative review of this research. On the basis of these criteria, the following individual and contextual characteristics are reviewed: motivation to learn, self efficacy, anxiety, learning strategy, learning delivery, feedback. Indeed, the role that learning outcomes play in learning transfer is mentioned.

3.1 PERSONNEL INFUENCES

A learner's characteristics influence learning performance; that is, one of the more important predictor is individual's motivation to achieve learning program (e.g. [43] – [52]).

3.1.1 MOTIVATION

Many researchers (e.g. [54]) define motivation as the degree to which trainees is willing to make efforts to enhance his or her performance of learning and work. Training motivation refers to the intention to invest high levels of consistent effort in a particular training program [76]. Various motivation constructs are examined in training or learning research, including pre - training motivation, post-training motivation and motivation to learn. Previous researches demonstrate that the motivation to learn predict learning outcomes and is influenced by both individual and situational factors (e.g. [54], [50], [51], [48], [62] – [8]).Several studies associate the motivation to learn to the training effectiveness. Mathieu et al. (1992) suggest that emotional response to the program moderate the relation between motivation to learn and learning. In fact, more trainees express more positive emotional responses, more the relation between motivation to learn and learning will be strong.

Quinone (1995) shows that motivation to learn is a variable key linking pre-training characteristics and training outcomes. Thus, trainees with higher training motivation would believe that participation in the training program and learn new knowledge and skills will influence training effectiveness [54].Tai (2006) demonstrates that individuals should expend effort to achieve a particular behaviour.

3.1.2 SELF EFFICACY

Self efficacy is shown to influence the behaviours of individuals towards the execution of actions. Thus, self efficacy is an individual's belief about his or her capacity to mobilize the resources requisite for successful task performance [5]. According to social cognitive theory [5], self efficacy is postulated to influence performance in interpersonal skills training [30], in military training programs (e.g. [19] – [73]), in computer software training [29], and home page design training course [14]. Self efficacy judgements vary along three dimensions that have robust performance implications: magnitude, strength and generality [7]. Magnitude refers to the level of task difficulty and complexity (low, moderate, high). Individuals with high magnitude judge themselves to be capable of performing more difficult activities and tasks than those with lower magnitudes. Strength refers to one's confidence in his or her capabilities to execute activities and tasks. Generality refers to the extent to which personnel efficacy is generalized across similar activity domains [39]. Past researches examine the relationship between self efficacy and learning performance. For example, Hill, Smith, and Mann (1987) examine the relationship between self efficacy and the readiness to use computers. This finding Results indicate that efficacy beliefs predicting the behavioural intentions are related to learning about computers. The investigation of Martocchio (1992) reports contradicting results. He finds that computer self efficacy is negatively related to learning performance in computer training.

Mathieu et al. (1993) found that individual antecedents of self efficacy (initial performance, achievement motivation and choice) influence self efficacy development. In this context, the authors find that self efficacy influence trainee reactions and performance improvement during training.

3.1.3 ANXIETY

According to literature, researchers generally agree that anxiety plays an important role in learning performance (e.g. [46] – [15]). Chou (2001) informs that anxiety influences learning performance. Colquitt et al. (2000) Meta – analysis shows that, anxiety produces negative correlations with every training outcome.

3.2 ENVIRONMENTAL INFLUENCES

Various training methods exist and play important role in learning program. The training research focuses on many methods: exploration, instructor – led lectures, and behaviour modelling. Behaviour modelling considers a combination of instructor-led training and exploration – based training [69]. Gist, Schewoever, and Rosen (1989) compare behaviour modelling trainees to computer – based tutorial trainees with respect to software self efficacy, performance, working style, affective response, and satisfaction. Behaviour modelling trainees attain higher mean scores on all measures than did computer – based tutorial trainees. Compeau and Higgins (1995, p132) compare behaviour modelling and lecture – based program. In this study, all trainees are first given a 40 –minute lecture on computing concepts, and then a 90 – minute software demonstration. Then, modelling trainees watch a 30 – minute modelling videotape and lecture trainees are given lecture notes to read which is followed by a two- hour practice session for both groups. The researchers find that participants in the modelling condition develop higher self efficacy and demonstrate higher training performance than those in the lecture based program. Simon and Werner (1996) compare behaviour modelling to exploration and instruction training. They find out that behaviour modelling trainees learn more than the other trainees, they do best at demonstrating the skills taught in training in a hand – on test, and they are satisfied with the computer system four weeks after training.

3.2.1 FEEDBACK

Training research suggest the importance of a feedback as a source of information that helps trainees to improve learning achievement (e.g. [48]). According to Bandura (1989), on the basis of social cognitive theory, feedback provides information about prior performance and serves as a basis for evaluating one's capability to perform successfully on subsequent tasks.

The research shows that feedback depends on the level of trainees' performance. Thus, when trainees' receive positive feedback, they are likely to achieve their learning successfully. On the other hand, trainees' who receive negative feedback may display lower performance. Feedback can be a source for both individual and group goal [53]. The authors examine the effects of feedback sign on task performance. In this study, participants are exposed to either positive or negative feedback after completing the task. The finding results suggest that, although groups receiving negative feedback are less satisfied, these groups set higher goals, develop more strategies and perform at higher levels than groups receiving positive feedback.

Martocchio and Webster (1992) examine the impact of performance feedback on software efficacy perceptions and on a variety of affective outcomes, including satisfaction with feedback, satisfaction with training and positive mood. The finding

results demonstrate that positive feedback generally results in higher test performance and more positive affective outcomes than does negative feedback. Feedback also can be an important source to supervisors to motivate individuals to show high performance. In this setting, Chakrabarty, Oubre, and Brown (2008) examine the effects of supervisor feedback on salesperson performance. The results indicate that positive feedback has a strong positive effect on salesperson performance, whereas negative feedback is unrelated to salesperson performance.

Feedback presents three most significant functions indicating a source of behavioural cues reduces uncertainty and motivates trainees [12]. The sources of feedback include the organization, immediate behaviour, co-workers, self and task [12].

3.3 BEHAVIORAL OUTCOMES

The individual and contextual characteristics reviewed above are often linked to training outcomes. Past researches show several criteria to measure learning outcomes. Kirkpatrick's model suggests four levels to evaluate learning program (reactions, learning, behaviour to change, and results) [1]. Thus, these criteria are linked in a positive and causal manner [8]. Alliger et al. (1997) point out the importance of reaction measure because trainees can be viewed as customers of learning program. Recent research demonstrates that trainees react to the learning program they receive in multiple ways. Warr and Bunce (1995) suggest three distinct reaction factors: reported enjoyment of the training experience, perceived usefulness of the training, and perceived difficulty of the training material. Alliger et al. (1997) conceptualize reactions as including both affective and utility components. Additional findings regarding reactions level are provided by Colquitt et al. (2000). The authors use meta- analysis to summarize the past 20 years of research in this area; they report little support for associations between reactions and learning. Similarly, small linkages are found between reactions and job behaviours. Mathieu et al. (1992) report further evidence of the influence of trainee reactions by analysing both linear and non linear relationships among training outcomes. They demonstrate that reactions moderate the relationship between training motivation and learning, and mediate the influences of training motivation and training assignment method on post test learning scores. To emphasize learning criteria, Kirkpatrick taxonomy focuses on skill acquisition. Kraiger et al. (1993), in recognizing this fact, argue that learning can take three categories of learning outcomes: cognitive (declarative knowledge), skill – based (skill acquisition), and affective (self efficacy).The authors suggest that a suitable evaluation of training effectiveness is made by measuring the relationships between learning goals achievement and behaviour change on the job [37]. As well, the integration of training program within an organization must improve the performance of this last. Trainees in charge must perform training program and transfer new knowledge, skills and behaviour learned during training [43].

Baldwin and Ford (1988) elaborate an integrated model on the process of learning and transfer [43]. They propose two conditions of transfer: maintenance and generalization. Maintenance refers to the length of time that trained skills continue to be used on the job. Generalization refers to the extent to which knowledge and skills acquired during training are applied to different tasks on the job [4]. According to them, trainees must understand, achieve and remember what was taught during training, and consequently incorporate their newly knowledge and behaviour learned on the job. Thus, learning performance (learning and retention) affects transfer performance (maintenance and generalization). Many researchers (e.g. [37]) suggest that retention score or the maintenance of training content is a good measure of learning performance. Alliger et al. (1997) argue that learning performance has a significant impact on transfer performance. Colquitt et al. (2000) inform that learning outcomes (e.g., knowledge acquisition, reactions) affect directly knowledge transfer into daily routines.

3.4 METHOD

Meta –analysis is a technique of statistical procedures that allows empirical findings from single studies to be collected and reckoned for the target of synthesizing and integrating these researches to ameliorate relationships estimation. A Meta – analysis is conducted to examine learning performance antecedents. The major goal of this Meta – analysis is to provide a precise summary of the overall factors used severally in the literature and that make sense to learning effectiveness. This method permits to generate new hypotheses and then allow us to draw the conceptual framework.

3.4.1 LITERATURE RESEARCH

Literature search involves using electronic reviews of available materials. To meet the search criteria, some combination of the keywords: web, online, or internet, and evaluate, learn, transfer, behavior, performance, effectiveness, knowledge, skills, achieve, or outcomes, had to be present. Studies had to meet several criteria to be included in the present review: a) the article is written in English or French; b) the article reports results that allowed the calculation of r statistic (e.g., t - test, r correlation, unvaried F – test, p value, p level) [63].

The search process is conducted using several online databases (Psych Info, Psyc ARTICLES, EBSCO, and Doctoral Dissertation Database).The present search covers the period from 1984 to 2009 and includes the following journals*: Journal of Applied Psychology, Personnel Psychology, Journal of organizational Behaviour, Human Resource Development Quarterly, J. of Acc .Ed, Journal of European Industrial Training, The American Journal of Distance Education, Information Systems Education Journal, Journal of Agricultural Education, Institute of Behavioural and Applied Management, Academy of Educational Leadership Journal, International Journal of Human Computer Studies, International Journal of Selection and Assessment, Personnel review, Computers in Human Behaviour, MIS Quarterly, Decision Sciences Journal of Innovative Education, Journal of Business Psychology, Group & Organization Management, Industrial Marketing Management, The Journal of Psychology, Learning and Instruction, International Journal of Information Management, .*

The initial computer search results in a list of 5,640 possible reports; a review of titles and abstracts reduces to list of 270 reports potentially containing relevant information. Reading the reports identifies 60 relevant studies. Unpublished studies are also searched. A request is sent to authors (Kurt Kraiger; Kenneth Brown; Colquitt Jason). They are asked to provide leads to unpublished work, as well as any manuscripts they may have.

3.4.2 INCLUSION CRITERIA

The goal of the literature research is to identify all research reports where employees or students are performing learning program to prepare them to reproduce and generalize knowledge and skills acquired on class tasks or job tasks. Researches that report gain scores, learning achievement, training performance are also gathered.

3.4.3 INDEPENDENT ASSUMPTION

When multiple learning outcomes dimensions are present in a study, each possible relationship between the independent factors (e.g., Motivation to learn, anxiety, self efficacy) and the dimensions is treated separately.

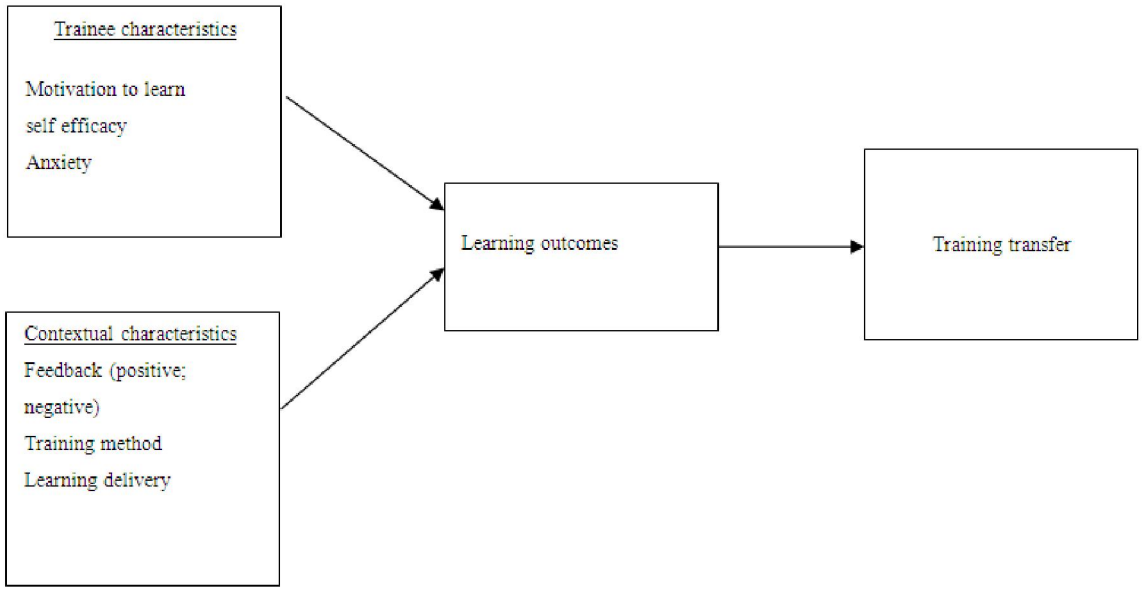

Fig.1. E-learning effectiveness antecedents

4 META –ANALYTIC METHOD

Effect sizes are reckoned by using the guidelines produced by Rosenthal and DiMatteo (2001). In fact, effect sizes (r) are important to estimate the magnitude and the strength between the relationships. Also, average effect sizes (r_{avg}) and average fisher's Z (Z_{avg}) were calculated.

4.1 EFFECT SIZE

The effect size essentially encodes the results of the selected papers finding into a numeric value [57]. There are two principle types of effect sizes: those based on mean differences (commonly called d) and those based on correlations (commonly called r).

Effect sizes based on mean differences (d) look to compare the average on a particular variable to two groups or between two time frames [57]. The standardized mean difference (d) can be calculated by inputting means and standard deviations; t – values, F- values, or p – values [63].

Cohen's (1992) suggests the following guidelines of interpreting the meaningfulness of the magnitude of the observed standardized mean difference effect size, if $d \leq 0.20$ the effect is small, if $d = 0.50$ the effect is medium, if $d \geq 0.80$ the effect is significant.

Effect sizes based on correlations compare the relative strength of the association between two variables [57]. The effect size for the relation between two variables can be calculated through t- test; F- values, p – value, or Cohen's d. These equations can be written (Rosenthal and DiMatteo, 2001, p. 71):

$$r = \sqrt{\frac{t^2}{t^2 + df}} \quad \text{or} \quad r = \sqrt{\frac{F}{F + df}}$$

Correlation coefficient effect sizes range in magnitude between 0 and 1, With 1 being an exact relation between the variables, and 0 denoting no relation at all. Cohen's (1992) suggests the following correlation coefficient: if $r \leq 0.1$ the effect is small, if $r = 0.30$ the effect is medium, if $r \geq 0.5$ the effect is large.

The effect size chosen for this research is the effect size based on correlation (r). In order to normalize the distribution, we calculate the standard normal deviate scores (Z_r) (Rosenthal and DiMatteo, 2001). The guidelines of Rosenthal and DiMatteo (2001) are utilized to calculate the fisher's Z and effect size r.

To calculate the average r and the average Z_r the software named Meta. EXE. Version III" is used.

Finally, the degree of heterogeneity is measured using X^2 distribution with k – 1 degree of freedom. When X^2_{k-1} is not significant, the effect is considered homogenous (no moderators effect). Whereas, when X^2_{k-1} value is very large, the effect is considered heterogeneous. To calculate Chi –square the same software Meta. EXE. Version III is employed.

5 RESULTS

The finding results of the Meta –analysis are presented below in table 2 to table 8. These tables include the results of 8 relationships that are consistent in the domain of training and learning research. In general, the number of studies considered in this Meta – analysis is the number of relationships that is 100. The contents of tables are analysed and discussed according to the relationships between motivation to learn, self efficacy, learning delivery, Training method, anxiety, feedback with learning outcomes and finally the relationship between learning outcomes and learning transfer.

- *Antecedents of learning outcomes*

In general, these results suggest that motivation to learn has a moderate relationship with learning outcomes. The average effect size is medium (r = 0.36), with the sign indicating that people motivated to learn tend to display important level of knowledge and skills performance.

Self efficacy has a small relationship with learning outcomes. The average effect size is small (r = 0.16). Anxiety has a significant relationship with learning outcomes. The average effect size is roughly large (r = 0.48). Training method has an important relationship with learning outcomes. The average effect size is large (r = 0.70). Learning delivery has a small relationship with learning outcomes. The average effect size is small (r = 0.14). Feedback has a strong relationship with learning outcomes. The average effect size is large (r = 0.64).

- *Relationships among outcomes*

Learning outcomes is positively related to transfer. Specifically, the average effect size is approximately medium (r = 0.29). It's important to emphasize that the correlations among learning outcomes and transfer support the results find in many researches (e.g. [8] – [43]).

6 ANALYSIS

This section provides the meta-analysis results on various relationships investigated in this research. Thus, this procedure presents information on how important and how significant these relationships are and also present information on the degree of the heterogeneity among Z_r scores and effect sizes.

Motivation to learn ⟶ Learning outcomes

Meta-analysis results regarding the relationship between motivation to learn and learning outcomes. 22 studies measure the effect of motivation to learn on learning outcomes. The average normal standard deviate of these studies is Z_r = 9.40 **.**The average effect size is r =0.36 a medium effect size according to Cohen's (1992). The Z_r score is not found to be heterogeneous to a significant degree, X^2_{k-1} = 55.25.

Self efficacy ⟶ learning outcomes

Meta-analysis reflects results regarding the relationship between computer self efficacy and learning outcomes. 28 studies measure the effect of self efficacy on learning outcomes. The average normal standard deviate of these studies is Z_r = 4.45**.** The average effect size is r = 0.16, a small effect size according to Cohen's (1992). The Z_r score is found to be heterogeneous to a significant degree, X^2_{k-1} = 164.75. This suggests the existence of possible factors that moderate the relationships between self efficacy and learning outcomes.

Anxiety ⟶ learning outcomes

Meta-analysis results regarding the relationship between computer anxieties and learning outcomes. 6 studies measure the effect of anxiety on learning outcomes. The average normal standard deviate of these studies is Z_r = 2.99**.** The average effect size is r = .48 a medium effect size according to Cohen's (1992). The Z_r score is not found to be heterogeneous to a significant degree, X^2_{k-1} = 3.86.

Learning delivery ⟶ learning outcomes

Meta-analysis results regarding the relationship between learning delivery and learning outcomes. 21 studies measure the effect of learning delivery on learning outcomes. The average normal standard deviate of these studies is Z_r = 4.48**.** The average effect size is r = .14 a small effect size according to Cohen's (1992). The Z_r score is not found to be heterogeneous to a significant degree, X^2_{k-1} = 64.89.

Training method ⟶ learning outcomes

Meta-analysis results regarding the relationship between training method and learning outcomes. 10 studies measure the effect of training method on learning performance. The average normal standard deviate of these studies is Z_r = 7.98**.** The average effect size is r = 0.70 a large effect size according to Cohen's (1992). The Z_r score is not found to be heterogeneous to a significant degree, X^2_{k-1} = 7.78.

Feedback ⟶ learning outcomes

Meta-analysis results regarding the relationship between feedbacks and learning outcomes. 6 studies measure the effect of feedback on learning outcomes. The average normal standard deviate of these studies is Z_r = 4.04**.** The average effect size is r = 0.64, a large effect size according to Cohen's (1992). The Z_r score is not found to be heterogeneous to a significant degree, X^2_{k-1} = 2.27.

Learning outcomes ⟶ learning transfer

Meta-analysis results regarding the relationship between learning outcomes and learning transfer. 4 studies measure the effect of learning performance on learning transfer. The average normal standard deviate of these studies is Z_r = 2.69. The average effect size is r = 0.29 a large effect size according to Cohen's (1992). The Z_r score is not found to be heterogeneous to a significant degree, X^2_{k-1} = 9.16.

7 DISCUSSION

The target of the present narrative and Meta – analytic review is to shed light on the learning effectiveness antecedents in an effort to determine the role of individual characteristics and situational one in training effectiveness. Thus, the present report looks at the degree to which individual and contextual characteristics predict learning outcomes and the degree to which learning outcomes predict changes in learning transfer. Theoretical implications of the finding results as well as limitations and directions for future research are discussed.

7.1 THEORETICAL IMPLICATIONS

The results of the Meta –analysis show that learning outcomes primary capture trainees' characteristics (e.g., Motivation to learn, anxiety, and self efficacy) and trainees' perceptions of the training environment (e.g., feedback, training method, and learning delivery). Across 56 studies and 11,326 trainees, motivation to learn (r_{avg} = 0.36) and anxiety (r_{avg} = 0.48) has most important effect on learning outcomes, whereas trainees' self efficacy (r_{avg} = 0.16) were smaller but still important predictor of learning effectiveness. Thus, the importance of this factor is supported by several researchers (e.g. [18], [22] - [30]), whose find self efficacy to be a strong and significant predictor of learning outcomes. Computer anxiety, roughly largest predictor, accounted for 43% of the variance in learning outcomes above other trainees' characteristics.

Contextual characteristics are also shown to be consistent. In fact, across 37 studies 8863 trainees, training method (r_{avg} = 0.70) and feedback (r_{avg} = 0.64) has the strongest effect on learning outcomes, whereas learning delivery is weaker (r_{avg} = 0.14).

Meta – analysis results indicate that learning delivery demonstrates a small relationship with learning outcomes. The results across studies are found to be statistically small. According to the literature, there are instances in which distance learning group outperformed the traditional instruction group, and there are instances in which the opposite occurred. However, the importance of this factor is supported by several researches (e.g. [26], [66] – [78]). Training method, the significant predictor, accounted for 33% of the variance in learning outcomes. However, some of those results are based on few studies.

The narrative review shows that learning outcomes distinguish between cognitive outcomes (e.g., declarative knowledge, behavioural knowledge) and affective knowledge (e.g., self efficacy, reactions, and satisfaction). Hence, the results of the Meta –analysis show that variables studied in the literature correlate with several dimensions of learning results.

Finally, the Meta analysis results indicate that learning outcomes is moderately related to learning transfer. However, the results across studies are consistent and are found to be statistically significant. Recent researches show a strong correlation between learning performance and learning transfer (e.g.[43] – [52]).

7.2 LIMITATION AND DIRECTIONS FOR FUTURE RESEARCH

As with any research, this Meta – analysis has some limitations that should be indicated. First, this research is based on studies that have directly examined training, learning, or online learning therefore subject to error. Second, some studies are based on small sample sizes. Third, this report focuses on the analysis of the variables that have been directly correlated to learning performance. Additionally, the possible moderators between self efficacy and learning outcomes are not examined. Further researches should focus on the extraction of these moderators.

Further research is necessary to focus on trainees' reaction as a primary measure of learning effectiveness. Specifically, we suggest considering trainees' reaction as an antecedents of learning outcomes. Additional research is needed to examine how learning delivery moderate the relationship between trainees' reaction and learning outcomes. Thus, we have examined that across narrative review, single effect sizes are small.

REFERENCES

[1] Alliger G. M , Tannenbaum. S. I , Bennett. W, Traver. H A meta-analysis of the relations among training criteria. Personnel psychology, Vol. 50, n°. 2, pp. 341- 358, 1997.

[2] Baldwin T. T. Effects of alternative modeling strategies on outcomes of interpersonal-skills training. *Journal of Applied Psychology*, Vol. 77, n°. 2, pp. 147–154, 1992.

[3] Baldwin T. T, Magjuka R. J, Loher B. T.The perils of participation: Effects of choice of training on training motivation and learning, P*ersonnel Psychology*, Vol. 44, n°.1, pp. 51–65, 1991.

[4] Baldwin T.T, Ford J. K. Transfer of training: a review and directions for future research. Personnel psychology 1988; 41 (1): 63 -105.

[5] Bandura A, Wood R. Social cognitive Theory of organizational management. Academy of Management Review, Vol. 14, n°. 3, pp. 361 -384, 1989.

[6] Bretz R.D, Thompsett R. E. Comparing Traditional and Integrative Learning Methods in Organizational Training Programs. Journal of Applied Psychology, Vol. 77, n°. 6, pp.941 – 951, 1992.

[7] Compeau D, Higgins C. A. Application of social cognitive theory to training for computer skills. Information systems Research, Vol. 6, n°. 2, pp. 118- 143, 1995a.

[8] Colquitt J. A, Lepine J. A, Noe R.A. Toward an Integrative theory of training motivation: A Meta – analytic path analysis of 20 years of research. Journal of Applied Psychology, Vol.85, n° 5, pp. 678- 707, 2000.

[9] Cohen J. A power primer. Psychological Bulletin, Vol. 112, n°.1, pp. 155-159, 1992.

[10] Combs J, Liu Y, Hall A, ketchen D. How much do high –performance work practices matter? A meta –analysis of their effects on organizational performance. Personnel Psychology, Vol. 59, pp. 501 – 528, 2006.

[11] Cybinski P, Selvanathan S. Learning experience and learning effectiveness in undergraduate statistics: modelling performance in traditional and flexible learning environments. Decision Sciences Journal of Innovative Education, Vol. 3, n°.2, 251 – 271, 2005.

[12] Champoux J.E. Designing feedback mechanisms into systems to enhance user performance. *Journal of Systems Management*, Vol.42, n° 8, pp. 28 – 30, 1991.

[13] Chakrabarty S, Oubre D.T, Brown G. The impact of supervisory adaptive selling and supervisory feedback on salesperson performance. *Industrial Marketing Management*, Vol. 37, pp. 447 – 454, 2008.

[14] Chau H. W, Wang T. B. The influence of learning style and training method on self – efficacy and learning performance in WWW homepage design training. *International Journal of Information Management*, Vol. 20, pp. 455-472, 2000.

[15] Chou H.W. Effects of training method and computer anxiety on learning performance and self efficacy. *Computers in Human Behaviour*, Vol. 17, pp. 51 – 69, 2001.

[16] Chen C. CH. Online Synchronous vs. Asynchronous Software Training Through the Behavioural Modelling Approach: A Longitudinal Field Experiment. *International Journal of Distance Education Technologies*, Vol. 4, n°. 4, pp. 88 – 102, 2006.

[17] Chiaburu D. S, Tekleab A.G. Individual and contextual influences on multiple dimensions of training effectiveness. *Journal of European Industrial Training*, Vol. 29, n° 8/9, pp. 604 – 676, 2005.

[18] Christoph R. T, Schoenfeld G. A. Jr, Tansky J. W. Overcoming barriers to training utilizing technology: The influence of self-efficacy factors on multimedia-based training receptiveness. *Human Resource Development Quarterly*, Vol. 9, n°. 1, pp. 25–38, 1998.

[19] Eden D, Ravid G. Pygmalion versus self- expectancy: effects of instructor and self expectancy on trainee performance. *Organizational Behaviour and Human Performance*, Vol. 30, pp. 351 – 364, 1982.

[20] Davis W.D, Fedlor D.B, Parsons CH. K, Herold D.M. The development of self efficacy during aviation training. *Journal of Organizational Behaviour*, Vol. 21, pp. 857 – 871, 2000.

[21] Davis A.L, Rothstein H.R. The effects of the perceived Behavioural Integrity of Managers on Employee Attitudes: A meta – analysis. *Journal of Business Ethics*, Vol. 67, pp. 407 – 419, 2006.

[22] De Ture M. Cognitive Style and Self efficacy: Predicting Student Success in online Distance Education. The American Journal of Distance Education, Vol. 18, n°. 1, pp. 21 – 38, 2004.

[23] Eyring J. D, Johnson D, Francis D. J. A cross-level units-of-analysis approach to individual differences in skill acquisition. J*ournal of Applied Psychology*, Vol. 78, n°. 5, pp. 805–814, 1993.

[24] Ford J.K, Smith E.M, Weissbein D.A. Gully S.M, Salas E. Relationships of goal orientation, Metacognitive activity, and practice strategies with learning outcomes and transfer. Journal of Applied Psychology, Vol. 3, n°. 2, pp. 218 – 233, 1998.

[25] Fredda J. V. Comparison of selected student outcomes for Internet- and campus-based instruction at the Wayne Huizenga Graduate School of Business and Entrepreneurship (ERIC Document Reproduction Service No. ED453743); 2000.

[26] Friday E, Friday – Stroud S.S, Green A. L, Hill A. Y. A multi- semester comparison of student performance between multiple traditional and online sections of two management courses. *Institute of Behavioural and Applied Management*, pp. 66 – 81, 2006

[27] Fillion G, Limayem M, Laferrieère T, Mantha R. Integrating ICT Into higher education: a study of onsite VS online students' perceptions. *Academy of Educational Leadership Journal*, Vol. 11, n°. 2, pp. 45 – 72, 2007.

[28] Gibson C.B. Me and Us: Differential relationships among goal –setting training, efficacy and effectiveness at individual and team level. *Journal of Organizational Behaviour*; Vol. 22, n° 7, pp.789 – 808, 2001.

[29] Gist M.E, Schwoerer C, Rosen B. Effects of alternative training methods on self-efficacy and performance in computer software training. *Journal of Applied Psychology*, Vol. *74, n°.* 6, pp. 884–891, 1989.

[30] Gist M. E, Stevens C. K, Bavetta A. G. Effects of self-efficacy and post-training intervention on the acquisition and maintenance of complex interpersonal skills. *Personnel Psychology*, Vol. *44, n°.* 4, pp. 837–861, 1991.

[31] Glenn A.S. A. Comparison of distance learning and traditional learning environments (ERIC Document Reproduction Service No. ED457778); 2001

[32] Hasan B.S. The influence of computer self efficacy and outcome expectations on computer training effectiveness. Unpublished Doctoral Dissertation: Mississippi University, pp. 1-197, 1997.

[33] Hancock D.R. Effects of test anxiety and evaluative threat on students' achievement and Motivation. *The Journal of Educational Research*, Vol. 94, n°. 5, pp. 284 – 290, 2001.

[34] Henss S.R. A comparison of Traditional and Web based Floral Design Courses, 2003 Doctoral Dissertation, Texas A &M University.
[35] Hill T, Smith N. D, Mann M. F. Role of efficacy expectations in predicting the decision to use advanced technologies: the case of computers. *Journal of Applied Psychology*, Vol. 72, n°. 2, pp. 307- 313, 1987.
[36] Kan A.C.N, Cheung L. LM. Relative effects of distance versus traditional course delivery on student performance in Hong Kong. *International Journal of Management*, Vol. 24, n°. 4, pp. 763 – 823, 2007.
[37] Kraiger K, Ford. J. K, Salas E. Application of cognitive, skill- based, and affective theories of learning outcomes to new methods of training evaluation. *Journal of applied psychology*, Vol. 78, n°. 2, pp. 311- 328, 1993.
[38] Klein H. J, Noe R.A, Wang CH .Motivation to learn and course outcomes: the impact of delivery mode, learning goal orientation, and perceived barriers and enablers. *Personnel Psychology*, Vol. 59, pp. 665 – 702, 2006
[39] Latham G.P. Human Resources Training and Development. *Annual Review of Psychology*, Vol. 39, pp. 545 -582, 1988.
[40] Locke E. A, Frederick E , Lee C , Bobko P. Effect of self-efficacy, goals, and task strategies on task performance. *Journal of Applied Psychology,* Vol. 69, n°. 2, pp. 241–251, 1984.
[41] Lepine J.A, Lepine M.A, Jackson CH. L. Challenge and hindrance stress: relationships with exhaustion, motivation to learn, and learning performance. Journal *of Applied Psychology*, Vol. 89, n°. 5, pp. 883 – 891, 2004.
[42] Lim J, Kim M, Chen S.S, Ryder C. E .An empirical investigation of student achievement and satisfaction in different learning environments. *Journal of Instructional Psychology,* Vol. 35, n°. 2, pp.113 – 119, 2007.
[43] Lim H, Lee S.G, Nam K. Validating e-learning affecting training effectiveness. *International Journal of Information Management*, Vol. 27, pp. 22 – 35, 2007.
[44] Martocchio J. J. Microcomputer usage as an opportunity: The influence of context in employee training. *Personnel Psychology*, Vol.45, n°. 3, pp. 529–551, 1992.
[45] Martocchio J. J. Effects of conception of ability on anxiety, self-efficacy, and learning in training. Journal *of Applied Psychology*, Vol. *79, n°.* 6, pp. 819–825, 1994.
[46] Martocchio J. J, Dulebohn J. Performance feedback effects in training: The role of perceived controllability. *Personnel Psychology*, Vol. 47, n°. 2, pp. 357 – 373, 1994.
[47] Martocchio J. J, Judge T. A. Relationship between conscientiousness and learning in employee training: Mediating influences of self-deception and self-efficacy. *Journal of Applied Psychology*, Vol. *82, n°.* 5, pp. 764–773, 1997.
[48] Martocchio J. J, Webster J. Effects of feedback and cognitive playfulness on performance in microcomputer training. *Personnel Psychology*, Vol. 45, n°. 3, pp. 553–578, 1992.
[49] Martin G. D .The effects of employee characteristics and work environment factors on learning during training and on pre training motivation to learn. Unpublished Doctoral Dissertation, Missouri: Columbia University; 1996, pp. 1 – 62.
[50] Mathieu J. E, Martineau J. W, Tannenbaum S. I. Individual and situational influences on the development of self-efficacy: Implications for training effectiveness. *Personnel Psychology*, Vol. 46, n°. 1, pp. 125–147, 1993.
[51] Mathieu J.E, Tannenbaum S.T, Salas E. Influences of individual and situational characteristics on measures of training effectiveness. *Academy of Management Journal*, Vol. 35, n°. 4, pp. 828 – 847, 1992.
[52] Mbarek R, Zaddem F. E-learning effectiveness determinant. Manuscript submitted for publication; 2009.
[53] Mesch D.J, Lih Farh J, Podsakoff P. M .Effects of feedback sign on group goal setting, strategies, and performance. Group & Organization Management, Vol. 19, n°. 3, pp. 309 – 333, 1994.
[54] Noe R. A. Trainees' attributes and attitudes: neglected influences on training effectiveness. *Academy of management review*; Vol. 11, n°. 4, pp. 736- 749, 1986.
[55] Johnson SD, Aragon SR, Shaik N , Palma –Rivas N. Comparative Analysis of Learner Satisfaction Outcomes in online and Face to Face Learning Environments. *Journal of Interactive Learning Research*, Vol. 11, n°. 1, pp. 29 – 49, 2000.
[56] Johnson R.D, Hornik S, Salas E. An empirical examination of factors contributing to the creation of successful e-learning environments. *International Journal of Human Computer Studies,* Vol. 66, pp. 356 – 369, 2008.
[57] O'Mara A.J, Marsh H.W, Craven R.G. Meta-Analytic Methods in Educational Research: Issues and Their Solutions. Paper presented at the AARE Conference: University of Western Sydney, Parramatta, Australia; 2005.
[58] Ouweneel A.P.E, Zolingen S.J.V, Schreurs P.J.G. How task characteristics and social support relate to managerial learning: Empirical Evidence From Dutch Home Care. *The Journal of Psychology*; Vol. 143, n° 1, pp. 28 – 44, 2009.
[59] Potter B.N, Johnston C.G. The effect of interactive on-line learning systems on student learning outcomes in accounting. *Journal of Accounting Education*, Vol. 24, n° 1, pp.16 – 34, 2006.
[60] Potosky D. A field study of computer efficacy beliefs as an outcome of training: the role of computer playfulness, computer knowledge, and performance during training. *Computers in Human Behaviour*, Vol. 18, pp. 241 – 255, 2002.
[61] Piccoli G, Ahmad R, Ives B. Web- based virtual learning environments: a research framework and a preliminary assessment of effectiveness in basic IT skills training. *MIS Quarterly*, Vol. 25, n°. 4, pp. 401- 426, 2001.
[62] Quinones M. A. Pretraining context effects: Training assignment as feedback. *Journal of Applied Psychology*, Vol. *80, n°.* 2, pp. 226–238, 1995.

[63] Rosenthal R, DiMatteo M.R. Meta – Analysis: Recent Developments in Quantitative Methods for Literature Reviews. *Annual Review of Psychology*, Vol. 52, pp. 59 – 82, 2001.

[64] Sagie A, Koslowsky M.Detecting moderators with meta-analysis: An evaluation and comparison of techniques. *Personnel Psychology*, Vol. 46, pp. 629 -640, 1993.

[65] Sexton J.S, Raven M.R, Newman M.E. A comparison of traditional and World Wide Web methodologies, computer anxiety, and higher order thinking skills in the in-service training of Mississippi 4-H extension agents. *Journal of Agricultural Education*, Vol. 43, n°. 3, pp. 25-36, 2002.

[66] Scott D.J, Steven R.A, Najmuddin S, Nilda P.R. Comparative analysis of leaner satisfaction and learning outcomes in online and face – to – face learning environments. *Journal of Interactive Learning American Psychologist Research*, Vol. 11, n°. 1, pp. 29 -49, 2000.

[67] Schmidt F.L. What do data really mean? Research findings, *meta –analysis, and cumulative knowledge in psychology*, Vol. 47, pp. 1173 – 1181, 1992.

[68] Schoenfeld –Tacher R, McConnell S, Graham M .Do no harm – a comparison of the effects of on-line vs. traditional delivery media on a science course. *Journal of science Education and Technology*, Vol. 10, n°. 3, pp. 257 -265, 2001.

[69] Simon S. J, Werner J. M. Computer training through behaviour modelling, self-paced, and instructional approaches: A field experiment. *Journal of Applied Psychology*, Vol. *81, n°* 6, pp. 648–659, 1996.

[70] Sitzmann T, Brown K. G, Caper W. J, Ely K, Zimmerman R.D. A review and Meta – analysis of nomological network of trainee reactions. *Journal of Applied Psychology*, Vol. 93, n°. 2, pp. 280 -295, 2008

[71] Shea CH.M, Howell J.M. Charismatic leadership and task feedback: a laboratory study of their effects on self efficacy and task performance. *Leadership Quarterly*, Vol. 10, n°. 3, pp. 375 – 396, 1999.

[72] Spiros R.K. Individual Differences in Motivation During Distance Training: The Influence of Goal orientation and Self efficacy on learning outcome. Doctoral Dissertation: California University, pp.1 – 95, 1991.

[73] Tannenbaum S. I, Mathieu J. E, Salas E, Cannon – Bowers J. A Meeting trainees' expectations: the influence of training fulfilment on the development of commitment, self – efficacy, and Motivation. *Journal of Applied Psychology,* Vol.76, n°. 6, pp. 759 – 769, 1991.

[74] Tai W. T. Effects of training framing, general self- efficacy and training motivation on trainees' training effectiveness. *Personnel review* 35 (1): 51- 65, 2006.

[75] Tracey J.B, Hinkin T.R, Tannenbaum S, Mathieu J.E. The influence of individual characteristics and the work environment on varying levels of training outcomes. *Human Resource Development Quarterly*, Vol. 12, n°. 1, pp. 5 – 23, 2001.

[76] Tziner A , Fisher M , Senior T, Weisberg J. Effects of trainee characteristics on training effectiveness. *International Journal of Selection and Assessment*, Vol. 5, n°. 2, pp. 168 – 174, 2007.

[77] Thomas H. F, Simmons R. J. Comparison of Student Outcomes for a classroom – based VS an Internet – based Construction safety course. *The Journal of SH&E Research*, Vol. 2, n°. 1, pp. 2 – 15, 2005.

[78] Tucker S. Distance Education: Better, Worse, Or As Good As Traditional Education?. *Online Journal of Distance Learning Administration*, Vol. 4, n°. 4, 2001.

[79] Ury G. A longitudinal Study Comparing Undergraduate Student Performance in Traditional Courses to the Performance in online Course delivery. *Information Systems Education Journal*, Vol. 3, n°. 20, pp. 2 – 9, 2005.

[80] Vollmeyer R, Rheinberg F. A surprising effect of feedback on learning. *Learning and Instruction*, Vol. 15, n° .6, pp. 589 – 602, 2005.

[81] Warr P, Bunce D. Trainee characteristics and the outcomes of open learning. *Personnel Psychology,* Vol. 48, n°. 2, pp. 347–375, 1995.

[82] Wegner S.B, Holloway K.C, Garton E. M. The Effects of Internet-Based Instruction on Student Learning. *JALN*, Vol. 3, n°. 2, pp. 98 – 106, 1999.

[83] Kirkpatrick. D. "Great ideas revisited: revisiting Kirkpatrick's four- level model", *Training and Development*, Vol. 50, n° 1, pp. 54- 57, 1996.

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Online monitoring of Electricity Data through wireless transmission using Radio Frequency

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ABSTRACT: Power system is becoming more complex with the passage of time, as non-linearity of the system invite major dynamic kind of problems. One of major problems in power system is the acquisition of electricity data. Energy meter reading is a tiresome and pricey concern. Planned system of energy meter data reading will allow to control room to access the customer's energy meter and also allow the service provider to monitor and control the whole energy consumption, acquisition of energy data and fault or energy theft case in its zone. Digital wireless meter is technological enhanced and improved version of meter reading with safe prestigious time of energy providing company employees as there is no need of manpower for manual meter reading while visiting home to home. Radio frequency is proposed source of wireless communication for data integration. Online monitoring of electricity is being addressed first time in this research paper for Pakistan's Distribution system using radio frequency (RF). Telemetry will really be helpful for safety purposes for both utility and consumers. This Microcontroller Based Electricity Data Acquisition and Wireless Transmission system is established in Rachna College of Engineering & Technology, Joura-sian in Region of 220KV Ghakar Grid station, Gujranwala under the control of National Transmission and Dispatch Company Pakistan.

KEYWORDS: Power System, MATLAB, Proteus, Microcontroller, Radio Frequency.

1 INTRODUCTION

International Journal of Innovation and Applied Studies (IJIAS) is a peer reviewed multidisciplinary international journal publishing original and high-quality articles covering a wide range of topics in engineering, science and technology [1]. IJIAS is an open access journal that publishes papers submitted in English, but also in French, Spanish and Arabic. It is published four times per year. The journal aims to give its contribution for enhancement of research studies and be a recognized forum attracting authors and audiences from both the academic and industrial communities interested in state-of-the art research activities in innovation and applied studies [2], [3], [4].

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This research paper is related to the acquisition of electricity data. Electricity data nowadays is being achieved by a line man, going door to door for attaining electricity data from energy meter and that line man goes back to Gujranwala Electric Power Company (GEPCO), one of the Distribution companies (DISCO's) of Pakistan Electric Power Company (PEPCO). These is very time consuming, costly due to pays of meter readers, and have chances of corruption and electricity theft [4]. So, to improve it a research is conducted at RCET, Pakistan.

This work has already been done in Georgia using radio frequency (RF) and in Singapore with Bluetooth [5,6]. The idea behind this research is to develop a proto type model which can be used as bench mark for comprehensive simulation of integrated network at National level to address the problems regarding electricity data acquisition and any mischief made by consumer.

Pakistan Electric Power Company (PEPCO), the only power sector utility in Pakistan, consist of nine power distribution companies along with national transmission and power dispatch company but unfortunately no online monitoring is currently being performed. It is first time in the history of Pakistan that analysis and complete online monitoring is conducted by getting voltage (V), Currant (A), Power factor (pf), Apparent Power (S) and Active Power (P) from prototype model for 24 hours. Although in some of the 3rd world counties and at some places in Pakistan electricity data acquisition is done using Global system for mobile communication (GSM) technology [7]. This has made some improvement in our data acquisition method like manpower has reduced. Thus saving valuable time and money, but there are still many problems in this data acquisition system like; data is sent to the supplier after a period of one month or according to the time set in programming. Otherwise, supplier has to ask for data transmission by making a call to the point from which data is required.

Data Acquisition and Wireless Transmission consists of a Microcontroller, encoder to encode, a Transmitter, a Receiver and decoder to decode. Microcontroller is used to control Transmitter and Receiver and to keep system noise free.

A powerful computer Windows eXPerience (Xp) built-in software HyperTerminal is used in this research paper for getting telemetric data [8].

Analysis performed during this research paper is based upon practical system comprising of single room load for 24 hours. A room consists of a fan, two energy savers and two bulbs.

2 BLOCK DIAGRAM AND CIRCUIT DIAGRAM OF EXPERIMENTAL WORK

In this research, in first section we design an energy meter by using microcontroller Atmega32L. Section 2 consists of interfacing of encoder PT2262 and modulator with Atmega32L. Section 3 deals comprises of interfacing of decoder with microcontroller Atmega8L and also interfacing of Atmega8L with computer serial port through MAX232 and DB9 [9].Section 4 deals with collection of telemetric data that is being displayed on HyperTerminal window and plotting a graph to study the behavior of power flow in Power system.

2.1 DESIGNED ENERGY METER

Energy meter is designed by using microcontroller ATmega32L.Energy meters operate by continuously measuring the voltage (V) and current (A) and finding the product of these to give electrical power and measured quantities are displayed on Liquid crystal display (LCD) which is interfaced with microcontroller. Energy meter was designed because of two reasons; one was limitation of funds and second was the interfacing problem of Solid state energy meter with transmission module. Alternating voltage is measured by using a simple method of rectifying the alternating voltage and converting it to a equivalent DC voltage. Then use voltage division rule as shown in Fig.2 .Finally A resistor is placed in series to the analog to digital converter (ADC) and a zener diode at the pin microcontroller to protect the microcontroller from transients that may destroy it. Current is measured with current transformer (CT) that is loaded with burden resistor i.e. place it across the terminals of the CT and for linearity it must be able to carry the full current of the CT at its maximum pass current. We had used a CT of rating as 30:5 which means if the main conductor is carrying 30A then the output of the CT will be 5A. Apparent power is measured by using S=V*I and Active power is measured by CT with burden resistor and by employing a formula $P=I^2*R$ (burden resistor).Power factor is measured by using a relation All these quantities are measured in microcontroller Armega32L and programming is done in C language.

$$\text{Power factor (pf)} = \frac{\text{KW (Active Power)}}{\text{KVA (Total Power)}}$$

2.2 INTERFACING OF PT2262 WITH MICROCONTROLLER

The Microcontroller ATmega32L is interfaced to the Encoder PT2262 which converts the displayed data into suitable transmitting form and then it is transmitted toward the receiver nibble by nibble through radio frequency of range 300-315MHz.

2.3 INTERFACING OF PT2272 WITH MICROCONTROLLER

The Microcontroller ATmega8L is interfaced to the decoder PT2272 which converts the received data into suitable form and then it is referred toward the MAX232.

Microcontroller ATmega8L is used to connect the receiver module and decoder with the Hyper Terminal to display the received data on Computer screen.

3 WORKING

All Fig (2) represents the complete circuit diagram of proto type hardware and representing the whole procedure of getting the displayed data from microcontroller through Port C, first four pins (as at one time one nibble is being transmitted). Microcontroller is interfaced through these four pins with Encoder PT2262 through its four pins. While doing interfacing optcouplers are employed to separate the circuits which are operating on 5V and 12V. After this PT2262 convert the code and values present at address A0 ~ A5 and A6/D5 ~ A11/D0 into a special waveform and give it to Dout when output (TE) Transmission Enable is put to zero (Low state) For example, where the transmission data in 4 data type ,has address of 8 bit then the transmission format given in fig. 06.

The transmission being made by above mentioned waveform fed to RF modulator. The RF demodulator rephrases the received potential waveforms and decode via decoder. PT2272 decodes the waveform data and Fitch it to DIN pin. The codes of the decoded data contain the address, data and synchronized bits are shown in fig 07.

PT2272 ensures the valid transmission code, either it is permitted for transmission codes. For valid transmission following points to be suited

1. Complete code word
2. Ensure that address bit and address pins must synchronized.

After two consecutive valid transmission, PT2272 (1) drives the data pins according to the data bits received, and (2) raises VT to high voltage (high state)

The Transmitting media is Radio Frequency (RF) and some important features are

1. Frequency: 315 MHz,
2. Modulation: ASKA

Amplitude shift keying (ASK) is a form of modulation that represents the digital data as a variation in the amplitude of a carrier wave. The amplitude of an analog carrier signal varies in accordance with the bit stream. In modulated signal, logic 0 is represented by the absence of a carrier, thus giving OFF/ON keying operation and hence the name given [13]

3. Receiver Data, Output: High - 1/2 V_{cc}, Low - 0.7v,
4. Transmitter Input Voltage: 3-12V (high voltage = more transmitting, power),
5. Receiver input Voltage: 5V,
6. Have range up to 500 feet

The decoder is interfaced with another Microcontroller ATmega8L, this Microcontroller is used to connect the receiver module and decoder PT2272 with the Hyper Terminal and display the received data on Computer. IC MAX232 is used for Serial Communication with the computer through DB9.In this way the whole data from the consumer end is transmitted to the destiny and display on computer, saving valuable time, man power, and keeping the process corruption free.

4 ANALYSIS

For the purpose of analysis we have connected a load almost equivalent to a room load for 24 hours and values of different parameters obtained as tabulated in table.1 up to five readings are taken in an hour from both, transmitter and receiver. Average of all the values is calculated. These values along with the respective time are written in the tables. By

using the telemetric data as given in the table.1 we draw a plot between different values with the help of MATLAB. The curve shows the variation of the load throughout the day. The points where the magnitude of the Active power is zero indicates the absence of electricity (i.e. Load Shedding). It also gives the indication of peak load hours and the maximum load in 24 hours. The consistency of load during midnight and early morning gives the indication of the high and constant power factor during these hours and its value is mostly graeater than 0.9 but, it decreases and show variations during hours of peak demand as voltage depressed.In this way one can learn the behavior of the system when connected to measure the load of a room. In the same manner one can use this system at different places like for distribution network, institution or a specified region. This will have advantages like improved accuracy, expanded set of features, saving of precious time, money and lessening of bribery. But one has to make some modification to use it for a large system because our scheme has some limitations due to components of small power ratings. We will do it for a large area when components of high power ratings are reachable. However it is more suitable to build with digital signal processing (DSP) chips for a quick response of change in load. While at service provider end a data base management system for manipulating the data received from the telemetric system will be quite helpful for load management and load forecasting.

5 APPLICATIONS

This arrangement can be used for different purposes and few of them require some enhancements. The most basic application of this project is online monitoring of electricity data. It can be employed at different locations in a plant for continuous monitoring the working and production rate of machines and checking the fluid levels in storage tanks. The same technology can be used in gas and water meters for online monitoring of gas and water flow rate.

6 TABLES AND FIGURES

6.1 TABLES

Table 1. Telemetric Data obtained for 24 hours of load equivalent t to room load

Sr. No	Voltage (V)	Currunt (A)	Apparent Power (VA)	Active Power (W)	Power Factor (pf)	Time (PST)
1	229	0.14	512	450	0.88	20:00-21:00
2	233	0.19	306	468	0.87	21:00-22:00
3	243	0.4	95	86	0.9	22:00-23:00
4	242	0.48	116	111	0.92	23:00-00:00
5	244	0.39	95	89	0.94	00:00-01:00
6	246	0.19	46	44	0.95	01:00-02:00
7	244	0.24	58	53	0.92	02:00-03:00
8	247	0.28	73	65	0.91	03:00-04:00
9	240	0.46	111	99	0.89	04:00-05:00
10	0	0	0	0	0	05:00-06:00
11	239	0.45	107	98	0.91	06:00-07:00
12	237	0.34	80	70	0.88	07:00-08:00
13	236	0.33	77	69	0.88	08:00-09:00
14	235	0.55	131	111	0.85	09:00-10:00
15	237	0.53	136	109	0.86	10:00-11:00
16	237	0.68	161	137	0.85	11:00-12:00
17	238	0.7	166	139	0.84	12:00-13:00
18	0	0	0	0	0	13:00-14:00
19	238	0.78	162	137	0.84	14:00-15:00
20	238	0.75	178	15	0.86	15:00-16:00
21	238	0.8	190	162	0.85	16:00-17:00
22	235	0.72	438	365	0.83	17:00-18:00
23	231	0.8	512	436	0.85	18:00-19:00
24	0	0	0	0	0	19:00-20:00

6.2 FIGURES

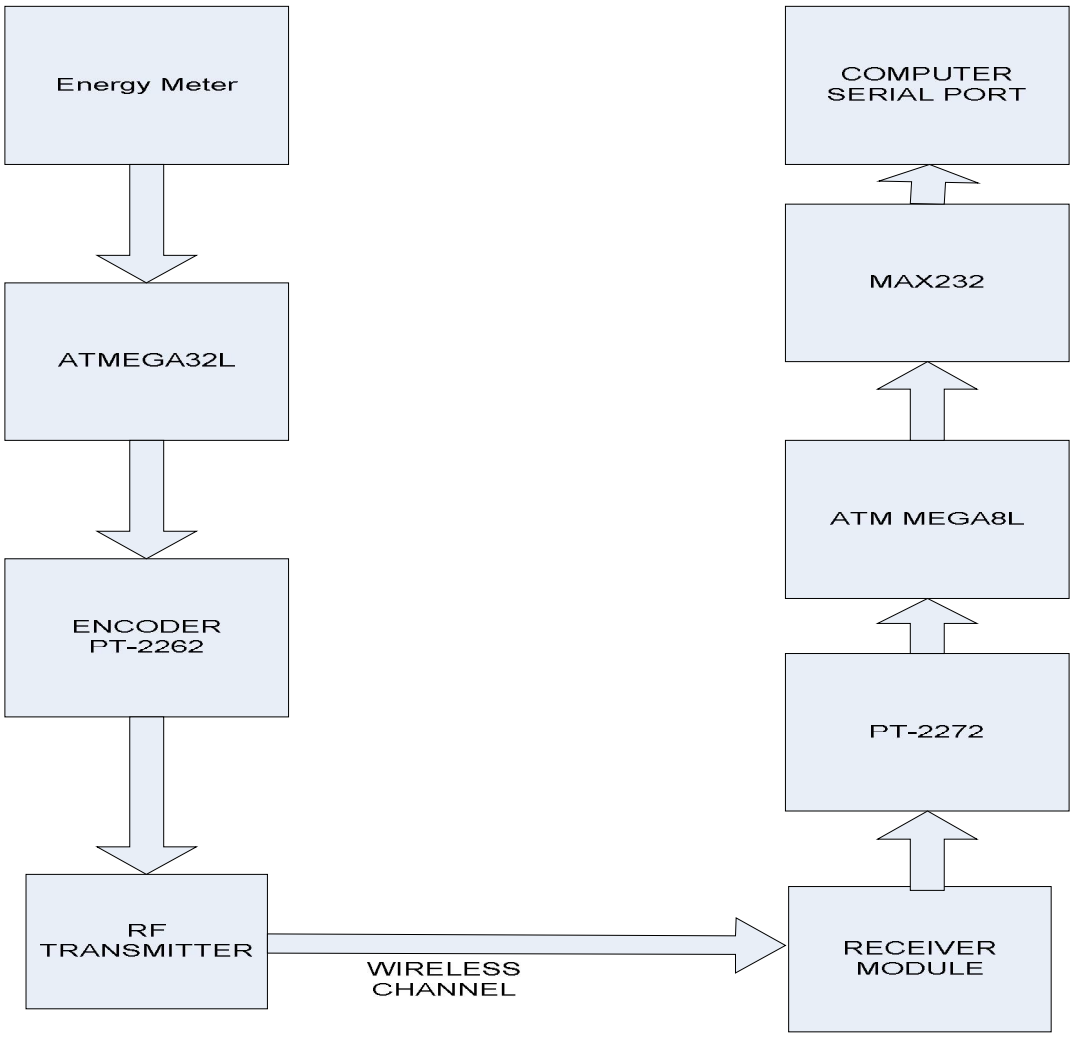

Fig.1 Block Diagram of Experimental Work

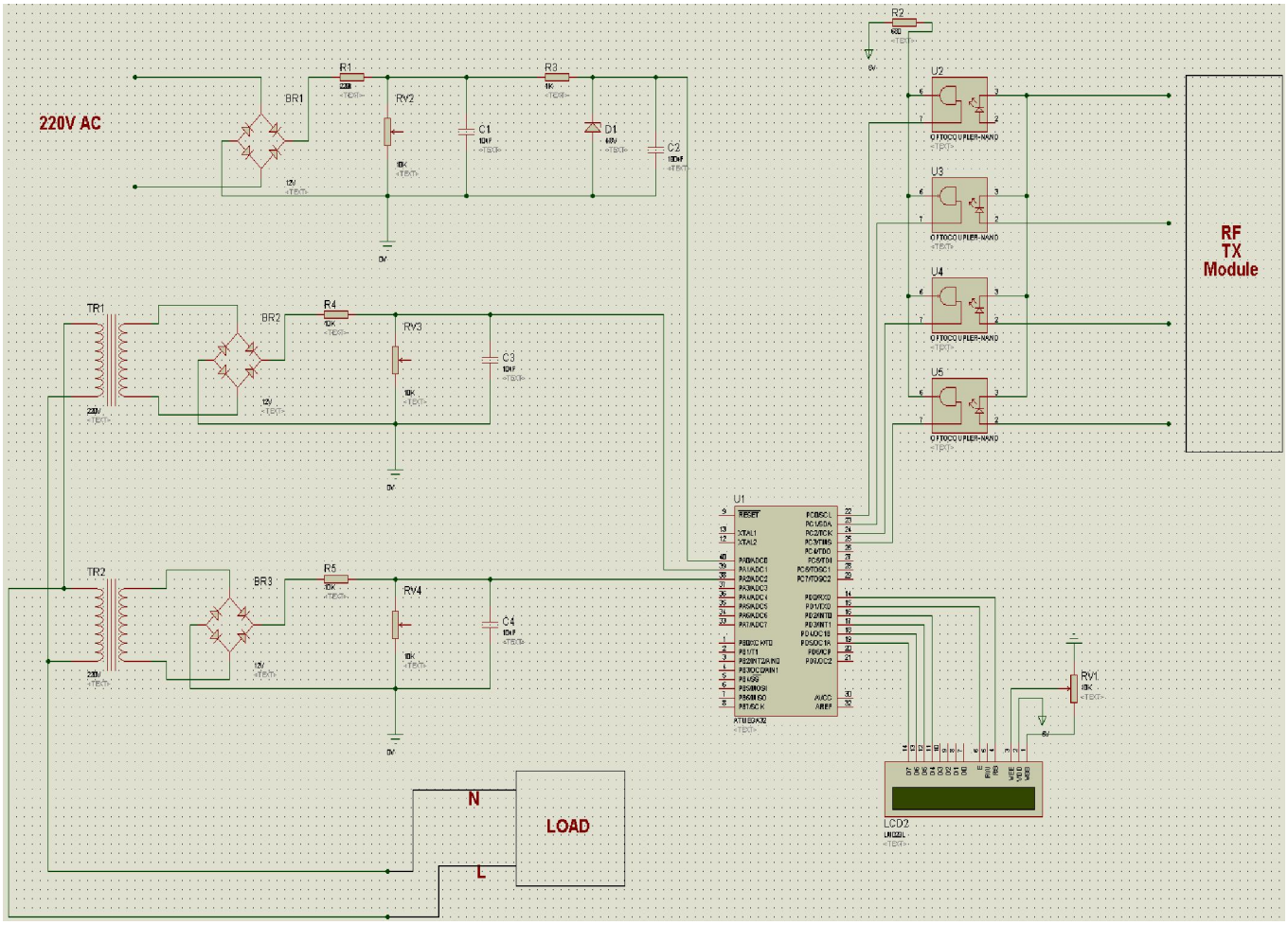

Fig.2: Circuit diagram of an Experimental Work of Energy Meter and Transmitter side

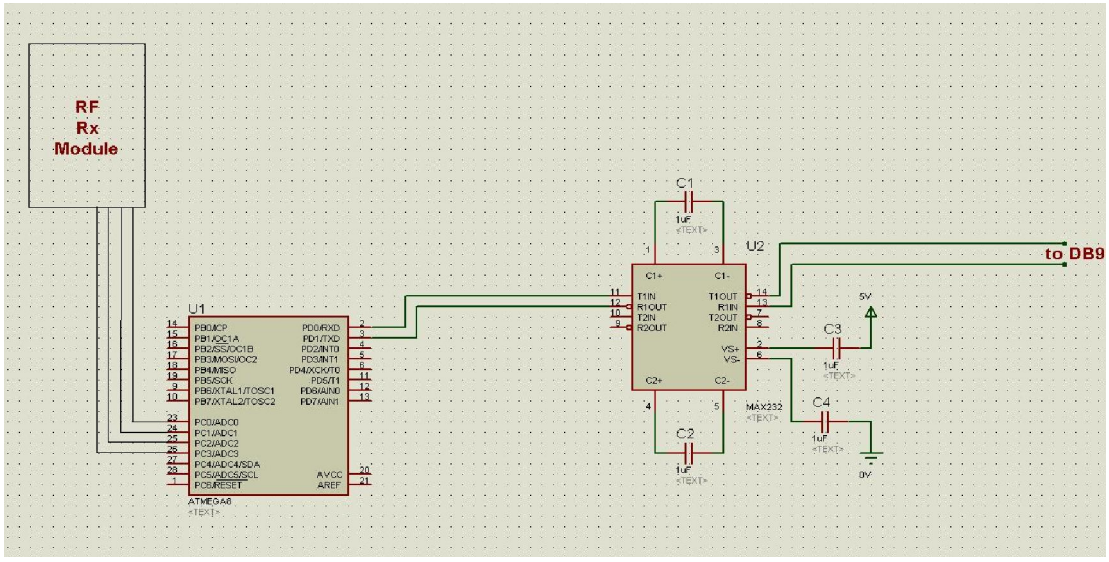

Fig.3: Circuit diagram of an Experimental Work of Receiver side

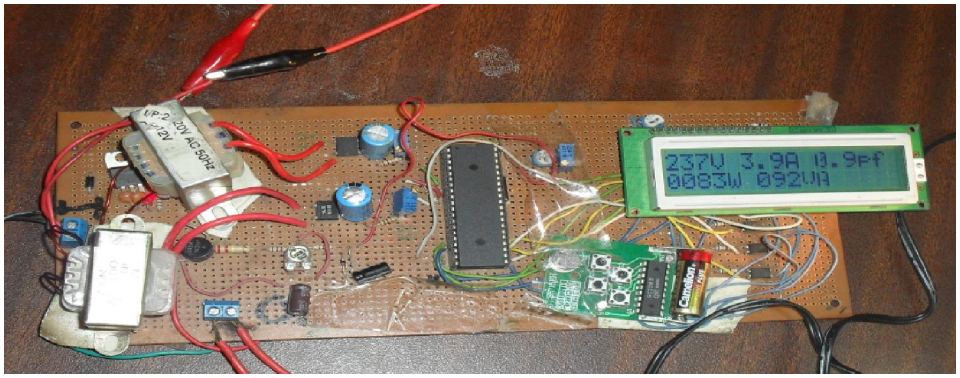

Fig.4: Energy Meter and Transmitter

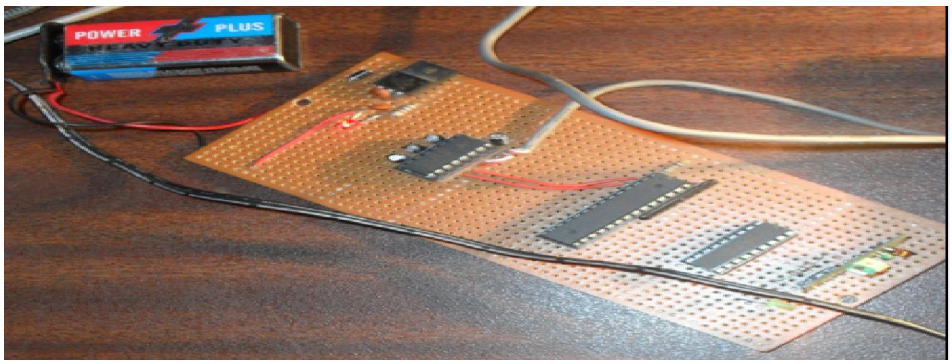

Fig.5: Receiver connected to through serial port to computer

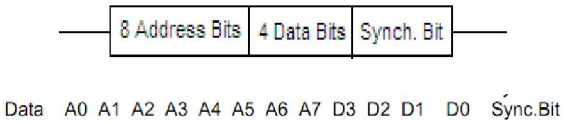

Fig.6: Transmitting Format [10, 11]

PT2272:

A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	SYNC

Fig.7: Code Word [10, 11]

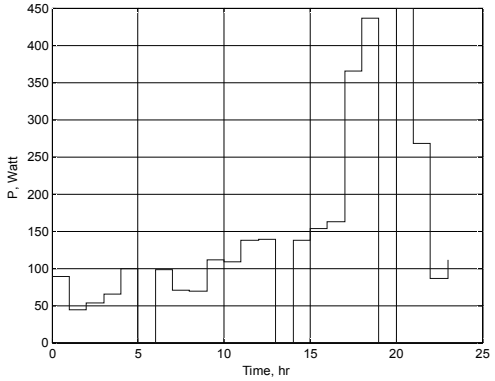

Fig.8: Variation of Load with PST

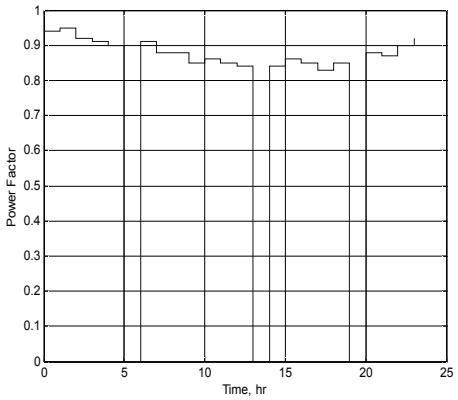

Fig.9: Variation of Power Factor with PST

Fig.10: Applications of online monitoring

7 CONCLUSION

Telemetry is a technology that allows remote measurement and reporting of information. Telemetry concept is an advanced approach for enabling Electric Energy Supplier to perform online monitoring of Electric Energy consumption, error detection, and acquisition of whole data at the electric utility grid. Thus there is no need of line man for attaining the reading from energy meter. In addition of it from analysis of telemetric data one can guess about load management, installment of capacitor bank at particular place and also can study the enhancement of existed power system. The major purpose for telemetric studies on this power system is to find dynamic performance which has great impact in the design and operation of the system. Usually it is owned by a Distribution Company like GEPCO.

REFERENCES

[1] Das, V.V, "Wireless Communication System for Energy Meter Reading," International Conference on Advances in Recent Technologies in Communication and Computing, Oct. 2009, pp:896-898, Kottayam Kerala.

[2] Bharath, P. Ananth, N. Vijetha, S. Prakash, K.V.J., "Wireless automated digital energy meter", IEEE International Conference on Sustainable Energy Technologies, Nov. 2008, pp:564-567,Singapore.

[3] Chih-Hung Wu; Shun-Chien Chang; Yu-Wei Huang, "Design of a wireless ARM-based automatic meter reading and control system", IEEE Power Engineering Society General Meeting, June 2004, Vol. 1, pp:957-962.

[4] De, S. Anand, R. Naveen, A. Moinuddin, S, "e-metering solution for checking energy thefts and streamlining revenue collection in India", Transmission and Distribution Conference and Exposition IEEE, Sep. 2003, Vol. 2, pp:654-658.

[5] Tom Tamarkin, "Electric kilowatt hour meter RF implant module used for walk by, drive by and Pole top collection AMR", 13th annual national meter reader's conference,1992, Atlanta Goergia,

[6] Koay, B.S. Cheah, S.S. Sng, Y.H. Chong, P.H.J. Shum, P. Tong, Y.C. and Wang, "Design and implementation of Bluetooth energy meter", International Conference on Communications and Signal Processing, Dec. 2003,vol. 3,pp:1474-1477

[7] Liting Cao, Jingwen Tian, Dahang Zhang," Networked Remote Meter-Reading System Based on Wireless Communication Technology", IEEE International Conference on Digital Object Identifier, 2006, pp:172-176.

[8] Bai yang, "the windows serial port programming hand book", CRC press company Landon, 2004, ISBN:0-8493-2213-8.

[9] Mazidi,Muhammad Ali, Mazidi Janice Gillimsie,Mckinlay Rolin D,"The 8051 microcontroller and embedded systems", 2nd ed, pearson prentice hall, india, ISBAN:978-81-317-1026-5.

[10] E.P. Yellow, "Mon crystal chip microcomputer Special manufacture precious", ISBN: 957-11-4471-1, pp:293-294.

[11] PT2262, Princten Technology Corp.

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Influence of the dynamics of *Albizia adianthifolia* and *Albizia zygia* on the dynamics of other woody forest

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ABSTRACT: The present survey aims at establishing the influence of the dynamic of two arborescent Legumes trees of the Mimosaceae family (*Albizia adiathifolia* and *Albizia zygia*) on the woody forest, their evolution during the reconstitution of post-cultural flora. It was conducted at Oumé (West-Center of Côte d'Ivoire) in semi deciduous forest zone. The main objective is to highlight the influence of *Albizia adianthifolia* and *Albizia zygia* two legumes tree, on the other woody forest species on the basis of the correlations between biological parameters (growth in height, growth in thickness) resulting of interspecific competition (Albizia-other woody forest species) in order to put it to use in the programs of forest regeneration. Flora inventories and measurements done in 45 gradual age plots (5 to 53 years) showed that at the youthful stadium (0 to 10 years), the growth in thickness of the woody forest is influenced by the one of the two arborescent Leguminous trees (*Albizia adianthifolia* and *Albizia zygia*). On the other hand, the influence of the height growth of the arborescent leguminous trees on the one of the woody forest is discernible between 0 and 25 years. Beyond of 25 years the woody forests are progressively higher than the Albizias and finish by imposing themselves after 65 years.

KEYWORDS: Albizia, Côte d'Ivoire, semi-deciduous forest, influence, woody forests.

1 INTRODUCTION

Among the major developments of the post-cultural vegetation there is a gradual variation of the diversity and richness of flora. These changes are observable through changes recorded in the physiognomy of the vegetation during the flora reconstitution in the forest zone of Côte d'Ivoire. The study of the dynamics of woody plants (growth, structure) requires a longer period of observation. Indeed, unlike the herbaceous layer characterized by numerous variations on the short or medium term, the changes occurring in the woody stratum are generally slow. This layer is mainly composed of species of the group "K" tardy in evolution and long life (CLAUDE *et al*., 1998 [1]). In addition, the overall analysis of the post-harvest reconstitution does not always gives a good understanding of the changes that are taking place within the community of woody arborescent. Also, the study of the process of recovery of arborescent woody vegetation is very important if we consider that, it is about an economic resource, multi-purpose utility and less available. In addition, this forest resource induces many changes in the vegetation, especially in the structure and appearance of it. AUBREVILLE (1947 [2]) and SCHNELL (1976 [3]) in their descriptions of the post-harvest flora have listed species of type Musanga, Trema, Terminalia etc. Moreover, KOUASSI *et al*. (2008 [4]) showed that the growth of *Albizia adianthifolia* and *Albizia zygia* in flora, inhibit shaded stage that of *Chromolaena odorata*. Thus, the decline in the adventice promotes the emergence of many sun-loving species including many woody forests. However, if these leguminous promote the emergence of these species, the nature of interactions between leguminous tree and woody forest remain unknown.

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The present study aims to highlight the influence of the dynamics of *Albizia adianthifolia* and *Albizia zygia* in the evolution of other woody arborescent during the post-harvest reconstitution in semi-deciduous forest of Côte d'Ivoire; this in order to better understand the new models of reconstruction and new adaptations of plants in relation to climatic variations. This influence was evaluated at two levels. These are: annual average increases relations of Albizia and those of other woody forest, average height of Albizia and that of those woody species.

2 MATERIALS AND METHODS

2.1 STUDY ENVIRONMENT

The study was conducted at Oumé (Central West), in semi-deciduous forest of Côte d'Ivoire (Fig 1). The Department of Oumé covers about 2400 km ². It is located at 260 km north-west of Abidjan, with geographical co-ordinates: 6 ° and 7 ° N and 5 ° and 6 ° west longitude. The cultivation plots and fallow land studied are located around and within two classified forests (Tene, Sangoué) and on the setting of Côte d'Ivoire cultures Company (CCIC), a company of agriculture exploitation. Classified forests Téné and Sangoué respectively covers 29,700 ha and 36,200 ha (SODEFOR, 2012 [5]). As for the farm of the CCIC, it extends over 2000 ha. All sites are under the influence of a sub-equatorial climate bimodal with 4 seasons: two rainy seasons a large one (March to June) and a little one (September to October) and two dry seasons, the longest from November to February and the shorter July to August (SODEFOR, 2012). The annual rainfall average in the region is about 1215 mm. The rainfall has considerable variability. The vegetation of both classified forests bases on slightly lateritic soils medium destructed (MONNIER, 1983[6]). In plots (45) divided into parcels unit 50 m X 50 m (2500 m²) and sub plots (Fig. 2) 20 m X 20 m (400 m²), floristic inventories and measurements were carried out stems of *Albizia adianthifolia* and *Albizia zygia* trees and other woody arborescent. Life parameters (height, diameter at breast height) were measured on all tree species of the said plots. In the measurement of the height of the trees, only individuals over 2 m were taken into account. The estimate circumferences focused exclusively on the stems more than 20 cm in circumference. Tree vegetation over 70 years with the final stages of reconstitution (climax), were selected as control plots. The plots were all located on sandy clay soils.

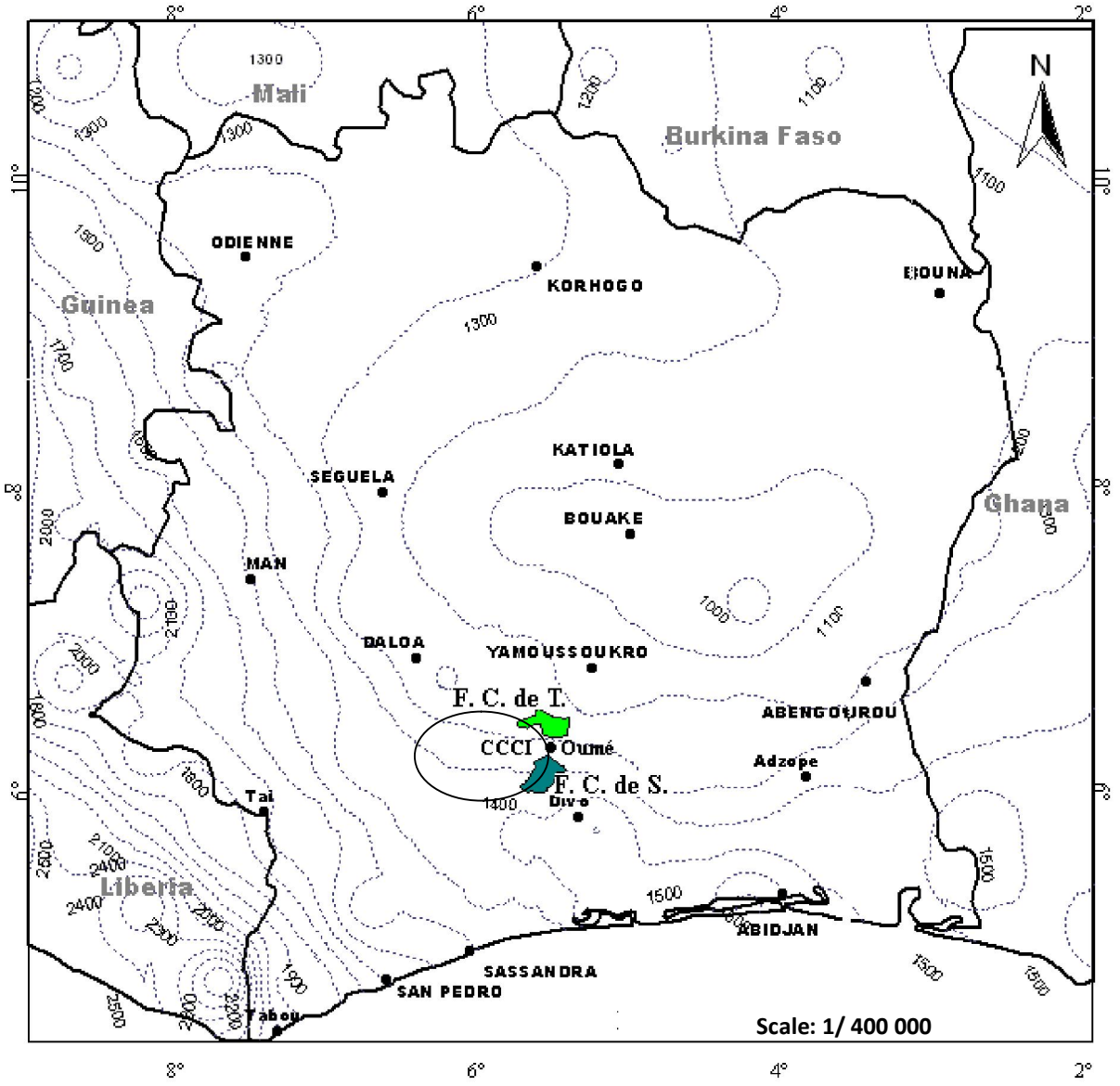

Fig. 1. Location of the study zone (MONNIER, 1983)

Zone of study

F. C. T. = classified forest of Téné

F. C. S. = classified forest of Sangoué

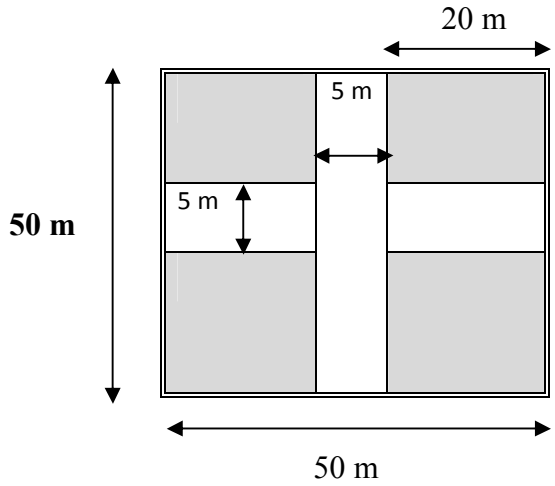

Fig. 2. Lie for the study plots

3 RESULTS

3.1 INTERACTION BETWEEN GROWTH IN THICKNESS OF *ALBIZIA ADIANTHIFOLIA*, *ALBIZIA ZYGIA* AND THAT OF THOSE WOODY FORESTS OVER TIME

The bilateral correlation realized between the evolutionary parameters (evolution of densities of Albizia adianthifolia, Albizia zygia and others arborescent woody forests) is significant at threshold 0.001 (table 1). And it shows an interrelation between those woody forests and Albizia during the thickness growth. Also a polynomial adjustment (Fig. 3) allows catching sight on this correlation nature. In fact, the obtained trend curves show an annual average growth of Albizia more accelerated at juvenile stage (0-10 years). After 10 years the increase in thickness of the other woody forests accelerate more, which is not the case with Albizia. This increase in thickness growth begins to slow for all species of trees after 30 years and eventually fade after 65 years for Albizia.

3.2 INTERACTION BETWEEN THE AVERAGE HEIGHTS OF ALBIZIA ADIANTHIFOLIA AND ALBIZIA ZYGIA AND OTHER WOODY FORESTS

The bilateral correlation (table 2) achieved between average heights of Albizia and others woody forests over time is significant at 0, 01 thresholds (table 2). Moreover, the polynomial curves adjustment (Fig. 4) achieved show that the average heights of Albizia exceed those woody forests up to 20 years. This adjustment shows height growth of Albizia more accelerated from 0 to 20 years. But beyond the age of 25 other woody forests take over up to the period of Albizia physiological decline (about 65 years).

Table 1. Correlation: Albizia annual average increases and other woody forests

		Annual growth average of Albizia	Annual growth average of others
Annual growth average of Albizia	Pearson Correlation	1,000	0,680
	Sig. (2-tailed)	0,000	0,000
	N	54	54
Annual growth average of others	Pearson Correlation	0,680	1,000
	Sig. (2-tailed)	0,000	0,000
	N	54	54

***** Correlation is significant at the 0, 01 level (2-tailed)***

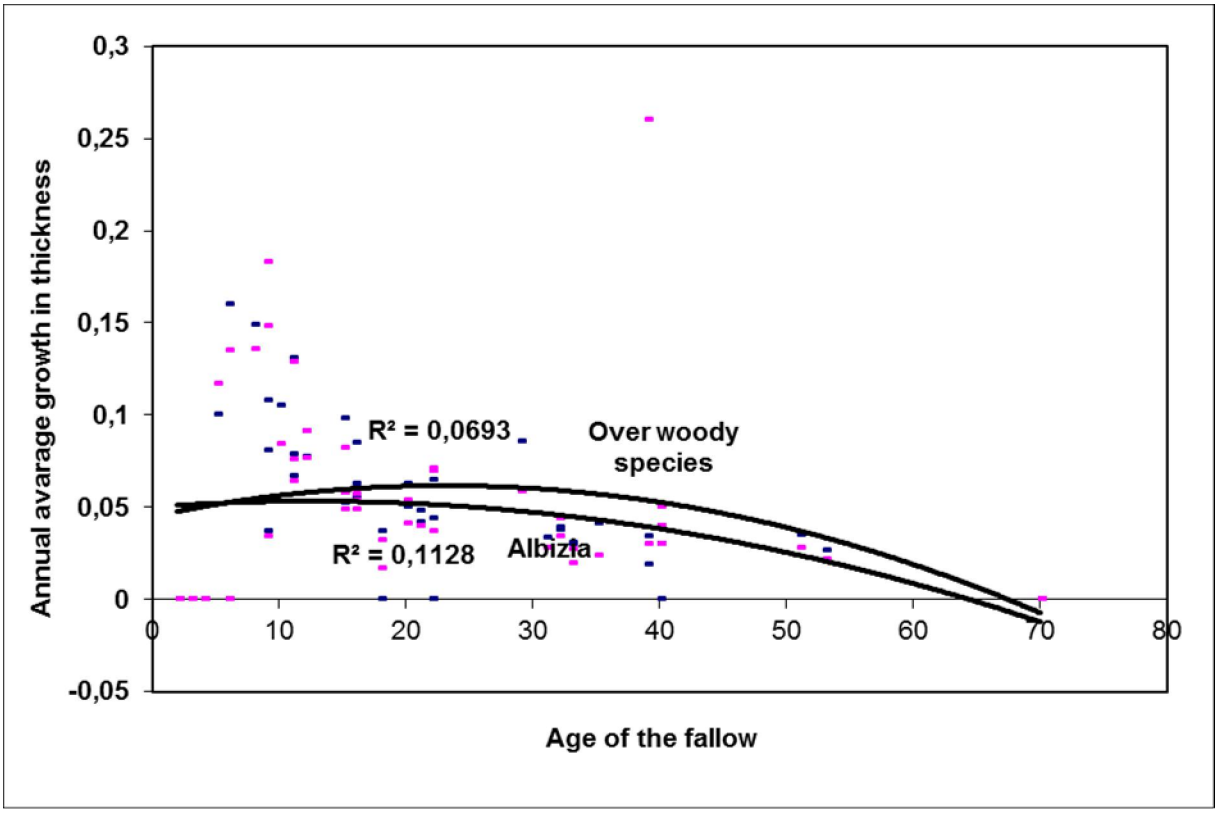

Fig. 3. Trend curves showing the evolution of the annual average increases in thickness of Albizia and over woody species over time

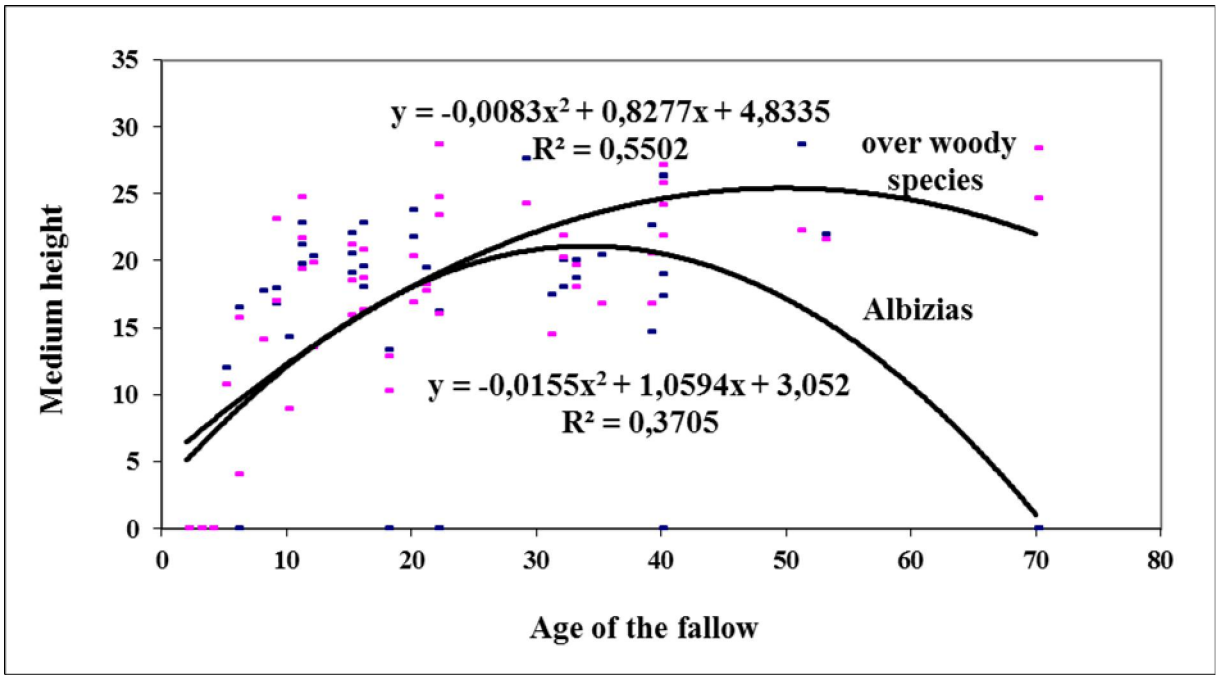

Fig. 4. Trend curves showing the evolution of the heights average evolution of Albizia and over woody species

Table 2. Correlation: average heights of Albizia and average heights of other woody forests over time

		Albizia	Average height of others woody forests
Average height of Albizia	Pearson Correlation	1,000	0,605
	Sig. (2-tailed)	0,000	0,000
	N	54	54
Average height of others	Pearson Correlation	0,605	1,000
	Sig. (2-tailed)	0,000	0,000
	N	54	54

*** Correlation is significant at the 0.01 level (2-tailed)*

4 DISCUSSION

4.1 INFLUENCE OF ALBIZIA DYNAMICS ON THE DYNAMICS OF OTHER WOODY FORESTS

The interpretation of mixed planting of multi-stratified structures in terms of competition or interaction is very complex as pointed out ROLLET (1970 [7]). That is why we have underlined the influence of the dynamics of Albizia on the other wood forests, basing the analysis on the sturdiness parameters such as thickness growth (annual averageincrease) and height growth (average heights). However, this simplification of analysis allows underlining the interactions (inter-specific competition, synergy, symbiosis ...), between individuals.

4.2 ANNUAL AVERAGE INCREASE

Albizia adianthifolia and *Albizia zygia* are more competitors and more qualified to develop early in fallow than other woody forests. This performance is between 0 and 10 years for the growth in thickness and is related to certain properties of Albizia such as, their rapid growth, fixation of atmospheric nitrogen and their ability to grow with little light in youthful stage. These skills were noted by ALEXANDRE (1989 [8]) and GNAHOUA (1997 [9]).

These skills make these arborescent leguminous species more competitors in youthful stage. This ability to influence others ligneous in juvenile stage of the thickness growth is illustrated by the trends with polynomial regression curves (Fig. 2). Indeed, the polynomial regression curve trend of Albizia is above that of other ligneous in the early fallow (0-10 years) period from which trend began to reverse. Moreover, the gradual decrease of annual average increase over the years is the proof that; the arborescent species do not grow indefinitely. However, the cohabitation Albizia and other woody forests lied in the fact that without inhibitor, the rapid development of Albizia in early fallows stills an indirect positive influence on the other woody forests slow growth. Albizia inhibits the development of one of *Chromolaena odorata* as is shown KOUASSI *et al*. (2008). This regression allows other woody forests to begin their development more easily.

4.3 AVERAGE HEIGHTS

The polynomial regression trend of height growth of Albizia adianthifolia, Albizia zygia and other woody forests highlight inter-specific interactions during development. Indeed, up to 25 years of fallow, Albizia grow more accelerated than other woody forests. This behavior is related to the reasons mentioned above. Moreover, BARIMA (2004 [10]) showed that under favorable conditions, the two arborescent leguminous can reach a height growth of more than 3 m / year. Abilities outlined above must be added the rapid seed germination which occurs between 3 and 6 days (TAYLOR, 1962 [11]), in contrast, the germination of other woody forests that sometimes occurs very slowly. The trend curves show the limits of the influence of Albizia up to 25 years of fallow period from which the trend reverses. Seen from this way, we could speak of mutual influences. Because, during competitions, intra-and inter-specific, each group of plant has its influence phase corresponding to a specific period.

The influence of Albizia is between 0 and 25 years. This period corresponds to the growth and development of Albizia. The longest influence phase of woody forests starts after 25 years, in the plant formations where often older stands of Albizia are undergoing regression phase and physiological decline. In addition, the influence of Albizia may be qualified as positive because it does not prevent the installation of ligneous rather promotes it. However, later, the action of other woody forests can be seen as a negative influence, because harmful to the development of Albizia. Indeed, although other woody forest with slow growth in early reconstitution, reaches after long years, considerable heights and form the forest canopy. Canopy formed thereafter becomes unfavorable to the development of Albizia, which explains their decline.

In this case, the assumption of the limited life of Albizia is not sufficient to explain this decline, because according to SCHNELL (1950 [12]) both species appear to be the remnants of semi humid dense forests. Albizia therefore, play the role of facilitating the installation of other woody forests in the post-harvest reconstitution. But it seems that this role is more noticeable in phases that characterize the transition from training under shrubs pioneer stages (stage to *Chromolaena odorata*) to the forested stages (stage woody pioneers).

5 CONCLUSION

The development of more woody forests is influenced by the dynamics of arborescent leguminous (*Albizia adianthifolia* and *Albizia zygia*). This influence is evident in the juvenile stage of growth in thickness and height. However, beyond 10 years, the density of other arborescent species negatively affects the growth in thickness of Albizia. This influence is seen over 25 years with regard to height growth. At these stages (beyond 10 for the growth in thickness and 25 years for height growth), it is rather woody forests which become more competitive. Actions performed by each group of plants appear as forms of mutual influences with Albizia at the juvenile stage and old stage for woody forests. Albizia play the role of forest pioneers and promote the installation of other woody forests. The influence phase of the two arborescent leguminous is not harmful to the development of other woody forests.

REFERENCES

[1] F. CLAUDE, Ch. FLORET, M. PAUL et D. JEAN, *Ecologie* : Approche scientifique et pratique. ed : Lavoisier Tec., 4è éd., 102 p., 1998.

[2] AUBREVILLE A., Les brousses secondaires en Afrique équatoriale (Côte d'Ivoire, Cameroun, A.E.F). *Bois et Forêts des Tropiques*, 2 : 24-49, 1947.

[3] R. SCHNELL, Introduction à la phytogéographie des pays tropicaux. La flore et la végétation de l'Afrique tropicale, Vol. 3, 1e partie, Gautiers-Villars, Paris, 1976.

[4] K.H. KOUASSI, G M. GNAHOUA et K.E. KOUASSI, Influence of the dynamic of *Albizia* : *Albizia adianthifolia* and *Albizia zygia* (Mimosaceae) on the covering off *Chromolaena odorata* (L.) R.M. King & H. Rob. (Asteraceae) in the post-farming Vegetations of Oumé in Semi-deciduous forest zone of Côte d'Ivoire. *European Journal of Scientific Research*, (20): 3, pp 677-687, 2008.

[5] SODEFOR, Plan d'aménagement de la forêt classée de Sangoué 2001-2010, *Société de Développement des forêts* (SODEFOR), Abidjan. 59 p., 2012.

[6] Y. MONNIER, Hydrologie végétation, les sols. In, *Jeune Afrique, Atlas de la Côte d'Ivoire*., 2e édition, pp 10-21, 1983.

[7] B. ROLLET, L'architecture des forêts denses humides sempervirentes de plaine *C.T.F.T.* Nogent sur Marne, 295 p., 1970.

[8] [8] ALEXANDRE D. Y., Dynamique de la régénération naturelle en forêt dense de Côte d'Ivoire, *Etudes et Thèses, Ostorm Paris*, 102 p., 1989.

[9] G.M. GNAHOUA, Analyse phytoécologique de la flore adventice des cultures post-jachères améliorées en zone de forêt semi-décidue de Côte d'Ivoire, D.E.A. *Ecologie Méditerranéenne*, Université Aix- Marseille III 34 p., 1997.

[10] Y.S. S., BARIMA., Dynamique de croissance et production de biomasse aérienne des légumineuses arborées en zone forestière d'Oumé. Mémoire de DEA de Botanique, option : Ecologie végétale, Côte d'Ivoire, *Université de Cocody*, Laboratoire de Botanique, 49 p., 2004.

[11] C. TAYLOR, Tropical forestry with particular reference to West Africa. *Oxford University* Press, U.K, 82 p., 1962.

[12] R. SCHNELL, La forêt dense. Introduction à l'étude Botanique de la région forestière d'Afrique occidentale. Ed, *Paul Lechevallier*, 339 p., 1950.

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Game theoretical approach of user behavior based on personal opinion in Online Video Social Networks

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ABSTRACT: In the last decade, the web has known a major evolution with the appearance of web 2.0 and its applications. One of those popular tools is the Online Video Social Networks (OVSN). Video content is becoming a predominant part of the daily life of users on the Web. Henceforth the study and modeling this kind of platforms, emerge as necessity.
In this paper, we study the interaction of user community with videos shared and viewed in online video social networks. The concept of freedom giving to users in these platforms allows them to express their opinion toward those videos. Based on the analysis of the mechanisms of interaction in OVSN, we developed a personal opinion model for online users in this case. To deal with this problem we constructed a Petri Net model and we use it to derive a payoff function, these bring us to the Game theory field.
Although our model is inspired from earlier studies, at the heart of our whole approach is abstracting the complex mechanism of interactions by the solution concept of Nash equilibrium, which allowed us to deal with richer problem instances. We conclude this paper by outlining several interesting lines of future work.

KEYWORDS: OVSN, Petri Net, Payoff, Nash Equilibrium.

1 INTRODUCTION

Web 2.0 was introduced, as term and concept, in October 2004 by Tim O'Reilly [1]. Since then, web 2.0 (known also as participative and social web) has been considered as the evolution of the web. Its fundamental concept is based on the involvement of users in the process of creating, producing and sharing the content. From this perspective rises the primordial role of users in the participative web. Many applications and tools constitute the core of this web: Blog, Social networks, Wiki, Content syndication and aggregation, video social networks... [2].

Online Video Social Networks (OVSN) nowadays becomes an essential part of users' daily life on the web. These platforms provide to users many features such as creating and sharing their own videos. Furthermore, they can view and share videos of other users. OVSN enhance the interaction between users by allowing them to behave toward these videos by liking, disliking, commenting, sharing or reporting [3], [4], [5].

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The video created or produced by users can be sorted into two forms: homemade content remixes of pre-existing works; and hybrid forms that combine some form of self-produced video with already existing content. Video content may be hosted on a user's personal website or blog, peer-to-peer networks or hosted by OVSN platforms such as *YouTube*, *Google Video*, *Dailymotion*, etc. Increasingly these sites are also enabled for access (upload and download) from mobile phones and devices. To illustrate the popularity of OVSN, we will use Youtube as reference [6] .For example; *Youtube*[1] has over 800 million unique users visit monthly. In term of video viewing, it had over 4 billion hours of watched video each monthly. The amount of video uploaded to Youtube every minute is 72 hours of video. The heterogeneous mixture of cultures in this OVSN can be noticed by analyzing the statistics collected about visitors: 70% of YouTube traffic comes from outside the US, whereas *YouTube* servers are localized in 53 countries and across 61 languages.

In this paper, we study the interaction of user community with videos shared and viewed in online video social networks. Many previous works tried to deal with similar problem in different situations and form different angles [6]-[7].

In the first section, we will introduce our vision to this problem as the Petri Net model which allowed us to clearly understand the relationship between the various components involved in the process and its mechanisms. In the next section we will use this Petri Net model to construct the payoff function for each user, thus the game theory framework. Finally we will terminate our paper by given a conclusion that summaries the work.

Throughout this paper we suppose that opinion expressed by users in the OVSN is a complex process where multiple contrasting influences are engaged in the action.

2 PETRI NET MODEL FOR ONLINE INTERACTION MECHANISMS IN OVSN

In many social networks research areas, the actions of users dependent on each other due to the interactions among users directly and indirectly.

In order to model a system interaction problem, scientists use "Petri Net" to illustrate the process of constructing a formal model from informal description [8]-[9]. Due to the complexity of the present problem we have been also obligated to use a Petri Net that satisfies the requirement of our case.

Let $G=(V,E)$ be a user graph for social network and suppose we have several classes of information $I=\{1,\cdots m\}$.

Let $x_i^{(j)} \in [0,1]$ be the probability that videos i to be liked by user j, let $y_i^{(j)} \in [0,1]$ be the probability that video i to be withheld by user j. And $z_i^{(j)} \in [0,1]$ is the probability that video i to be liked by user j. Then we have:

$$x^{(j)} + y^{(j)} + z^{(j)} = 1$$

Let:

$$\overline{x}_i^{(j)} = \frac{1}{|N(j)|} \sum_{k \in N(j)} x_i^{(k)}$$

Where $N(j)$ is the neighborhood of user j in G. We make similar definition for $\overline{y}_i^{(j)}$ and $\overline{z}_i^{(j)}$.

The user actions' are organized as following:

- First category action: Like, Withhold and Dislike.
- Second category action: Report, Comment+, Sharing and Comment- .

[1] http://www.youtube.com/yt/press/statistics.html

We assume that four elements constitute each user's objective function:

- Social admission gained by making a second category action.
- Personnel privacy benefit gained from just making a first category action.
- Social reject cost caused by a subjective comment.
- Moral cost caused by subjective comment or report.

Based on the elements cited above, we constructed the following Petri Net:

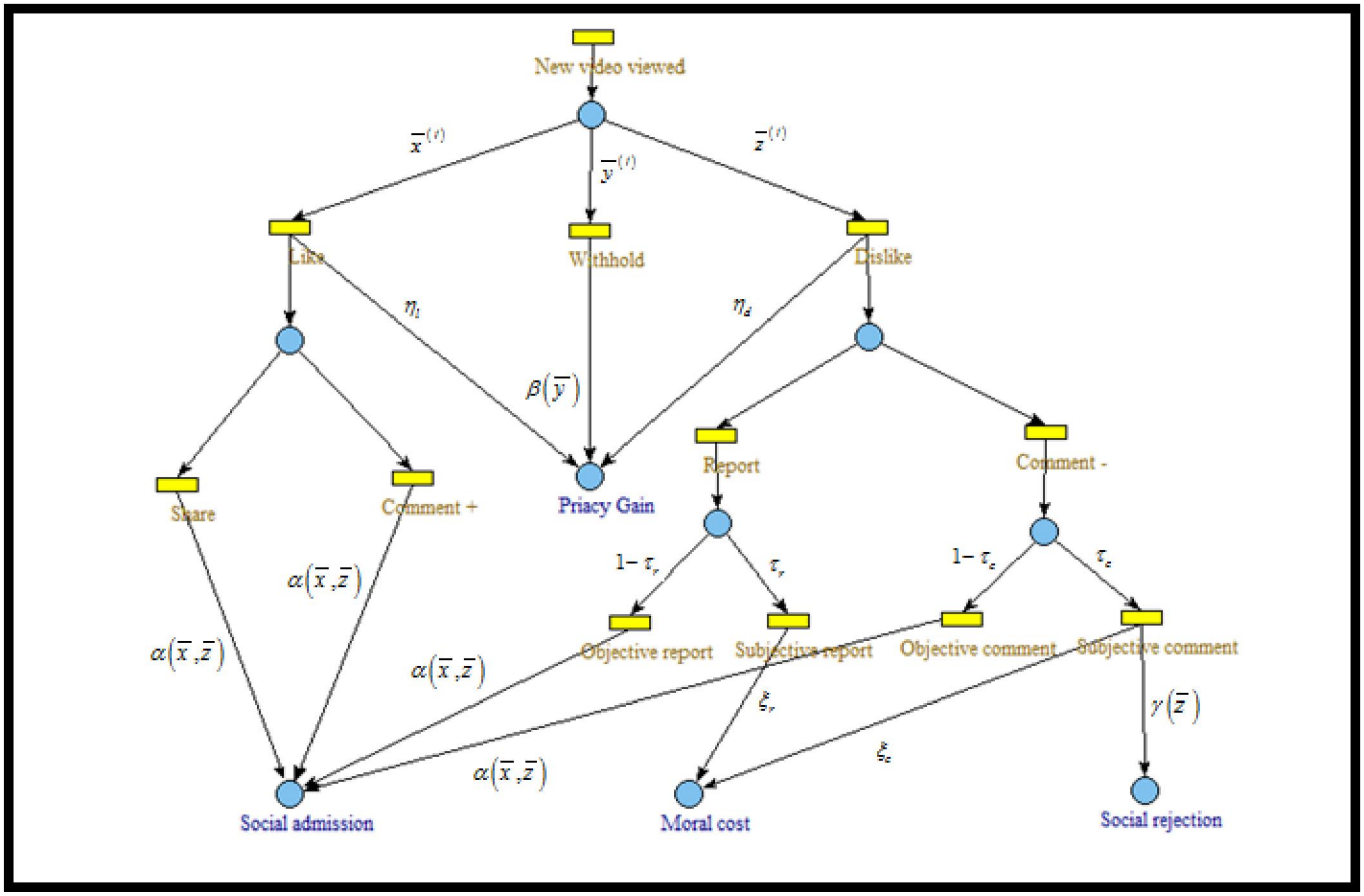

Fig. 1. The Petri Net illustration of the mechanisms generated by viewing a new video.

This model allows us to clearly understand the relationship between the various components involved in the process and its mechanisms. Such illustration will serve us to build a formal model.

3 USERS' PERSONAL OPINION IN OVSN BY GAME THEORETIC MODEL

In order to build our game theoretic model, we will reuse the terminology and the notations used in the Petri Net illustration bellow. The structure of the model is as follows: there is a user j among a set of *N* users where there are *N-1* neighbors in each single video in an OVSN. Each player (user) j makes a choice from a finite set {Like, Withhold, Dislike} .

We let $X^{(j)}$, $Y^{(j)}$ and $Z^{(j)}$ be correlated random variables whose dynamics are chosen by user j .

At time t , user $j's$ stochastic payoff function is:

$$\pi^{(j)}(t) = \omega_1 \alpha\left(X^{(j)}(t), Z^{(j)}(t), \overline{x}^{(j)}(t), \overline{z}^{(j)}(t), t, \tau_c(t), \tau_r(t)\right) + \omega_2\left[\beta\left(Y^{(j)}, \overline{y}^{(j)}, t\right)Y^{(j)}(t) + \eta_d\left(Z^{(j)}(t)\right) + \eta_l\left(X^{(j)}(t)\right)\right] - \omega_3\gamma\left(Z^{(j)}, \overline{z}^{(j)}, t, \tau_c(t)\right) - \omega_4\left[\xi_r\left(Z^{(j)}(t), \tau_r(t)\right) + \xi_c\left(Z^{(j)}(t), \tau_c(t)\right)\right]$$

In this equation:

- $\alpha\left(X^{(j)}(t), Z^{(j)}(t), \overline{x}^{(j)}(t), \overline{z}^{(j)}(t), t\right)$ is a *social admission* that provide reward obtained by reacting with videos in OVSN.
- $\beta\left(Y^{(j)}, \overline{y}^{(j)}, t\right)$ is privacy capital function that provide the reward obtained by not making an action toward a video.
- $\gamma\left(Z^{(j)}, \overline{z}^{(j)}, t\right)$ is cost function represent social rejection resulted from writing a subjective commentary.
- ξ_r and ξ_c are moral cost functions associated respectively to subjective reporting and commenting.
- η_d and η_l are privacy capital functions that provides the reward obtained respectively by just by liking and disliking.
- $\tau_r(t)$ and $\tau_c(t)$ are the probabilities of making respectively subjective reporting and commenting.

The variables $\omega_k \ (k = 1, \cdots, 4)$ are relative weights user j places on each component of his objective function.

Over a period of time, the complete stochastic payoff function for user j is:

$$\Pi^{(j)} = \sum_{t=0}^{T} \pi^{(j)}(t)$$

The solution to the game is then defined by the simultaneous optimization problem:

$$\forall j \begin{cases} \max E\left(\pi^{(j)}\left(x(t), y(t), z(t)\right)\right) \\ \text{s.t} \quad x(t) + y(t) + z(t) = 1 \\ x(t), y(t), z(t) \geq 0 \ \forall \text{t} \end{cases}$$

Where $x(t), y(t), z(t)$ are the vectors of decision variables for the users. Let

$$\Omega = \prod_{j,t}\left\{\left(x^{(j)}(t), y^{(j)}(t), z^{(j)}(t)\right) \in [0,1]^3 : x^{(j)}(t) + y^{(j)}(t) + z^{(j)}(t) = 1, x^{(j)}(t), y^{(j)}(t), z^{(j)}(t) \geq 0\right\}$$

This is the *complete strategy* space for all users over the course of time $t \in [0, T]$. Any Nash equilibrium will be chosen from this strategy space. The theorem 1 of [10] provides the following results:

Lemma: If $E\left(\pi^{(j)}\left(x\left(t\right),y\left(t\right),z\left(t\right)\right)\right)$ is concave for all j , then there is a Nash equilibrium in Ω for this game. Furthermore, the uniqueness of this equilibrium is completely a function of the structure of specific objective functions.

The structure of $E\left(\pi^{(j)}\left(x\left(t\right),y\left(t\right),z\left(t\right)\right)\right)$ is complicated. For simplification, we replace the functions in equation with piecewise constant multipliers. Then we have a specific form of the stochastic payoff function:

$$\begin{aligned}\pi^{(j)}\left(t\right)=\omega_1\alpha\left(x^{(j)}\left(t\right),z^{(j)}\left(t\right),\overline{x}^{(j)}\left(t\right),\overline{z}^{(j)}\left(t\right),t\right)\left(X^{(j)}\left(t\right)+\left(2-\tau_c\left(t\right)-\tau_r\left(t\right)\right)Z^{(j)}\left(t\right)\right)\\+\omega_2\left[\beta\left(y^{(j)},\overline{y}^{(j)},t\right)Y^{(j)}\left(t\right)+\eta_d Z^{(j)}\left(t\right)+\eta_l X^{(j)}\left(t\right)\right]\\-\omega_3\gamma\left(z^{(j)},\overline{z}^{(j)},t\right)\tau_c\left(t\right)Z^{(j)}\left(t\right)-\omega_4\left(\xi_r\tau_r\left(t\right)+\xi_c\tau_c\left(t\right)\right)Z^{(j)}\left(t\right)\end{aligned}$$

Henceforth,

$$\begin{aligned}E\left(\Pi^{(j)}\left(t\right)\right)=\sum_{t=0}^{T}\omega_1\alpha\left(x^{(j)}\left(t\right),z^{(j)}\left(t\right),\overline{x}^{(j)}\left(t\right),\overline{z}^{(j)}\left(t\right),t\right)\left(x^{(j)}\left(t\right)+\left(2-\tau_c\left(t\right)-\tau_r\left(t\right)\right)z^{(j)}\left(t\right)\right)\\+\omega_2\left[\beta\left(y^{(j)},\overline{y}^{(j)},t\right)y^{(j)}\left(t\right)+\eta_d z^{(j)}\left(t\right)+\eta_l x^{(j)}\left(t\right)\right]\\-\omega_3\gamma\left(z^{(j)},\overline{z}^{(j)},t\right)\tau_c\left(t\right)z^{(j)}\left(t\right)-\omega_4\left(\xi_r\tau_r\left(t\right)+\xi_c\tau_c\left(t\right)\right)z^{(j)}\left(t\right)\end{aligned}$$

That is, a user's expected payoff engaging in this game is a function of time duration in which he expressed his opinion toward the video. Since we assumed that the social gain/cost functions are implicitly controlled by neighbors' strategies, then the user's stochastic payoff function is so.

We have showed that while this game has at least one Nash equilibrium (see the Lemma above), hence we can apply the well known algorithm such as the Eliminating Dominated Strategies.

A possible future development is to study the application of our mathematical framework on different technological fields, That involves the complexity of human interactions with others or artificial intelligence. We hope that some researcher with an expertise in those fields may be interested in extending our findings.

4 CONCLUSION

In this paper, we gave an introductory model on users' opinion expression and their interactions' toward a video in an OVSN platform. The model is inspired from a Petri Net illustration of the mechanisms generated by viewing an OVSN's content. We used this Petri Net to construct objective function for each user in which the stochastic payoff function to a given user depends not only on his actions but also on his neighbors' ones'.

We showed that there is a unique Nash equilibrium for this game; henceforth the ground it has been setup to the classical game theory algorithm's.

This work will open new directions in the field of social networks and its applications. Our future work will be focused in the study of social interactions phenomenon in similar web 2.0 applications.

REFERENCES

[1] T. O'Reilly, "what Is Web 2.0",2005, Available: http://oreilly.com/web2/archive/what-is-web-20.html, accessed 2 March 2010

[2] Shelly, Gary B. and Frydenberg, M, "Web 2.0: Concepts and Applications", Course Technology, 1 edition, March 2010.

[3] Lange, P. G., "Publicly Private and Privately Public: Social Networking on YouTube". Journal of Computer-Mediated Communication, 2007, 13: 361–380.

[4] Burgess, Jean E. & Green, Joshua B. "YouTube: online video and participatory culture", Digital Media & Society. Polity Press, Cambridge, 2009.

[5] Cheng, X., Dale, C., and Liu, J. "Statistics and Social Network of YouTube Videos.", Proceeding of the 16th International Workshop on Quality of Service IWQoS 2008., June 2-4 , pp. 229 – 238

[6] Benevenuto, F., Rodrigues, T., Cha, M. and Almeida, V. "Characterizing user behavior in online social networks", Proceedings of the 9th ACM SIGCOMM conference on Internet measurement conference 2009 (IMC '09). ACM, New York, NY, USA, 49-62.

[7] Benevenuto, F., Rodrigues, T., Almeida, V., Almeida, J., and Ross, K. "Video interactions in online video social networks". *ACM Trans. Multimedia Comput. Commun. Appl.* 5, 4, Article 30, November 2009.

[8] Reisig, W. and Rozenberg, G., "Lectures on Petri Net I: Basic Models", Springer; 1998 edition.

[9] Squicciarini, A. and Griffin, C., "An Informed Model of Personal Information Release in Social Networking Sites", Proceedings of the ASE/IEEE International Conference on Privacy, Security, Risk and Trust – June 2012.

[10] Rosen,J. B.. "Existence and uniqueness of equilibrium points for concave n-person games", Econometrica, 33(3): 520–534, 1963.

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Politiques industrielles dans les pays développés et émergents: cas de la Tunisie

[Industrial policies in developed and emerging countries: the case of Tunisia]

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ABSTRACT: Industrial policy is a microeconomic form of state intervention in industry. It monitors the performance of the secondary sector with stimulating the competitiveness of firms, overcoming market failures and adjusting its structure to economic, organizational and technological changing. Although this state intervention creates much debate, it regains interest in university research, in political discourse and economic practices. In this work, the experiences of France, Japan and the four dragons were analyzed in terms of objectives, instruments and conditions for success. The purpose behind is to learn from their actions and to try to form recommendations for others country. We also presented the state measures implemented in favor of Tunisian industry emphasizing their evolution over time, their effectiveness in achieving the goals and their impact on the evolution of the industry. We have shown that these measures are ineffective since they did not realize most of the time the objectives associated with it such as improving the competitiveness of industrial firms, increase technological content in production cycle and decreasing regional imbalance. We tried so to understand the causes behind the inefficacity of the Tunisian effort for its industry. Finally we conclude that these state efforts cannot build a genuine industrial policy.

KEYWORDS: Industrial policy, R&D, Upgrading program, Fund of promotion and decentralization of industry, Tunisia.

RESUME: La politique industrielle est une forme d'intervention microéconomique de l'Etat dans l'industrie. Elle veille sur la performance de ce secteur en stimulant la compétitivité des firmes industrielles, en palliant les échecs du marché et en réajustant ses structures aux mutations économiques, organisationnelles et technologiques. Bien que cette intervention étatique crée beaucoup de débats, elle regagne l'intérêt dans les travaux de recherches universitaires, dans les discours politiques et dans les pratiques économiques. Dans ce travail, les expériences de la France, du Japon et des quatre dragons ont été analysées en termes d'objectifs, d'instruments et des conditions de réussites. Le but derrière est de tirer des enseignements de leurs démarches et d'essayer de formuler des recommandations pour les autres pays. Nous avons également présenté les mesures étatiques mises en place en faveur de l'industrie tunisienne, en insistant sur leur évolution au fil du temps, leur efficacité dans la réalisation des objectifs et leur impact sur l'évolution de l'industrie. Nous avons pu démontrer que ces mesures sont peu efficaces et ne réalisent pas dans la plupart du temps les objectifs qui lui sont associés tels que l'amélioration de la compétitivité des entreprises industrielles, l'augmentation du contenu technologique dans le cycle de production et la réduction de la disparité régionale. Nous avons essayé de comprendre les causes de l'inefficacité des efforts de l'Etat tunisien en faveur de son industrie. Enfin, nous concluons que ces mesures ne peuvent pas construire une véritable politique industrielle.

MOTS-CLEFS: Politique industrielle, R&D, Programme de mise à niveau, Fond de promotion et de décentralisation de l'industrie, Tunisie.

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1 INTRODUCTION

L'ouverture des économies à l'échelle internationale a participé à la fragmentation du processus de production et a fait apparaître une division mondiale du travail. Cette dernière se prolonge par l'apparition des firmes multinationales composée d'un réseau d'entreprises interconnectées et disséminées dans le monde. Chaque unité produit ce qu'elle maitrise le mieux suivant les avantages comparatifs que procure le pays où elle est installée, puis les opérations d'échange se réalisent entre eux. Ce phénomène a contribué à l'essor du commerce de masse, à la croissance économique et à l'émergence de certains pays du Sud qui continuent à rattraper de plus en plus leur retard économique [1].

L'ouverture à l'échelle mondiale a été accompagnée d'une libéralisation du fonctionnement des mécanismes des marchés dans le cadre de la concurrence pure et parfaite. Ce mouvement de libéralisation et de déréglementation suppose que les activités s'autorégulent d'une façon libre et systématique, l'équilibre général de plein en emploi se réalise spontanément, les intérêts collectifs sont pleinement satisfaits et l'efficacité économique est considérée meilleure. Sous cet angle, plusieurs théories économiques dont par exemple la théorie de croissance endogène soutiennent l'idée que le double processus d'ouverture et de libéralisation constitue un excellent moyen pour augmenter le produit intérieur brut des pays, pour favoriser l'investissement et pour créer de nouveaux emplois [2]. Ceci explique les raisons pour lesquelles tous les pays du monde participent à la mondialisation et se réinscrivent dans le cadre de l'économie de marché. Il en résulte nécessairement une décision d'écarter l'Etat de la vie économique au profit du fonctionnement libre des mécanismes des marchés [3].

Cependant, cette nouvelle situation a provoqué la rigidité et le sous-emploi des marchés, la perte de la capacité de production intérieure, la dégradation des industries nationales, la délocalisation de certaines activités vers d'autres pays attractives. Toutes ces mutations ont mené les économies vers une situation de récession susceptible de s'aggraver et d'atteindre une dépression de longue durée, assortie de niveaux élevés de chômage, d'inégalité sociale et de pauvreté [4].

Les économistes remettent en question les faveurs de l'ouverture internationale des marchés et le système de l'économie libéral, sur lesquels la plupart des organisations modernes ont été fondées. La nécessité de mettre en œuvre des politiques publiques interventionnistes dans ce système d'économie de marché se justifie alors, pour rectifier le tir et atteindre la situation optimale recherchée [5].

Éveillé du rôle déterminant de l'industrie dans l'économie, pour sa part de contribution dans la richesse nationale et les exportations et par son effet d'entraînement sur les autres secteurs d'activité [6], les économistes et les politiciens recommandent à ce que les actions prises et les politiques adoptées par les pouvoirs publics soient orientés vers le secteur industriel. C'est ainsi que nous nous intéressons à la politique industrielle.

La politique industrielle a fait l'objet d'un débat très vif à propos de sa définition, ses moyens et ses objectifs. Elle a provoqué une divergence d'opinions entre les économistes à propos de sa légitimité, sa faisabilité et son efficacité. Cet aspect théorique fera l'objet de la deuxième et la troisième section de cet article. Puis, dans une quatrième, nous allons nous focaliser sur les expériences de quelques pays développés et émergents en matière de politique industrielle, en vue de les analyser en terme d'objectifs, d'instruments et de conditions de réussite. Il en découle alors, de vérifier si les actions étatiques mises en place par l'Etat tunisien en faveur de son industrie peuvent être qualifiées comme étant de véritables instruments de politique industrielle et jusqu'à quel degré elles ont été efficaces ? La réponse à cette question fera l'objet de la dernière section de ce présent travail. En conclusion, nous allons récapituler et aligner les faiblesses et les limites des actions interventionnistes de l'Etat tunisien en faveur de son industrie.

2 LA POLITIQUE INDUSTRIELLE ENTRE LE REJET ET LA NÉCESSITÉ

2.1 LE BIEN-FONDÉ DE LA POLITIQUE INDUSTRIELLE

La politique industrielle n'a pas un fondement théorique propre. Toutefois, elle trouve sa justification dans plusieurs courants économiques qui défendent sa mise en place et insistent sur son efficacité. Dans ce qui suit, nous allons présenter quelques arguments avancés par différents approches économiques. Nous commençons par citer les arguments dites « standards » ou classiques de la politique industrielle. Ces arguments s'articulent autour de l'échec du marché. Dans ce sens, il est considéré que seul l'Etat a la capacité de pallier efficacement ces échecs qui prennent la forme d'externalités positives et ou négatives, des imperfections de concurrence liées à l'asymétrie de l'information et aux économies d'échelles [7].

En se référant à l'approche interventionniste notamment aux pensées keynésiennes, la politique industrielle tire sa légitimité et prouve son efficacité dès qu'elle vise l'amélioration de la performance d'un secteur pilier de l'économie. Un secteur qui vérifie une forte corrélation entre son développement et celui économique et social [8] :

- La première corrélation s'affiche entre l'augmentation de la productivité des facteurs de production et l'accroissement de production de l'output industriel ce qui va stimuler la croissance de la richesse nationale et du PIB du pays.

- La deuxième corrélation se vérifie entre le développement de l'industrie et l'augmentation de la valeur ajoutée générée dans l'ensemble de l'économie.

- Une autre corrélation se justifie par la contribution de l'industrie dans l'efficacité économique, sociale et productive vue que ce secteur occupe le premier rang dans l'économie en matière de volume de production, du montant de salaire distribué et de l'effet d'entraînement sur les autres secteurs d'activités.

- Enfin l'industrie est le champ d'innovation et de concrétisation des efforts de recherche et de développement. L'intervention de l'Etat prouve sa nécessité et son efficacité dans la contribution à la compétitivité de la nation.

En outre, la théorie des coûts de transaction a avancé certains arguments justificatifs de l'efficacité de la politique industrielle dans l'organisation économique. Les partisans de ce courant adoptent l'hypothèse que l'échange ne peut être considéré comme simple et libre entre individu sans pour autant prendre en compte les institutions qui le régissent. C'est ainsi qu'ils soutiennent l'importance de l'intervention publique dans l'activité productive. En effet, ils considèrent l'Etat comme le seul agent qui peut instituer un système de contrôle et de sanction permettant de baisser les coûts et les pratiques frauduleuses et il est le seul doté d'un potentiel de renforcement de réaction stratégique des firmes et d'orientation des restructurations organisationnelles du secteur [9].

2.2 LE REJET DE LA POLITIQUE INDUSTRIELLE DANS L'APPROCHE DES LIBERAUX

Les libéraux rejettent toute forme d'intervention de l'Etat dans l'industrie et affirment, d'une part, que l'efficience de l'industrie ne dépend que de la performance des actions réalisées par les firmes industrielles, ainsi ce secteur devrait s'organiser exclusivement par les décisions des entrepreneurs et des conditions macroéconomiques et jamais par une intervention extérieure. D'autre part, ils ajoutent que toute intervention étatique est nécessairement basée sur la sélectivité. Cette dernière est toujours établie en fonction des intérêts politiques et ou privés ce qui pourrait générer un ciblage de certains secteurs et entreprises d'une façon irrationnelle marginalisant le reste des entreprises [10].

Les libéraux soutiennent l'idée que l'intervention de l'Etat ne fait qu'augmenter le coût d'inefficience pour toute l'économie puisque dans tous les cas de figure elle va nuire à l'intérêt général par l'apparition des monopoles, par le ralentissement du progrès technique qu'elle provoque en protégeant les industries naissantes, par le déséquilibre structurel entre l'offre et la demande en fixant et contrôlant les mécanismes du marché… En revanche, ils acceptent l'intervention conjoncturelle de l'Etat dans l'industrie pour pallier les échecs du marché [11].

Dans tout ce que nous avons évoqué au niveau de l'étude du statut de la politique industrielle et de son analyse théorique, nous observons à chaque fois un contraste flagrant entre des auteurs qui recommandent le libre fonctionnement des mécanismes de marché et d'autres qui mettent en lumière le rôle prépondérant de la politique industrielle en recommandant l'intervention de l'Etat dans la vie économique. Une évolution dans les perspectives, dans les objectifs et dans les outils de la politique industrielle est alors indispensable afin de l'aligner aux nouvelles conditions de l'économie libérale et de légitimer sa mise en place.

3 VERS UNE NOUVELLE POLITIQUE INDUSTRIELLE

Les politiques industrielles traditionnelles appartiennent à un cadre d'intervention de l'Etat dans les choix économiques des firmes. Elles sont associées à l'usage par les pouvoirs publics d'un certain nombre d'outils d'intervention directe sur les entreprises comme par exemple le financement administré et le protectionnisme actif, en vue d'assurer le développement d'une branche ou d'une filière industrielle particulière**.** Cependant cette forme d'intervention traditionnelle a été remise en échec, d'une part parce qu'elle se base sur un système de protection sélective qui crée une distorsion entre les firmes et prive les firmes industrielles protégées d'apprendre à être compétitives, et d'autre part, parce que ce mode d'intervention traditionnelle se base sur les incitations directes qui pèsent lourd sur les avoirs des Etats et qui entraînent un déficit budgétaire [12].

Ainsi et avec les restrictions imposées par les règles internationales, les mesures traditionnelles qui entraînent la désorganisation des dispositifs anticoncurrentiels et la dérèglementation sont de plus en plus limitées [3]. Une nouvelle forme de politique industrielle est indispensable pour une meilleure insertion dans la nouvelle division internationale du travail, pour assurer une croissance économique continue et robuste et pour faire face aux limites des mesures interventionnistes traditionnelles. Sous cet angle, la nouvelle politique industrielle va viser de nouveaux objectifs plutôt

horizontaux tels que : le renforcement technologique, le réajustement de l'éducation et de la formation, la sauvegarde de l'environnement des firmes et l'abandon des politiques de protection sélective et d'aides directes [13].

4 LEÇONS A TIRER DES EXPERIENCES DE POLITIQUE INDUSTRIELLE

Dans ce qui suit, nous allons étudier les expériences de politique industrielle adoptées par la France, le Japon et les quatre dragons. Notre objectif est de voir comment les pratiques d'intervention en faveur de l'industrie ont évolué ces dernières décennies, de déterminer les priorités de leur nouvelle démarche et de déduire les résultats qui ont abouti. Ceci va nous aider de tirer des leçons et des enseignements de leur politique.

4.1 EXPÉRIENCE DE LA FRANCE

La politique industrielle de la France a changé et a évolué en fonction des perspectives et des défis qui se présentaient vers la fin des années quatre-vingt-dix, à savoir le niveau élevé de la dette publique, la faible compétitivité des produits français, et l'accentuation du phénomène de désindustrialisation. Les mesures interventionnistes traditionnelles dans l'industrie étaient incapables de résoudre ces problèmes [14].

La référence [15], montre que les montants des aides publiques à l'industrie française ont subi une baisse massive traduisant les nouvelles orientations de la politique industrielle française vers des moyens d'aides moins explicites, de plus en plus indirectes et qui s'articulent autour de quatre principales tendances :

i) La transformation progressive des aides à l'industrie sous forme de soutiens de moins en moins directs (réductions fiscales, prêts remboursables, capital-risque,…).
ii) L'amélioration des conditions cadre de l'industrie par la modernisation de l'infrastructure administrative et de l'infrastructure logistique et communicationnelle.
iii) L'amélioration des niveaux de qualification du travail et du potentiel technologique des firmes.
iv) Le développement de la coopération industrie-Etat-recherche fondamentale.

Les principaux objectifs de la nouvelle politique industrielle française sont : le renforcement de la compétitivité de l'industrie, le développement d'une industrie régionale équilibrée et la lutte contre la délocalisation. Pour réussir ces objectifs, la France a mis en place différents organismes. Ceux qui veillent au renforcement du contenu technologique dans les firmes industrielles et soutiennent leurs efforts de recherche et d'innovation tels que : l'agence nationale de recherche, l'agence nationale pour la valorisation de la recherche et l'agence de l'innovation industrielle. D'autres organismes créés pour attirer les capitaux étrangers et pour lutter contre la délocalisation et le déséquilibre régional tel que le fond de compétitivité des entreprises qui consacre plus de 40 millions d'euros au financement des dépenses de R&D des pôles de compétitivité, à l'amélioration du cadre environnemental de l'industrie et au développement de l'infrastructure technologique territoriale [16].

D'après le tableau de bord de l'innovation européenne, la France occupe en 2011 le 11ème rang en matière d'innovation sur 27 pays membres dont les leaders sont la Suède, la Finlande, le Danemark, l'Allemagne, le Royaume-Uni, les Pays-Bas, l'Autriche, le Luxembourg, l'Irlande et la Belgique. Son retard par rapport aux autres pays peut être expliqué par le faible nombre de firmes innovatrices, le faible partenariat entre le secteur public et privé en matière de recherche et de développement et la faible contribution des efforts de recherche dans la productivité des facteurs de production. En outre, malgré les efforts étatiques en matière de mise en place des pôles de compétitivité sur tout le territoire français, la vague de délocalisation des activités vers des pays de l'Europe de l'Est et des pays asiatiques n'a pas subi un recul et le problème du déséquilibre régional persiste encore [17].

Beaucoup de travaux de recherche ont été formulés afin d'étudier les causes derrière les difficultés des entreprises en matière d'innovation. Les plus explicatifs sont le chevauchement entre les mécanismes d'aide à l'industrie, la forte spécialisation de l'industrie française dans les secteurs à faible contenu technologique et la concentration de l'aide publique à la R&D dans les secteurs de la défense et des grands programmes historiques (l'aéronautique, le spatial, le nucléaire, et le secteur nanoélectronique) [16].

4.2 EXPÉRIENCE DU JAPON

Dans les années quatre-vingt-dix, le Japon était le pays le plus impliqué dans les aides publiques destinées à l'industrie par rapport aux autres pays membres de l'OCDE. La part des aides à l'industrie s'élevait à 88% du total des dépenses publiques dont plus de la moitié est destinée au soutien des PME et à la R&D [18].

Cette politique industrielle traditionnelle a prouvé son efficacité et a bien réussi à atteindre les objectifs visés. Cependant, le nouveau contexte mondial avait exigé une réforme non seulement du système économique japonais mais aussi des objectifs, des instruments et des moyens d'intervention de l'Etat dans l'industrie. Ainsi, les objectifs de la nouvelle politique industrielle japonaise visent le soutien de l'industrie innovatrice, le soutien des PME, le développement de la politique des clusters d'une façon de plus en plus horizontale [18].

En se référant à l'institut international de gestion et de développement à Genève, le Japon occupe en 2007 le 2ème rang en matière d'innovation technologique. Une recherche conduite en 2005 sur les PME montre clairement que le système de crédit garanti réalisé par le « Financial Services Agency » joue un rôle positif et significatif dans le développement et la croissance des PME surtout en matière de performance. Une autre enquête conduite entre janvier et mars 2006 auprès de 6777 entreprises participant aux clusters industriels le METI et 1413 chercheurs, affirme que les entreprises avaient obtenu des résultats positifs par rapport à la période qui précédait leur adhésion au projet et que les mérites de celui ci étaient bien visibles et concrets [17].

4.3 EXPÉRIENCE DES QUATRE DRAGONS

Historiquement les quatre dragons ne s'inscrivaient pas dans le cadre d'une économie libérale où le contrôle de crédit était excessif et les mesures de protection de l'industrie locale étaient dominantes. La complexité des problèmes intérieurs et le changement des règles de la concurrence internationale ont révélé la question de la compétitivité et de la spécialisation des firmes industrielles [19].

Les quatre dragons ont suivi des politiques offensives axées sur un passage de l'imitation vers l'innovation et qui ont bien révélé leur efficacité. La banque mondiale a qualifié leurs expériences par le modèle miraculeux. Le tableau n°1 présente les principales caractéristiques de ces politiques :

Tableau 1 : Les caractéristiques des politiques industrielles des quatre dragons

	Restructuration industrielle	**Stratégie des IDE**	**Politique technologique**
Hong Kong	Aucun	Ouverture passive	Développement technologique des PME
Singapore	Forte orientation vers l'amélioration des qualifications de la main d'œuvre	Sélection des IDE en attirant ceux à forte valeur ajoutée	Développer le processus de R&D des multinationales
Taiwan	Augmenter le facteur capital, améliorer le facteur travail et augmenter le contenu technologique	Limiter l'entrée des IDE quand il y 'a des grandes firmes locales dans le même domaine	Orientée vers le soutien du processus de R&D
Corée de sud	Augmenter le facteur capital, améliorer le facteur travail et augmenter le contenu technologique	IDE trop limités, seulement ceux à fort contenu technologique ou à tendance exportatrice, stratégie de joint-venture et de production sous licence	Orientée vers le soutien du processus de R&D et l'infrastructure technologique

Source : traduit par l'auteur à partir du [19]

Il s'avère donc, que les expériences de la France, du Japon et des quatre dragons en matière de politique industrielle visent les mêmes objectifs à savoir le renforcement de la compétitivité de leurs industries, l'augmentation du contenu technologique dans le cycle de production et le développement régional. La réalisation de ces finalités a nécessité l'adoption de différents instruments, dont notamment la création en France des organismes de soutien des PME et du processus de R&D et le lancement des pôles de compétitivité. Quant au Japon, la création d'un système de crédit garanti pour financer les projets de l'industrie innovatrice et la mise en place des clusters. Au Singapore comme aux Taiwan et la Corée de sud moyennant le lancement de certains programmes d'amélioration du savoir-faire du facteur travail, le développement d'un système de soutien institutionnel et des mesures d'incitation à la R&D et d'attraction des IDE.

L'étude de ces expériences nous a permis de tirer plusieurs leçons. D'abord, l'orientation vers les composantes de l'économie de savoir et l'avancement dans la chaine de valeur technologique mondiale sont des conditions obligatoires pour

une meilleure insertion dans la nouvelle division internationale du travail. Ensuite, les erreurs à éviter sont multiples, d'une part, il ne faut pas condenser les programmes et les organismes qui visent des finalités similaires ce qui pèsent lourds sur les avoirs publics et rendent la tâche d'évaluation des résultats délicate. D'autre part, il ne faut pas unifier les mesures de soutien à tous les secteurs industriels indépendamment de leurs perspectives d'avenir, de leurs contenus technologiques et de leurs potentiels de croissance, en d'autres termes, il est indispensable de mener une étude sur les priorités de chaque branche et de lui faire convenir les efforts de promotion et de correction appropriées. Enfin, nous devons mentionner qu'il faut éviter de calquer les expériences qui ont prouvé leur réussite dans d'autres pays sans approfondir l'étude de leur cohérence avec les conditions macroéconomiques locales.

5 EVOLUTION DE LA POLITIQUE INDUSTRIELLE TUNISIENNE

L'appui au développement industriel ainsi que la correction des insuffisances qu'il comporte, ont constitué l'objet des actions publiques mises en œuvre par l'Etat tunisien en faveur de l'industrie depuis l'indépendance en 1956 et que nous présenterons chronologiquement comme suit :

Tableau 2 : Evolution des mesures étatiques et leurs impacts sur l'industrie tunisienne

période	Mesures étatiques en faveur de l'industrie tunisienne	Résultats
60	-Nationalisation des unités de production -Création de l'industrie lourde -Création de l'industrie légère d'import de substitution	-Base industrielle fragile et dépendante d'un marché intérieur étroit et extérieur très concurrent -Secteur privé marginalisé -Faible productivité des investissements industriels -Aggravation du chômage
70	-Industries d'import de substitution -Encouragement du secteur privé exportateur (loi 72) -Réduction des inégalités régionales (FOPRODI*)	-Augmentation de la part des investissements privés -Création de l'emploi -Augmentation du volume des exportations industrielles -Apparition des obstacles de structure et des difficultés macroéconomiques
80	-Promotion des exportations -Libéralisation et privatisation de l'investissement industriel	-Légère augmentation du volume d'investissement industriel -Augmentation du volume de l'exportation -Faible amélioration de la compétitivité -Accentuation du problème du chômage
Depuis les années 90 jusqu'à 2012	-Mise en vigueur du code d'incitation à l'investissement industriel -Lancement du PMN** -Restructuration du FOPRODI -Renforcement de la technologie dans l'industrie	-Croissance de l'investissement privé dans l'industrie tunisienne entre 2004 et 2011 -Croissance des exportations industrielles entre 2004 et 2011 -Solde commercial du secteur industriel déficitaire -Accentuation du problème du chômage et une faiblesse de contribution de l'industrie dans la création de l'emploi -Accentuation du déséquilibre régional

Source : [20], [21], [22], [23]-[24].

*Fond de promotion et de décentralisation de l'industrie

**Programme de mise à niveau

A ce niveau, les questions qui peuvent se poser sont les suivantes : Pouvons-nous considérer que l'évolution de niveau de l'investissement industriel privé dans les dernières années est expliquée significativement par l'efficacité des actions interventionnistes mises en place et est-ce que l'augmentation des exportations industrielles est due à une amélioration de la compétitivité des produits industriels tunisiens sur les marchés internationaux ? Enfin, est ce que cette légère évolution de l'industrie tunisienne est suffisante pour confronter les nouveaux impératifs qui se présentent au secteur et à l'ensemble de l'économie tunisienne notamment après la révolution du 14 Janvier 2011 ?

Pour répondre à ces interrogations, nous allons procéder à une évaluation des actions étatiques mises en place en faveur de l'industrie tunisienne.

5.1 LE FOND DE PROMOTION ET DE DÉCENTRALISATION DE L'INDUSTRIE (FOPRODI)

Durant la période 2007-2011, le FOPRODI a financé 46% des projets déposés par les nouveaux promoteurs. Ces derniers estiment stimuler 67% du total de l'investissement privé et prévoient créer 77.2% du total de nouveaux postes à générer dans l'industrie tunisienne dans le cadre des efforts du FOPRODI. En revanche, le FOPRODI a financé dans la même période jusqu'à 80% des investissements déposés pour l'extension des PME déjà existantes. Cette catégorie de projet n'estime stimuler que 34% des investissements industriels privés et ne crée que 22.7% de nouveaux emplois. En outre, ce fond de décentralisation industrielle enregistre une baisse continue depuis 2007 dans le financement des investissements à implanter dans les zones encouragées et n'a financé en 2011 que 43% du total des projets [20].

Ceci nous amène à conclure que les mesures interventionnistes dans le cadre du FOPRODI contribuent à la croissance des investissements privés mais qui ne sont pas suffisamment efficaces pour générer une croissance économique forte et pour lutter contre le déséquilibre régional. Ceci peut être expliqué d'une part, par le faite que le FOPRODI ne stimule pas assez la création de nouveaux projets qui ont l'effet le plus significatif dans la création de l'emploi. D'autre part, à cause du recul enregistré dans la contribution à l'investissement des zones de développement régionales.

5.2 LE PROGRAMME DE MISE À NIVEAU

En 2011, les primes d'investissement matériel (achat de nouveaux équipements…) constituent 66.17% de la prime totale approuvée par le PMN. En revanche, la prime d'investissement immatérielle (dépenses en R&D, formation des employés, achat des logiciels conseils en organisation, brevet et licence…) représente seulement 30.20% de la prime totale. Ceci est évident car les investissements matériels sont beaucoup plus élevés que les autres formes d'investissements [20].

Une enquête effectuée sur 104 entreprises industrielles qui ont achevé leurs plans de mise à niveau a abouti aux résultats suivants [25]:

- L'évolution de la productivité apparente du facteur travail s'est améliorée dans environ 93% des cas. Ce pourcentage élevé semble s'expliquer, surtout, par l'importance des investissements matériels (acquisition ou renouvellement d'équipements de production).

- Dans moins de 17% des cas, l'application du PMN n'a pas induit une amélioration de la position concurrentielle des firmes, et l'accroissement des parts de marché reste généralement entre 5 et 10%.

- L'effectif total des employés a augmenté dans moins de 61% de l'ensemble des entreprises. L'évolution de l'emploi dans ces firmes est le résultat des recrutements et des licenciements qu'elles ont effectués depuis leur adhésion au PMN. Ces recrutements se font plus au près des ouvriers spécialisés et des techniciens supérieurs qu'au près des cadres et des ingénieurs (environ 13%). Cependant, près de 58% des entreprises ont licencié des employés qui étaient le plus souvent des ouvriers.

- Une évolution du taux de rentabilité et de l'endettement est enregistrée puisque les investissements de mise à niveau sont surtout financés par des emprunts bancaires. Ainsi, depuis qu'elles avaient appliqué le PMN, plus de 91% des firmes enquêtées se trouvaient plus endettées.

Le PMN tunisien cible les PME de bonne santé financière. Toutefois, un tel ciblage n'est pas suffisant pour toucher de nombreuses firmes tunisiennes de petite taille, "price takers" et moins bien structurées pour qui, une mise à niveau peut se présenter comme une condition pour préserver leurs parts de marché, voire d'assurer leurs survies. En plus, les investissements immatériels restent le maillon faible du PMN de l'industrie, en dépit des avantages supplémentaires accordés à ce titre. Enfin, le coût de ces investissements, par comparaison à leur rentabilité retardée et incertaine, constitue toujours un embarras majeur qui remet en doute l'efficacité du programme dans l'amélioration de la compétitivité des firmes industrielles locales [26].

En effet, les exportations du secteur industriel découlent plutôt d'une dynamique des échanges des firmes sous-traitantes qui dominent la structure de l'industrie tunisienne que d'un avantage compétitif acquis par des programmes de mise à niveau.

5.3 LE FINANCEMENT DES DEPENSES DE R&D

L'Etat tunisien consacre de plus en plus de fonds pour le financement du processus de R&D. Ceci traduit et prouve une orientation du pays vers une politique technologique active dont le souci reste l'amélioration de la compétitivité internationale de son économie. Bien que l'évolution du ratio ((dépense intérieure de recherche et développement) /

(Produit intérieur brut)) est remarquable et a atteint le niveau de 1.25 % en 2009, celui-ci reste insuffisant pour permettre une amélioration concrète de la compétitivité technologique du système productif tunisien. La part de financement des entreprises publiques et privées dans la dépense intérieure de recherche et développement est en croissance continue, mais affiche toujours des valeurs très faibles par rapport à celles supportées par l'Etat. La part des fonds étrangers dans les dépenses de R&D reste dans des limites raisonnables, mais elle parait tout de même proche de celles des entreprises tunisiennes [27].

Le vrai problème dans le système de R&D est la faible contribution des entreprises nationales dans le processus de développement technologique. Ceci est justifié en grande partie par l'insuffisance des mesures incitatives publiques mises en place pour encourager les entreprises à investir en R&D, l'inefficacité de l'investissement de l'Etat dans l'enseignement et la coordination avec du système productif, et l'orientation des investisseurs tunisiens vers la rentabilité immédiate et l'ignorance d'une vision stratégique forte en contenu stratégique dans leurs productions [28].

Les mesures publiques d'incitation à la R&D sont insuffisamment ciblées sur le secteur industriel. Bien entendu, ceci relève du caractère horizontal des mesures incitatives dans l'industrie qui ont un impact limité sur la compétitivité technologique de l'industrie tunisienne [29]. Ceci nous amène à conclure, que la croissance du niveau des exportations tunisienne n'est pas expliquée par l'avantage compétitif technologique des produits industriels.

5.4 LA POLITIQUE DE DÉVELOPPEMENT DE L'INFRASTRUCTURE TECHNOLOGIQUE

Le pôle de compétitivité est un espace géographique regroupant une multitude d'acteurs soumis à des règles juridiques différentes : entreprises, pépinière d'entreprises, institutions de formation, centres de recherche, universités. Les différentes expériences dans le monde (clusters, pôles de compétitivité, parcs scientifiques ou technologiques, réseaux de compétence) s'inscrivent dans leur quasi-totalité dans une perspective stratégique planifiée et mise en œuvre par le gouvernement. L'objectif ultime de la mise en place d'un pôle de compétitivité est de stimuler la croissance et l'emploi à travers le développement de l'innovation et de la R&D, réalisées par des partenariats croisés entre secteur public et secteur privé [30]. En vue d'étudier l'expérience de la Tunisie en matière de technopôle et afin d'évaluer ses résultats, nous allons nous référer au premier technopôle installé en Tunisie : le technopôle de Technologies de l'Information et de la Communication El-Gahzala.

El-Gazala Technoparc héberge en 2012, 88 entreprises dont 12 filiales regroupant des grands groupes mondiaux (Microsoft, ST Microélectroniques, Ericsson, Alcatel Lucent ...), emploie 1770 personnes dont 95% sont des cadres, des techniciens et des ingénieurs [31].

L'Institut Tunisien de la Compétitivité et des Etudes Quantitatives a mené en 2005 une étude auprès des 51 entreprises installées au pôle d'El-Ghazala, afin de déterminer dans quelles mesures celles-ci avaient bénéficié des services offerts. Près de la moitié des entreprises ont réussi grâce à leur localisation dans ce technopôle à assurer le développement et l'expansion de leurs exportations. La majorité ont aussi fait état d'une augmentation de leurs activités de recherche et développement. L'implantation à El-Ghazala avait conduit, pour plus de 40% de ces entreprises à l'élaboration d'au moins deux nouveaux produits au cours des cinq années précédentes, et 46% avaient des demandes de brevet en instance. Enfin, 53% avaient attiré des capitaux étrangers. Toutefois, les entrepreneurs ont confirmé que la dynamique et la croissance affichées ne sont pas expliquées par un dispositif étatique incitatif. Ceci est justifié par un ensemble d'arguments avancés, dont nous citons : la limite des programmes nationaux d'appui à l'innovation à couvrir les différents types de dépenses pendant les différentes étapes du processus d'innovation et de R&D. L'inéligibilité de nombreuses activités et structures dans ce technopôle des primes et subvention. La faible visibilité des dispositifs de subventions et d'aides existants. En outre, la totalité de ces entreprises souffrent de certains comportements de captation de rente et d'une atmosphère de concurrence excessive entre elles engendrant souvent des comportements non-coopératifs [30]-[32].

Cette expérience technopolitaine a montré des limites dans la réalisation des objectifs qui lui sont attribués, à savoir ; la coordination entre recherche fondamentale et industrielle et la dynamisation du processus d'innovation en vue de garantir la compétitivité industrielle [33].

En synthétisant, la politique technologique en Tunisie dans sa totalité (R&D, technopôle, brevetage, valorisation des compétences…) souffre de plusieurs insuffisances limitant ses répercussions positives sur le développement et l'amélioration de la compétitivité du secteur industriel. Un ensemble de contraintes explicatives de l'inefficacité de la politique technologique de la Tunisie ont été formulées [33]-[34].

- La contrainte de financement : une atonie du marché boursier, un accès difficile aux crédits bancaires et une absence de financement approprié de projets innovants.

- La contrainte d'investissement : les flux des IDE sont faibles et s'orientent principalement dans des activités de sous-traitances.

- La contrainte de marché : les activités d'innovation technologique ont longtemps été menées par des grandes entreprises et des centres de recherche publics en position de monopole.

- La contrainte technologique : l'absence de grands groupes industriels et la concentration de l'appareil productif dans des activités à faible contenu technologique.

- La contrainte scientifique : le potentiel de recherche reste fortement concentré dans les universités et s'oriente le plus souvent vers des activités de recherche fondamentale en rupture avec les besoins du système productif.

- La contrainte institutionnelle : la non-reconnaissance du statut de chercheur, une gestion inefficiente des programmes de recherche, les carences du système de protection des droits intellectuels, l'éclatement de la communauté scientifique nationale et l'exode des compétences à l'étranger ont été autant de facteurs défavorables à l'efficacité de la politique technologique de la Tunisie.

6 CONCLUSION

Dans le contexte actuel de l'économie mondiale, certain pays développés et en développement cherchent à restructurer et à développer leurs systèmes productifs afin de maintenir leurs compétitivités ainsi que leurs stabilités économique et financière. Sous cet angle, la France, le Japon et les quatre dragons, les expériences que nous avons évoquées dans notre travail, ont adopté des politiques industrielles actives et ils ont essayé toujours de les adapter aux changements économiques, organisationnels et technologiques. La démarche des pays asiatiques a été la plus efficace vue que ces pays ont beaucoup travaillé sur l'amélioration des composantes de l'économie de savoir (Innovation, Technologie de l'information et de la communication, R&D et Qualification du capital humain).

Cependant, ces différentes expériences ne sont pas exempts des erreurs et de problèmes qu'il faut éviter. Tout d'abord, il ne faut pas unifier les mesures de correction et de promotion à toutes les branches industrielles sans un ciblage bien étudié. En plus, il faut bien éviter la spécialisation des économies dans les branches industrielles à faible contenu technologique comme le cas de la France. Enfin, il est indispensable de créer des institutions capables de garantir la transparence de l'information, de réussir à diriger, à suivre et à contrôler l'avancement de la mise en place de différentes actions de la politique industrielle.

Quant à la Tunisie, la politique industrielle était orientée vers, la mise à niveau des firmes industrielles, le soutien de la R&D et de l'innovation et à la création et le développement d'une infrastructure technologique.

Le présent travail a décrit les différentes mesures adoptées pat l'Etat tunisien depuis l'indépendance jusqu'à 2011 en faveur de son industrie, en mettant l'accent sur l'apport de chaque politique sur la performance de l'industrie. Nous avons tenté de cerner les limites des instruments de la politique industrielle tunisienne adoptée au cours de la dernière décennie. Le FOPRODI, a montré son inefficacité quand il tient moins à l'importance des incitations qu'au mode de leur octroi et aux critères de leur ciblage. Le PMN est dominé par une approche microéconomique et une vision fragmentaire du tissu productif et n'a pas pallié l'insuffisance de l'investissement immatériel dans les firmes industrielle. L'insuffisance des efforts de R&D pour améliorer concrètement la compétitivité du système productif. Et enfin, la limite de l'expérience technopolitaine dans la coordination entre recherche fondamentale et recherche industrielle, dans l'attraction des firmes multinationales et dans la dynamisation du système d'innovation.

L'analyse de l'évolution de la performance du secteur industriel tunisien montre que l'ensemble des mesures interventionnistes mises en place par l'Etat n'ont permis ni une amélioration concrète de la compétitivité structurelle du tissu industriel ni de générer une croissance économique suffisante pour faire face aux problèmes du chômage et de la disparité régionale. Ceci est expliqué par des multiples faiblesses d'ordre institutionnel, de marché, de financement, d'investissement, scientifique… qui continuent à fragiliser ce secteur face à la concurrence des pays européens disposant d'un avantage comparatif en technologie de pointe et à celle d'autre PED plus compétitifs en termes de coût de travail.

Par conséquent, il nous parait que le problème qui devrait actuellement se poser avec plus d'acuité, n'est pas celui de la légitimité de la politique industrielle mais celui de la redéfinition et du ciblage des objectifs et des moyens d'une telle politique pour qu'elle soit plus efficace par rapport aux nouveaux défis qui viennent de s'imposer après la révolution du 14 janvier 2011. Il faudrait accélérer ainsi la transformation du système productif en passant d'une économie de sous-traitance à une économie d'innovation et de compétences.

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REFERENCES

[1] Lall, Sanjaya. "The employment impact of globalisation in developing countries", in E. Lee and M. Vivarelli (eds), Understanding Globalization, Employment and Poverty Reduction, Basingstoke Hampshire and New York: Palgrave Macmillan, 2004.
[2] Farla, Kristine. "industrial policy for growth". AFD - MGSoG/UNU-Merit Working paper series on institutions, governance and long term growth, 2012.
[3] Bianchi, Patrizio et Sandrine Labory. "Industrial policy in a global perspective", International Handbook of industrial policy, Chtenham, UK and Brookfield, USA: Edward Elgar, 2006.
[4] Cimoli, Mario, Giovanni Dosi and Joseph E. Stiglitz. "Industrial policy and development: The political economy of capabilities accumulation". New York, Oxford University: Springer-Verlag, 2011.
[5] Björkroth, Tom, Sonja Grönblom and Johan Willner. "Liberalization and regulation of public utility sectors: theories and practice". In Industrial policy in a global perspective, International Handbook of industrial policy, pp 180-97. Chtenham, UK and Brookfield, USA: Edward Elgar, 2006.
[6] Postel.V, George. "La politique industrielle et d'innovation : nouveaux contextes, nouveaux défis'', Observatoire des Stratégies Industrielles, Ministère de l'Economie, des Finances et de l'Industrie. http://postel-vinay.net/osi/, 2004.
[7] Martin, Stephen and Paola Valbonesi. "State aid to business". In Industrial policy in a global perspective, International Handbook of industrial policy, pp134-52. Chtenham, UK and Brookfield, USA : Edward Elgar, 2006.
[8] Morvan, Yves. "Fondement d'économie industrielle''. Paris: Economica, 1991.
[9] Williamson, Olivier.E. "Outsourcing: Transaction Cost Economics and supply chain management". Journal of Supply Chain Management, 44(2): 5-16, 2008.
[10] Cesaroni, Fabrizio et Paola Giuri. "Intellectual Property Rights and Market Dynamics". Laboratory of Economics and Management. Sant'Anna, school of Advanced Studies LEM Papers. Series 2005/10, 2005.
[11] Cohen, Elie. "Theoretical foundations of industrial policy", EIB papers, European Investment Bank, Economics Department, N°4: pp 84-102, 2006.
[12] Nabli, K.Mustapha, Jennifer Keller, Claudia Nassif and Carlos S. Jauregui. "The political economy of industrial policy in the middele east and north Africa". World Bank, 2006.
[13] Sepulveda, Leandro and Ash Amin. "Decentralizing industrial policies: threator opportunity in developing countries?". In Industrial policy in a global perspective, International Handbook of industrial policy, pp321-41. Chtenham, UK and Brookfield, USA : Edward Elgar, 2006.
[14] Goldstein, Andrea. "State-owned enterprises, privatization and industrial policy". In Industrial policy in a global perspective, International Handbook of industrial policy, pp198-214. Chtenham, UK and Brookfield, USA : Edward Elgar, 2006.
[15] The European Economic Advisory Group report chapter 4 CEsifo pp 105-124, 2008.
[16] Beffa, J. L. "Pour une nouvelle politique industrielle", Rapport au Président de la République, La Documentation Française, 2005.
[17] Buigues, Pierre.A et Khalid Sekkat. "Industrial Policy in Europe, Japan and the USA, Amounts, Mechanisms and Effectiveness". Chippenham and Eastbourne, UK: Palgrave Macmillan, 2009.
[18] Hanjo, Yuji and Nobuyuki Harada. "SME policy, financial structure and firm growth: Evidence from Japan'', Small Business Economics, vol. 27: 289-99, 2006.
[19] Lall, Sanjaya. "Industrial policy in developing countries: what can we learn from East Asia?''. In Industrial policy in a global perspective, International Handbook of industrial policy, pp 79-97. Chtenham, UK and Brookfield, USA : Edward Elgar, 2006.
[20] Agence de promotion de l'industrie tunisienne API, 2012.
[Online] Available: http://www.tunisieindustrie.nat.tn/fr/download/conjoncture.pdf (April 2013)
http://www.tunisieindustrie.nat.tn/fr/download/news/Syntheseduraport2011.pdf (April 2013)
[21] Dlala, Habib. "Le reconversion compétitive de l'industrie tunisienne: arrimage à l'Europe et mise à niveau". Revue d'économie industrielle, Vol 87, pp87-98, 1997.
[22] Thommaso, Marco, Elena Lanzoni et Lauretta Rubini. "Soutien aux PME dans les pays arabes. Le cas de la Tunisie'', UNIDO, 2009.

[23] Yaccoub, Lamia. “Légitimité et faisabilité de la politique industrielle dans le contexte de la mondialisation : cas de la Tunisie”. Thèse de doctorat d’Etat en sciences économiques, FSEG de Tunis, 2007.
[24] Ben romdhane, Mahmoud. “Commerce et stratégie de développement : Cas de la Tunisie’’, Commission économique pour l’Afrique CAPC, N°53, 2007.
[25] Yaccoub, Lamia. “Le programme de mise à niveau de l’industrie un moyen efficace de la politique industrielle tunisienne ?’’, Cahiers du laboratoire R.II, Université de la littorale côte d’opale, Laboratoire de Recherche sur l’Industrie et l’Innovation, 2008.
[26] Marniesse, Sarah et Ewa Filipiak. “Compétitivité et mise à niveau des entreprises Approches théoriques et déclinaisons opérationnelles’’. Paris AFD : Magellan & Cie, 2003.
[27] Kamoun, Olfa et Sami Hammami. ‘‘ Mondialisation et Nouvelle Politique Industrielle en Tunisie’’, Colloque organisé par la commission économique pour l’Afrique. Tunisie, 2008.
[28] Del Vecchio, Pasquale, Elia Gianluca and Secundo Giustina. “Sustaining Tunisian SMEs’ Competitiveness in the Knowledge Society”. Springer verlag, vol 111: 180-89, 2010.
[29] Gabsi, Foued, Hatem Mhenni and Karim Koubaa. “Innovation determiants in emrging countries: an empirical study at the Tunisian firms level”. International Journal of Technological Learning, Innovation and Development (IJTLID). MPRA Paper No. 17940, 2008.
[30] Banque mondiale. “ Les pôles de compétitivité en Tunisie : note de problématique. Washington, 2010.
[31] Ben Miled-M’rabet, Nadia. “Le Système national d’innovation en Tunisie”. Le courrie de l’industrie. Janvier 2012, 18-55, 2012.
[32] http://www.ieq.nat.tn/upload/files/Rapports_eco_savoir/rap_eco_sav_2005.pdf, 2005.
[33] Mathlouth,Yamina, Mihoub Mezouaghi et Jacques Perrat. “Dynamiques technopolotaines et développement : le cas du parc des communications elgazala’’, XLIIème Colloque de l’Association de Science Régionale de Langue Française Sfax (Tunisie) – 4-6 septembre, 2006.
[34] Magazine OMPI. “Développement et propriété intellectuelle Tunisie une nouvelle économie du savoir”. Octobre 27, 20-22, 2007.

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Case study of the number of injuries (considering several key indicators) in 2012 in real enterprises in Bitola region, Republic of Macedonia

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ABSTRACT: The aim of this paper is to represent the results from the conducted research, based on the number of injuries in all of the real organizations that gravitates in the Bitola's region, Republic Macedonia in the period frame January 2012-December 2012. The basic aim of the conducted research is to represent relevant information for the number of injuries in Bitola's region, no ether of the type of the organization, the basic field of action, the size of the same and the number of employees. Actually, this paper is a representation of the conducted research based on the number of injuries, conduced as a part of every year activity of the Safety and Health organization NGO Bitola from Bitola. The paper represents the relevant information about the number of injuries in real enterprises; information's given by the enterprises that are working in the Bitola's region. The given information's are analyzed from several aspects such as: the gender of the person that is injured, the education of the injured person, the work period of the day when the injury is spotted, the body part that is injured, number of work days that are lost as a result of the injury, etc. The paper represents some of the main criteria's that were under research in 2012.

KEYWORDS: Safety at work, Number of injured persons, Work injury, OSHAS systems, Safety management on work places.

1 INTRODUCTION

Safety on the work places is one of the key aspects that directly lead to motivated staff members, whose feeling as safer as can be in their workplaces, leads directly to maximum motivation and achievement on the defined business objectives. Considering that Republic of Macedonia is a country that adheres to global recommendations for the application of the so-called OSHAS safety systems in the work organizations on one hand, but on the other hand, and with the appropriate legislation in the field of safety and health in the workplaces, in the Bitola's region there is an NGO Bitola that is functioning in the field of Occupational Safety and Health on direct work places. The main objective of the association is to educate, to analyze the number and the nature of the injuries in the Bitola's region annually, and to have continued efforts in terms of educational and practical advices to business enterprises in the field of occupational safety and health.

As one of the main activities of the association is the evidential of the injuries, taking in considerations two relevant sources such as [2]:

- Submitted evident sheets (records for the number of injuries with a description of the injury, time interval of occurrence, data for the injured person and the number of lost working days due to the occurrence of the injury) given by business enterprises that work and gravitate in the Bitola's region
- Submitted relevant records for the number of injuries, given by competent inspectors from the Bitola region

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Actually, the basic aim why two sources of information are used is to eliminate the situation where an injury is not recorded. So, when the relevant information is gathered, the same are analyzed from more criteria's such as [2]:

- The gender of the injured person
- The education of the injured person
- The time interval when the injury is spotted
- The body part that is injured
- Number of lost work days as a result of the injury

The information's (number of spotted injuries) represented in this paper are analyzed in one year period, starting from January 2012 and with a deadline in the end of December 2012. Considering the criteria's given before in the paper, I can say that there are several other sub-criteria's such as: the type of the business entity (private or public service), the field of work (industry, education, etc.) and the size of the entity (small, medium, large).

The represented information are a relevant picture for the number and the character of the injuries, that in a different stage can be analyzed comparatively with information's from past years, and with information's from other cities or regions from Republic Macedonia [1].

The basic aim of the paper is to present some of the analyzed information (criteria's) in Bitola's region, considered in the time period January 2012-December 2012 [2].

2 PRESENTING THE RESULTS FROM THE CONDUCTED RESEARCH

All of the results from the conducted research about the injuries on direct work places were analyzed and categorized considering several key points such as [2]:

- Gender of the injured person
- Age of the injured person
- The aimed education
- Number of lost work days as a result of the injury
- Body parts that are injured
- Day time, when the injury is spotted
- Comparative analyses regarding the previous years (considering every criteria)
- Comparative analyses regarding number of injuries in other regions in R. Macedonia, etc.

The conducted research was done on several organizations and several branches in Bitola's region. In addition, in Table 1, all of the organizations, together with the number of spotted injures are presented. I must say that in the table column Organizations, the original names of the researched organizations are used.

Table 1. List of organizations that were under research in 2012 in Bitola's region

Organization	Number of injured employees
A.D. ELEM REK Bitola	80
DOOEL FOD Bitola	28
A.D. METALEC Bitola	16
Agency for temporarily employments	13
SOCOTAB DOOEL Bitola	11
EVN Macedonia, branch office in Bitola	6
DOOEL ENIGMA Z.D. Bitola	1
VEROPOLUS DOOEL Skopje, local supermarkets in Bitola	1
DOOEL LAJCAR TOYS Bitola	1
DOOEL GRUNI VIT Bitola	1
DOOEL PET Z.D.	3
DOOEL MODUL PROM Bitola	2
DOO SIMPEKS Bitola	1
MLEKARA A.D. Bitola	5
Z.K. PELAGONIJA A.D. Bitola	18
A.D. SEKERANA Bitola	10
SVR Bitola (police)	9
IDEAL SIPKA DOOEL Bitola	2
FALKO DOO	1
TRIKOTAZA A.D. Bitola	6
DOOEL RODON Bitola	10
DOOEL SAITIS	9
A.D. MOKEL EEII Bitola	5
DOOEL BT-MANIFACTURE Bitola	1
METEORIT DOOEL Bitola	4
TOTAL NUMBER OF INJURIES	**244**

Also the research was conducted in other branches that are shown graphically in Table 2 in addition.

Table 2. List of branches that were under research in 2012 in Bitola's region

Branch	Number of injured employees
Construction industry	8
Public services	21
Graphic industry (including all of the organizations in Bitola)	15
Education (including all public primary, secondary and high educational schools)	9
Trade industry	2
Transport industry	9
Public health (hospitals, child care etc.)	24
Food Industry (including all of the organizations in this industry in Bitola)	4
TOTAL NUMBER OF INJURED PERSONS	**92**

Considering all of the organizations and branches that were under research, total number of injured persons is 336 persons. On the other hand considering the number of information gathered and analyzed, several of the criteria's with the appropriate results are represented in the addition of this paper.

2.1 ANALYSING THE INJURIES CONSIDERING GENDER OF THE INJURED PERSON

Taking into consideration that the gender of the injured person is actually one of the key elements for the process of creating an official record for the accident (fulfilled by the organization and the inspection on the scene), I must start showing the results from the conducted research with the gender of the injured person as a criteria [2].

Also very important information for this part is the total number of the injured persons, that is 336 people in the year 2012 (given by the organizations in the Bitola region). All of the information's first of all are given in Table 3 and after that are represented graphically in Figure 1.

Table 3. The gender of the injured person as criteria – summarized information for year 2012

Gender	Total number of injured persons	In percent (%)
Male	90	26.8
Female	246	73.2
TOTAL	336	100 %

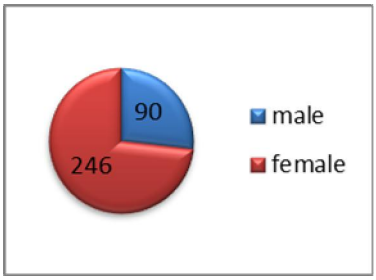

Fig. 1. Illustrated view on the information given into Table 3

2.2 ANALYSING THE INJURIES CONSIDERING THE SEVERITY OF THE INJURY

The severity of the injury is also one of the key aspects, and a point of view that is more than important. I must say that there are three main categorization of the severity in R. Macedonia, such as [2]: light injury, heavy injury and death of the injured person. Considering this criteria, the only good thing is that the number of fatal injuries in 2012 is 0 (there was 1 dead person as a result of work activities in the previous year). All of the information's from the conducted research are given into Table 4 and Figure 2.

Table 4. The severity of the injury as criteria – summarized information for year 2012

Severity	Total number of injured persons	In percent (%)
Light injury	7	2
Heavy injury	329	98
Fatal injury	0	0
TOTAL	336	100 %

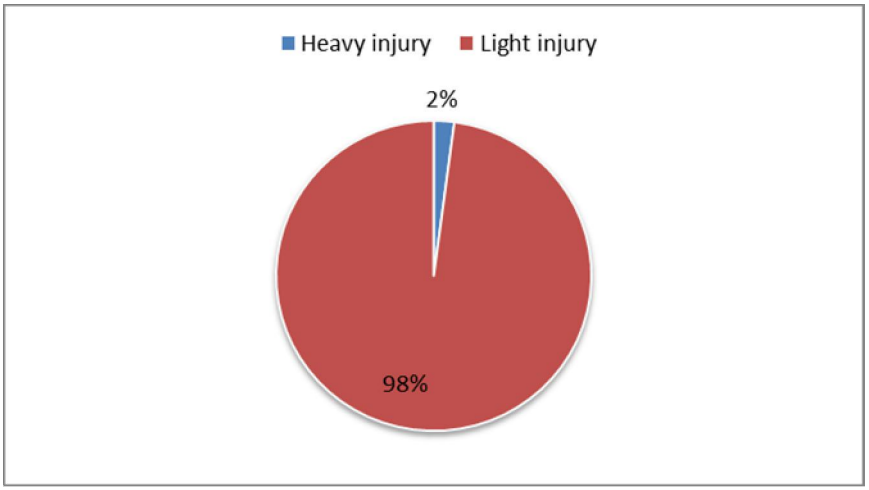

Fig. 2. Illustrated view on the information given into Table 4

2.3 ANALYSING THE INJURIES CONSIDERING THE AGE OF THE INJURED PERSON AS A CRITERIA

Taking in consideration that the total number of injuries was 336, and on the other hand considering the age of the injured person, there are several main intervals of the ages such as [2]: 18-25; 25-35; 35-45; 45-64. The first one (18 years old) is taken into considerations because that is the lowest age for employment according to Macedonian laws, and 64 is the age when people go to a retirement into R. Macedonia. All of the information's are given into Table 5 and Figure 3.

Table 5. The age criteria – summarized information for year 2012

Age (in years)	Total number of injured persons	In percent (%)
18-25	9	2.7
25-35	56	16.7
35-45	67	19.9
45-64	204	60.7
TOTAL	336	100 %

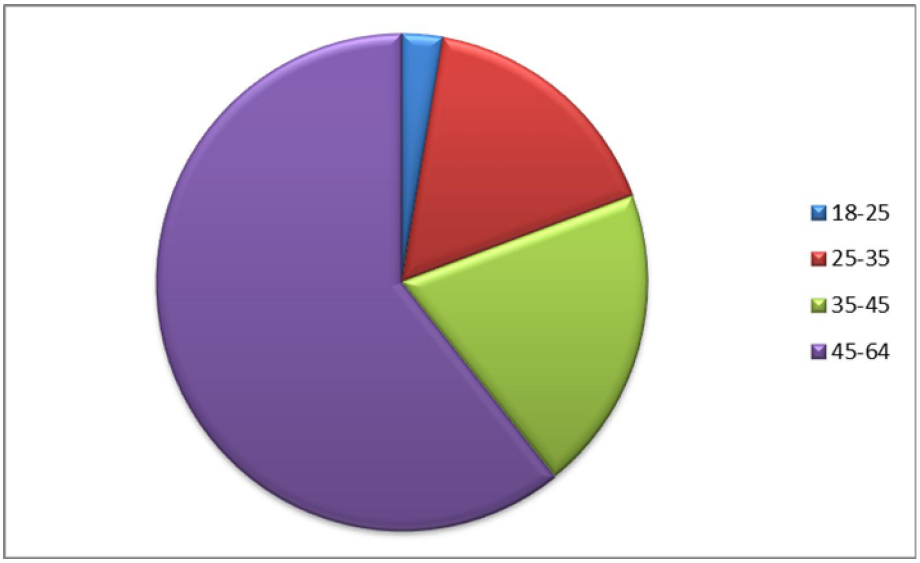

Fig. 3. Illustrated view on the information given into Table 5

3 CONCLUSION

The basic aim of this paper is to represent the results from the long term research, on the field of Safety at work places, or to be more specific the number and the nature of the spotted work injuries in Bitola's region in the period of research January 2012 – December 2012. All of the activities from the research are part of the long term aims of the NGO Bitola from Bitola, R. Macedonia. Actually if you see the results, the conclusion is that there is no way to avoid work injuries during the work period of the day (no meter of the organization), but conclusion is also that with continuous efforts in a matter of education of the employees, appropriate ergonomically analyses on every single work place, appropriate and on time evaluation of the work risks and continuous usage of the HTZ equipment and many other activities, are key elements for reduced number of injuries. Considering that all of the Macedonian enterprises, according to the legislation and national laws, must have an expert from the field of Safety on work places, and considering the results from the research from the past years, conclusion is that the results are more and more positive from year to year (reduced number of injuries), but always can be done more.

REFERENCES

[1] I. Kuzmanov, "*Branding and implementing an OSHAS 18001 and ISO 9001:2008 in a real industrial system",* PhD. dissertation, Faculty of Technical Science in Bitola, pp. 107-120, 2012

[2] I. Kuzmanov, Z. Angelevski, "*Conducted research on the number of injuries into Bitola's region in 2012*", NGO Bitola from Bitola, 2012

[3] S. Angelevska, I. Kuzmanov, Z. Angelevski, "*Survey of the number of injuries related with work places in Bitola Region", International Scientific Magazine HORIZONS*, pp. 33-36, Volume 8, December 2012.

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Relationship between Dividend Payout and Economic Value Added: A Case of Square Pharmaceuticals Limited, Bangladesh

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ABSTRACT: The financial goal of a firm is to maximise the economic welfare of the owners. Owners' economic welfare could be maximised by maximising the shareholders wealth as reflected in the market value of shares. The value of shares is represented by their market price which is a reflection of the firm's financial decisions that include investment or long-term asset-mix decision, financing or capital-mix decision and dividend or profit allocation decision. Among the critical decisions, decision relating to dividend is the most crucial as the financial manager must decide whether the firm should distribute all profits or retain them or distribute a portion and retain the balance. However, the preachers of shareholders value theory have discouraged distribution of earnings in the form of dividend as it implies inefficiency on the part of the management towards shareholder's wealth maximisation. Taking this argument into account, this paper attempts to study the relationship between dividend payout and economic value added (EVA), an indicator to shareholders wealth creation, introduced by United States based consultants Stern Stewart and Company, New York, in 1990, using data of Square Pharmaceutical Limited (SPL), one of the largest pharmaceutical companies in Bangladesh, for the periods 2004-05 to 2010-11. Using simple regression equation method, the study comes to the conclusion that there is an inverse relationship between dividend payout and EVA and recommends SPL to continue the existing dividend policy of retaining a bulky portion of earnings rather than high payout ratio.

KEYWORDS: Dividend, retained earnings, economic value added, cost of capital employed, shareholders wealth.

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1 INTRODUCTION

1.1 RATIONALE OF THE STUDY

Maximising shareholders wealth has become a new corporate paradigm due to globalization, rapid and complex changes in the economic and business environment as well as intense competition in every field of economic activity. To maintain competitiveness, sustain and attain the objective of shareholders wealth maximisation, corporate managers have to make critical, strategic and time oriented business and financial decisions. Among them, decision relating to dividend (distribution of earnings among the shareholders in proportion to their ownership) is the most important as the company has to choose between distributing the profits to the shareholders as dividend and ploughing them back into the business as retained earnings. Therefore it is imperative for SPL to access the current dividend policy and its impact on shareholders wealth creation on the basis of the relationship between dividend payout and EVA in order to decide whether to continue the existing dividend policy or to incorporate a new one that is consistent with the goal of maximising the company's stock price which leads to maximisation of shareholders wealth and thereby ensures more rapid economic growth [1]. The study shows the relationship between dividend payout and shareholders wealth creation on an individual firm basis as the importance of dividend varies from one industry to another even from one firm to another within the same industry.

1.2 LITERATURE REVIEW

The study aims at adding a conclusion on the matter that whether dividend payment positively or negatively affects shareholders wealth maximisation that is represented in the market price of the company's common stock. This section focused on the thoughts regarding the impact of different dividend policy on shareholders value creation and wealth maximisation. The first thought is that the company should retain the earnings if it has profitable investment opportunities that will earn a return more than the cost of capital. In such a case the market price of shares will be maximised by ploughing back the earnings. This policy of retaining earnings, instead of paying dividend in cash, is supported by the empirical work of Friend and Puckett [2]; Diamond [3]; and Barker et al. [4]. Litzenberger and Ramaswamy [5] stated that firms could increase their share price by reducing dividends. The second thought is that if the company does not have any profitable investment opportunities, the shareholders will be better off if earnings are paid out to them so as to enable them to earn a higher return by using the funds elsewhere. In such a case, the market price of shares will be maximised by the distribution of the earnings as dividend. This policy of paying dividend, instead of retaining earnings, is supported by the study of Gordon and Shapiro [6], Gordon [7], [8], Lintner [9], Walter [10], Barker et al. [11], Partington [12]. They argued for the bird in the hand theory, suggesting that investors prefer dividends rather than capital gains because of their certainty. Al-Malkawi, Rafferty and Pillai [13] support this theory by arguing that "a dollar of dividends has, on average, four times the impact on stock prices as a dollar of retained earnings". Therefore the companies which adopt low dividend payout rate policy are not favoured by investors. Because shareholders can choose to sell the shares if they are not satisfied with the dividend policy, these companies may experience a drop in their share prices. In their study, Barker and Powell [14] surveyed 603 cheif financial officers of US firm listed in New York stock exchange and observed that 90% of the total respondents believed that dividend payout policy positively affects a firm's value and therefore shareholders wealth. The third and final thought is the philosophy of dividend irrelevance introduced by Miller and Modigliani [15] which stated that with the presence of perfect capital markets and rational investors, shareholders wealth is not affected by the dividend decision. They revealed that shareholders wealth is affected by the income generated by the investment decision a firm makes, not by how it distributes that income. Dividend irrelevance is supported by the empirical research conducted by leading financial economic researchers such as Black and Scholes [16], Miller and Scholes [17], [18], Hess [19], Miller [20], Siddiqi [21], Bernstein [22], and Casey and Dickens [23]. Their studies suggested that dividend policy makes no difference on either share prices or the cost of equity. So empirical study showed mixed evidence about the relationship between dividend payout and shareholders wealth creation. Therefore, an attempt has been made in this study to unfold the relationship between dividend payout and shareholders wealth creation by using simple regression technique and taking SPL as example. One recent innovation that depicts a clear picture of whether a business is creating or destroying shareholder wealth is EVA. EVA is considered to be the best known of the shareholder value metrics [24]. EVA is the difference between net operating profit after tax (NOPAT) and the required return of the financing of debt and equity. If EVA is positive, the firm has created value for the shareholders over the periods and if EVA is negative, it connotes the firm is destroying shareholders wealth. In a rational market, maximising EVA should maximise the company's share price and hence the shareholders wealth [25]. Therefore, this study takes EVA as the indicator to shareholders value creation and wealth maximisation and concludes on its relationship with dividend payout.

1.3 OBJECTIVES OF THE STUDY

The study has been conducted with the principal objective of determining the relationship between dividend payout and EVA i.e. whether there is an inverse or a positive impact of dividend payout on shareholders wealth creation expressed in terms of EVA. To accomplish this objective, the study covers the following specific objectives:

(i) To calculate EVA for SPL for the periods 2004-05 to 2010-11.
(ii) To appraise whether SPL has created wealth to the shareholders during the study periods.

2 MATERIALS AND METHODS

The nature of the research design was exploratory. Case study method was used to measure the value addition by SPL to shareholders. The study used only secondary data that were collected from published annual reports of SPL, books, journals and Dhaka stock exchange (DSE) limited and used with due care as per the requirements of the study. To analyse the data, statistical tools that had been used were simple regression technique and student's 't' test at 5% level of significance. For this purpose, total dividend paid in a year (Y) was taken as a dependent variable and EVA (X) as an independent variable. Bangladesh government investment bond yield 6.5% was taken as the risk free rate of return in this study. Capital asset pricing model was used to calculate the cost of equity. The data used for the analysis were relating to SPL for the periods of 7 years (2004-05 to 2010-11). The hypotheses used were:

Null hypothesis (H_o): There is a positive relationship between dividend payout and EVA.

Alternative hypothesis (H_1): There is an inverse relationship between dividend payout and EVA.

The study used the following methodology to calculate EVA:

(i) EVA = NOPAT – Cost of capital employed (COCE);
(ii) NOPAT = Operating profit × (1 - t), where t = tax rate;
(iii) COCE = Capital employed × Weighted average cost of capital (WACC);
(iv) Capital employed = Shareholders equity + Long-term loans;
(v) WACC = = $k_1.K_d + k_2.K_e$ + ...
Where, $K_{1,2}$ = Weights of individual sources in the capital structure, K_d = Cost of debt, K_e = Cost of equity;
(vi) Cost of debt (K_d) = I × (1-t), where I = Interest rate, t = tax rate;
(vii) Cost of equity is the return expected by the investors to compensate them for the variability in return caused by fluctuating earnings and prices. Cost of equity (K_e):

$= R_f + (R_m - R_f) \times \beta$

$= 6.5\% + (5.83\% - 6.5\%) \times 0.58$

$= 6.11\%$

For calculation of R_m (Expected market rate of return) and β (beta), annexure may kindly be referred;

(viii) Interest rate, on an average, was taken as 12% per annum;
(ix) Tax rate was taken as 27.5% as SPL is a publicly traded company.

3 RESULTS AND DISCUSSION

Table 1 reveals the calculation of EVA of SPL for the study periods. The result shows that SPL has added value to the shareholders consistently during 2004-05 to 2010-11. EVA growth rate as compared to base year 2004-05 are positive in the following years that indicate the good economic earning capacity of SPL, the precondition to maximise shareholders wealth. A company that has generated a positive EVA connotes efficient management of shareholders invested funds and the company is in the right track. Therefore, during the study periods SPL has added wealth to the shareholders by productive employment of their invested funds.

Table 1. Table showing EVA Trends: 2004-05 to 2010-11

(Bangladeshi Taka in crores)

Particulars	Years						
	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
Shareholders equity*	556.87	640.20	733.32	841.70	994.93	1155.43	1381.77
Long-term loans*	38.91	60.23	49.25	60.25	44.97	103.26	65.56
Capital employed	595.78	700.43	782.57	901.95	1039.90	1258.69	1447.33
K_e (%)	6.11	6.11	6.11	6.11	6.11	6.11	6.11
K_d (%)	8.70	8.70	8.70	8.70	8.70	8.70	8.70
WACC (%)	6.28	6.33	6.27	6.28	6.22	6.32	6.22
COCE	37.41	44.33	49.06	56.64	64.68	79.55	90.02
NOPAT*	96.98	114.56	132.36	123.92	171.71	194.99	218.98
EVA	59.57	70.23	83.30	67.28	107.03	115.44	128.96
EVA growth (%)	--	17.89	39.83	12.94	79.67	93.78	116.48

Source: SPL annual reports: 2004-05 to 2010-11.

Table 2 and 3 provide necessary calculations to conclude on whether dividend payout has positive or negative relationship with EVA during the study periods using 't' distribution at 95% confidence level. Table 2 shows that SPL has followed the policy of retaining a significant portion of its earnings per share (EPS) in each year. On an average, SPL has retained 73.20% of its earnings per share during 2004-05 to 2010-11 i.e. for every Taka 100 earnings, the company has paid Taka 26.80 cash to the shareholders as dividend per share (DPS). This policy of retaining higher portion of earnings expressed that SPL had investment opportunities with positive net present value (NPV). The positive value addition shown in Table 1 is the reflection of that policy which express the increasing trend of value addition to shareholders and that is well backed-up by the result of 't' test shown in Table 3. Table 3 shows that the calculated 't' value is 5.28 while the table value at 5% level of significance with 6 (7-1) degrees of freedom is 1.94. Since the calculated value is more than the table value, alternative hypothesis is accepted i.e. there is an inverse relationship between dividend payout and EVA for SPL during the study periods. Hereby, it is concluded that the company namely SPL has added value to the shareholders during 2004-05 to 2010-11 by declaring and paying less dividend out of total earnings and using the retained funds for investing in profitable ventures.

Table 2. Table showing the relationship between dividend payout and EVA

(Bangladeshi Taka in crores)

Years	EVA (X)	Cash divided* (Y)	X^2	XY	EPS* (Taka)	Cash DPS* (Taka)	Retention Ratio (%)
2004-05	59.57	33.26	3548.58	1981.29	290.71	77.00	73.51
2005-06	70.23	37.26	4932.25	2616.76	234.67	75.00	68.04
2006-07	83.30	29.80	6938.89	2482.34	145.74	50.00	65.69
2007-08	67.28	35.76	4526.59	2405.93	154.53	40.00	74.11
2008-09	107.03	48.28	11455.42	5167.40	156.56	40.00	74.45
2009-10	115.44	52.81	13326.39	6096.38	138.36	35.00	74.70
2010-11	128.96	58.85	16630.68	7589.29	166.05	30.00	81.93
	631.81	296.02	61358.80	28339.39			

Source: SPL annual reports: 2004-05 to 2010-11.

$$b = \frac{n.\sum XY - \sum X \sum Y}{n.\sum X^2 - \left(\sum X\right)^2}$$

= 0.37

$$a = \frac{\sum Y}{n} - \frac{b.\sum X}{n}$$

= 8.89

Y = a +b X

= 8.89 + 0.37 X

Table 3. Table showing the standard error of estimate

Years	EVA (X)	Cash divided (Y)	$\hat{Y}$	$(Y-\hat{Y})^2$	$(X-\bar{X})^2$
2004-05	59.57	33.26	30.93	5.42	941.26
2005-06	70.23	37.26	34.87	5.71	400.80
2006-07	83.30	29.80	39.71	98.20	48.30
2007-08	67.28	35.76	33.78	3.92	527.62
2008-09	107.03	48.28	48.49	0.04	281.56
2009-10	115.44	52.81	51.60	1.46	634.53
2010-11	128.96	58.85	56.60	5.06	1498.46
	631.81	296.02		119.81	4332.53

$$\sigma = \sqrt{\frac{\Sigma\left(Y-\hat{Y}\right)^2}{n-2}}$$

= 4.89

Calculated 't' value:

$$t = \frac{\hat{b}}{\hat{\sigma}.\sqrt{\frac{1}{\sum(X-\bar{X})^2}}}$$

= 5.28

4 CONCLUSION

The goal of financial management is to create and maximise wealth of the shareholders, as reflected by company's share price that can be attained by using one of the two variables- (i) paying dividend at a consistent rate and (ii) retaining earnings instead of paying dividend and investing in positive NPV projects. The literature on dividend policy however has produced mixed and inconclusive results as to which alternative use is consistent with the objective of value creation for shareholders. Therefore, this study attempts to add a conclusion on the matter that whether dividend payout affects shareholders wealth. For this purpose, the study used EVA as a measurement tool to shareholders value creation and wealth maximisation as it correlates better with stock price than any other measures: by 50%, compared with up to 30% for other metrics [26]. Hypothesis statements were framed and testing carried out using 't' distribution. The test revealed that, as far as the SPL concerned, EVA is negatively influenced by the dividend payout. For SPL, retained earnings act as an important source of financing in positive NPV projects that positively affects the value addition to the shareholders. SPL has taken all the necessary steps to ensure the effective use of funds, both invested and retained, by taking priority to increase the wealth of the shareholders. The study, therefore, highly recommends SPL to continue the current residual dividend policy of paying dividends out of earnings, only after investing in positive NPV projects, if any, rather than high payout ratio. The study also recommends SPL to (a) incorporate a remuneration system to managers in terms of a proportion to the total EVA and the positive growth in EVA that will motivate them in guiding company's systems, strategies, processes, techniques and cultures towards the maximisation of shareholders wealth and (b) disclose a statement on EVA with financial statements as an additional disclosure so that shareholders would be better informed which would contribute in attracting new investors and the reduction of additional debts.

REFERENCES

[1] S. N. Mageshwari, Financial management: principles and practices, 6th revised Ed., *S. Chand & Sons,* 1992.

[2] I. Friend and M. Puckett, "Dividend and stock prices", *American Economic Review*, vol. 54, no. 5, pp. 656-682, 1964.

[3] J. J. Diamond, "Earnings distribution and the valuation of shares: some recent evidence", *Journal of Financial and Quantitative Analysis*, vol. 2, no. 1, pp. 15-30, 1967.

[4] H. K. Barker, E. P. Gary, and E. T. Veit, "Revisiting the dividend puzzle: do all of the pieces now fit?," *Review of Financial Economics*, vol. 11, no. 4, pp. 241-261, 2002.

[5] R. H. Litzenberger and K. Ramaswamy, "The effect of personal taxes and dividends on capital asset prices", *Journal of Financial Economics*, vol. 7, pp. 163-195, 1979.

[6] M. J. Gordon and E. Shapiro, "Capital equipment analysis: the required rate of profit", *Management Science*, vol. 3, no. 1, pp. 102-110, 1956.

[7] M. J. Gordon, "Dividends, earnings, and stock prices", *Review of Economics and Statistics*, vol. 41, no. 2, pp. 99-105, 1959.

[8] M. J. Gordon, "Optimal investment and financing policy", *Journal of Finance*, vol. 18, no. 2, pp. 264-272, 1963.

[9] J. Lintner, "Dividends, earnings, leverage, stock prices and supply of capital to corporations", *The Review of Economics and Statistics*, vol. 64, pp. 243-269, 1962.

[10] J. E. Walter, "Dividend policy: its influence on the value of the enterprise", *Journal of Finance*, vol. 18, no. 2, pp. 280-291, 1963.

[11] H. K. Baker, G. E. Farrelly, and R. B. Edelman, "A survey of management views on dividend policy", *Financial Management*, vol. 14, no. 3, pp. 78-84, 1985.

[12] G. H. Partington, "Dividend policy and its relationship to investment and financing policies: empirical evidence", *Journal of Business Finance and Accounting*, vol. 12, no. 4, pp. 531-542, 1985.

[13] H. Al-Malkawi, M. Rafferty, and R. Pillai, "Dividend Policy: A review of theories and empirical evidence", *International Bulletin of Business Administration*, Issue 9, pp. 171-200, 2010.

[14] H. K. Baker and G. E. Powell, "How corporate managers view dividend policy", *Quarterly Journal of Business and Economics*, vol. 38, no. 2, pp. 17-35, 1999.

[15] M. H. Miller and F. Modigliani, "Dividend policy, growth and the valuation of shares", *Journal of Business*, vol. 34, no. 4, pp. 411-433, 1961.

[16] F. Black and M. Scholes, "The effects of dividend yield and dividend policy on common stock prices and returns", *Journal of Financial Economics*, vol. 1, no. 1, pp. 1-22, 1974.

[17] M. H. Miller and M. S. Scholes, "Dividends and taxes", *Journal of Financial Economics*, vol. 6, pp. 333-264, 1978.

[18] M. H. Miller and M. S. Scholes, "Dividend and taxes: some empirical evidence", *Journal of Political Economy*, vol. 90, no. 6, pp. 1118-1141, 1982.

[19] P. J. Hess, "The dividend debate: 20 years of discussion, in the revolution in corporate finance", *Blackwell Publishers*, Cambridge, 1981.

[20] M. H. Miller, "Behavioral rationality in finance: the case of dividends", *Journal of Business*, vol. 59, no. 4, pp. 451-468, 1986.

[21] M. A. Siddiqi, "An indirect test for dividend relevance", *Journal of Financial Research*, vol. 18, no. 1, pp. 89-101, 1995.

[22] P. L. Bernstein, "Dividends: the puzzle", *Journal of Applied Corporate Finance*, vol. 9, no. 1, pp. 16-22, 1996.

[23] K. M. Casey and R. N. Dickens, "The effect of tax and regulatory changes in commercial bank dividend policy", *Quarterly Review of Economics and Finance*, vol. 40, pp. 279-293, 2000.

[24] J. Brown, D. Macaskill, and H. Owen, "The Stern Stewart and Marakon shareholder value added metrics: a comparative study with implications for the management accountant", Napier university business school, paper presented at the BAA (Scotland) conference, pp. 37, 2000.

[25] M. Kumar and V. Charles, "Productivity growth as the predictor of shareholders wealth maximization: an empirical investigation", *Journal of CENTRUM Cathedra*, vol. 2, no. 1, pp. 73-84, 2009.

[26] J. M. Stern and J. S. Shiely, The EVA challenge: implementing value-added change in an organization, *John Wiley & Sons,* New York, 2004.

ANNEXURE

(i) R_m calculation

Years	Initial share price* (Taka)	Closing share price* (Taka)	Capital appreciation	Cash DPS** (Taka)	Total (Taka)
2004-05	2367.00	3768.75	1401.75	77.00	1478.75
2005-06	3744.75	2276.25	(1468.50)	75.00	(1393.50)
2006-07	2259.00	2447.50	188.50	50.00	236.5
2007-08	2425.25	4110.25	1685.00	40.00	1725.00
2008-09	4189.50	2935.50	(1254.00)	40.00	(1214.00)
2009-10	2921.75	3581.00	659.25	35.00	694.25
2010-11	3575.00	3272.00	(303.00)	30.00	(273.00)
	21482.25				1254.00

Source: *DSE limited and **SPL annual reports: 2004-05 to 2010-11.

$$R_m = \frac{1254.00}{21482.25}$$

$$= 0.0583$$

$$= 5.83\%$$

(ii) β calculation

Years	DSE Index* (Taka)	Share price of SPL* (Taka)	Market excess return (x)	Portfolio excess return (y)	x^2	y^2	xy
2003-04	973.88	2,272.00	--	--	--	--	--
2004-05	1919.25	3,768.75	97.07	65.87	9422.58	4338.85	6394.00
2005-06	1491.77	2,276.25	(22.27)	(39.60)	495.95	1568.16	881.89
2006-07	1760.87	2,447.50	18.03	7.52	325.08	56.55	135.58
2007-08	3016.48	4,110.25	71.30	67.93	5083.69	4614.48	4843.40
2008-09	2446.92	2,935.50	(18.88)	(28.58)	356.45	816.81	539.59
2009-10	5582.33	3581.00	128.13	21.98	16417.29	483.12	2816.29
2010-11	6352.10	3272.00	13.79	(8.63)	190.16	74.47	(119.00)
			287.17	86.49	32291.20	11952.44	15491.75

Source: *DSE limited.

$$\beta = \frac{n.\sum xy - \sum x \sum y}{n.\sum x^2 - \left(\sum x\right)^2}$$

$$= 0.58$$

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Generalized Mittag-Leffler function method for solving Lorenz system

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ABSTRACT: In this paper, generalizations Mittag-Leffler function method is applied to solve approximate and analytical solutions of nonlinear fractional differential equation systems such as lorenz system of fractional oreder, and compared the results with the results of Homotopy perturbation method (HPM) and Variational iteration method (VIM) in the standard integer order form. The reason of using fractional order differential equations (FOD) is that fractional order differential equations are naturally related to systems with memory which exists in most systems. Also they are closely related to fractals which are abundant in systems. The results derived of the fractional system are of a more general nature. Respectively, solutions of fractional order differential equations spread at a faster rate than the classical differential equations, and may exhibit asymmetry. A few numerical methods for fractional differential equations models have been presented in the literature. However many of these methods are used for very specific types of differential equations, often just linear equations or even smaller classes put the results generalizations Mittag-Leffler function method show the high accuracy and efficiency of the approach. A new solution is constructed in power series. The fractional derivatives are described by Caputo's sense.

KEYWORDS: Lorenz system, Caputo fractional derivative, Mittag-Leffler function.

1 INTRODUCTION

Between a large number of chaotic systems obvious that the Lorenz model is the most classical and paradigmatic problem because it was the first model of chaotic behaviour. the Lorenz model is a simplification of a previous more complicated model of Saltzman to describe buoyancy driven convection patterns in the classical rectangular Rayleigh–Bénard problem applied to the thermal convection between two plates perpendicular to the direction of the Earth's gravitational force [1]-[5]. The components of the basic tree-component model are proportional to the convective velocity, the temperature difference between descending and ascending flows, and the mean convective heat flow is denoted respectively by *x(t), y(t), z(t).* The famous Lorenz equations are [6]:

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$$\frac{dx}{dt} = s(y-x),$$
$$\frac{dy}{dt} = r\,x - y - xz, \qquad (1.1)$$
$$\frac{dz}{dt} = xy - bz.$$

with the initial conditions:

$$x(0) = M_1, \qquad y(0) = M_2\ , \qquad z(0) = M_3\ . \qquad (1.2)$$

s, b are real constants, and r so-called bifurcation parameter.

Now we introduce the generalized chaotic dynamical system (Lorenz system). The system is described by the following system of fractional differential equations:

$$D^{\alpha_1} x = s(y-x),$$
$$D^{\alpha_2} y = r\,x - y - xz, \qquad \text{where} \qquad 0 \prec \alpha_1,\ \alpha_2, \alpha_3 \le 1 \qquad (1.3)$$
$$D^{\alpha_3} z = xy - bz.$$

Where D^{α_i} , $i = 1,2,3$ is the derivative of order α_i in the sense of Caputo.

with the initial conditions

$$x(0) = M_1, \qquad y(0) = M_2\ , \qquad z(0) = M_3\ . \qquad (1.4)$$

The purpose of using fractional differential equations is that The fractional calculus approach provides a powerful tool for the description of memory and hereditary properties of various materials and processes [7]–[14]. It has been applied to many fields in science and engineering, such as viscoelasticity, anomalous diffusion, fluid mechanics, biology, chemistry, acoustics, control theory, etc.

The motivation of this paper is the application of the generalizations Mittag-Leffler function method for solving generalized lorenz system and compared the results with the results of Homotopy perturbation method (HPM) and Variational iteration method (VIM) in the standard integer order form [6].This method used by Rida and Arafa for solving Linear fractiona differential equations [15].

2 BASIC DEFINITIONS

In this section, we mention the basic definitions of the fractional calculus.

2.1 DEFINITION:

The fractional derivative of *f*(x) in the Caputo sense is defined as:

$$D^{\alpha} f(x) = J^{n-\alpha} D^{n} f(x) = \frac{1}{\Gamma(n-\alpha)} \int_0^x (x-t)^{n-\alpha-1} f^{(n)}(t)\, dt \qquad (2.1.1)$$

for $n-1 \prec \alpha \le n,\ n \in N,\quad x \succ 0$, for the caputo derivative we have $D^{\alpha} c = 0$, c is constant

$$D^{\alpha} t^{m} == \begin{cases} 0 & m \le \alpha - 1 \\ \frac{\Gamma(m+1)}{\Gamma(m-\alpha+1)} t^{m-\alpha}\ , & m > \alpha - 1 \end{cases} \qquad (2.1.2)$$

2.2 DEFINITION

For n to be the smallest integer that exceeds α, the Caputo fractional derivatives of order α > 0 is defined as

$$D^{\alpha}u(x,t)=\frac{\partial^{\alpha}u(x,t)}{\partial t^{\alpha}}=\begin{cases}\frac{1}{\Gamma(n-\alpha)}\int_0^t(t-\tau)^{n-\alpha+1}\frac{\partial^n u(x,\tau)}{\partial\tau^n}d\tau, & for\ n-1<\alpha\le n,\\ \frac{\partial^n u(x,t)}{\partial t^n}, & for\ \alpha=n\in N.\end{cases} \quad (2.2.1)$$

3 ANALYSIS OF THE METHOD

The Mittag-Leffler (1902–1905) functions $E_{\alpha}\ and\ E_{\alpha,\beta}$ [16], defined by the power series

$$E_{\alpha}=\sum_{n=0}^{\infty}\frac{z^n}{\Gamma[n\alpha+1]}\quad,\quad E_{\alpha,\beta}=\sum_{n=0}^{\infty}\frac{z^n}{\Gamma[n\alpha+\beta]}\ ,\qquad \alpha,\beta\succ 0 \quad (3.1)$$

have already proved their efficiency as solutions of fractional order differential and integral equations and thus have become important elements of the fractional calculus theory and applications.

In this paper, we will show how to solve system of nonlinear fractional differential equations(lorenz system) through the imposition of the generalized Mittag-Leffler function $E_{\alpha}(z)$. The generalized Mittag-Leffler method suggests that $y_i(t),\quad i=1,2,3,...$ are decomposed by an infinite series of components [15]:

$$y_i(t)=E_{\alpha}(a_i\,t^{\alpha})=\sum_{n=0}^{\infty}a_i^n\frac{t^{n\alpha}}{\Gamma[n\alpha+1]}\ ,\qquad i=1,2,3,... \quad (3.2)$$

We will use the following definitions of fractional calculus:

$$D^{\alpha}y_i(t)=\sum_{n=1}^{\infty}a_i^n\frac{t^{(n-1)\alpha}}{\Gamma[(n-1)\alpha+1]}\ ,\qquad i=1,2,3,... \quad (3.3)$$

This are based on the Caputo fractional is derivatives. The convergence of the Mittag Leffler function discussed in [16].

4 APPLICATIONS AND RESULTS

In this section, we applied the generalized Mittag-Leffler function method for solving system of fractional differential equations (lorenz system).and Compare the results with the results of other two methods. Considering the fractional lorenz system:

$$\begin{aligned}&D^{\alpha_1}x=s(y-x),\\ &D^{\alpha_2}y=r\,x-y-xz,\\ &D^{\alpha_3}z=xy-bz.\end{aligned}\qquad 0\prec\alpha_1,\ \alpha_2,\alpha_3\le 1 \quad (4.1)$$

with the initial conditions

$$x(0)=M_1\ ,\qquad y(0)=M_2\ ,\qquad z(0)=M_3\ . \quad (4.2)$$

By using generalized Mittag-Leffler function method we put

$$x(t) = E_\alpha(at^\alpha) = \sum_{n=0}^{\infty} a^n \frac{t^{n\alpha}}{\Gamma[n\alpha+1]},$$
$$y(t) = E_\alpha(dt^\alpha) = \sum_{n=0}^{\infty} d^n \frac{t^{n\alpha}}{\Gamma[n\alpha+1]}, \quad (4.3)$$
$$z(t) = E_\alpha(lt^\alpha) = \sum_{n=0}^{\infty} l^n \frac{t^{n\alpha}}{\Gamma[n\alpha+1]}$$

By using (4.3) and (3.3) into (4.1) when $\alpha_1, \alpha_2, \alpha_3 = \alpha$ we find this relation

$$\sum_{n=1}^{\infty} \frac{a^n t^{(n-1)\alpha}}{\Gamma[(n-1)\alpha+1]} - s\sum_{n=0}^{\infty} \frac{d^n t^{n\alpha}}{\Gamma[n\alpha+1]} + s\sum_{n=0}^{\infty} \frac{a^n t^{n\alpha}}{\Gamma[n\alpha+1]} = 0,$$
$$\sum_{n=1}^{\infty} \frac{d^n t^{(n-1)\alpha}}{\Gamma[(n-1)\alpha+1]} - r\sum_{n=0}^{\infty} \frac{a^n t^{n\alpha}}{\Gamma[n\alpha+1]} + \sum_{n=0}^{\infty} \frac{d^n t^{n\alpha}}{\Gamma[n\alpha+1]} + \sum_{n=0}^{\infty} c_1^n t^{n\alpha} = 0, \quad (4.4)$$
$$\sum_{n=1}^{\infty} \frac{l^n t^{(n-1)\alpha}}{\Gamma[(n-1)\alpha+1]} - \sum_{n=0}^{\infty} c_2^n t^{n\alpha} + b\sum_{n=0}^{\infty} \frac{l^n t^{n\alpha}}{\Gamma[n\alpha+1]} = 0$$

Combining the alike terms and replacing (n) by (n +1) in the first sum, we assume the form

$$\sum_{n=0}^{\infty} \frac{a^{n+1} t^{n\alpha}}{\Gamma[n\alpha+1]} - s\sum_{n=0}^{\infty} \frac{d^n t^{n\alpha}}{\Gamma[n\alpha+1]} + s\sum_{n=0}^{\infty} \frac{a^n t^{n\alpha}}{\Gamma[n\alpha+1]} = 0,$$
$$\sum_{n=0}^{\infty} \frac{d^{n+1} t^{n\alpha}}{\Gamma[n\alpha+1]} - r\sum_{n=0}^{\infty} \frac{a^n t^{n\alpha}}{\Gamma[n\alpha+1]} + \sum_{n=0}^{\infty} \frac{d^n t^{n\alpha}}{\Gamma[n\alpha+1]} + \sum_{n=0}^{\infty} c_1^n t^{n\alpha} = 0, \quad (4.5)$$
$$\sum_{n=0}^{\infty} \frac{l^{n+1} t^{n\alpha}}{\Gamma[n\alpha+1]} - \sum_{n=0}^{\infty} c_2^n t^{n\alpha} + b\sum_{n=0}^{\infty} \frac{l^n t^{n\alpha}}{\Gamma[n\alpha+1]} = 0$$

Where

$$c_1^n = \sum_{k=0}^{n} \frac{a^k l^{n-k}}{\Gamma[k\alpha+1]\Gamma[(n-k)\alpha+1]},$$
$$c_2^n = \sum_{k=0}^{n} \frac{a^k d^{n-k}}{\Gamma[k\alpha+1]\Gamma[(n-k)\alpha+1]} \quad (4.6)$$

We have

$$\sum_{n=0}^{\infty} (a^{n+1} - sd^n + sa^n) \frac{t^{n\alpha}}{\Gamma[n\alpha+1]} = 0,$$
$$\sum_{n=0}^{\infty} (d^{n+1} - ra^n + d^n + c_1^n \Gamma[n\alpha+1]) \frac{t^{n\alpha}}{\Gamma[n\alpha+1]} = 0, \quad (4.7)$$
$$\sum_{n=0}^{\infty} (l^{n+1} - c_2^n \Gamma[n\alpha+1] + bl^n) \frac{t^{n\alpha}}{\Gamma[n\alpha+1]} = 0$$

With the coefficient of $t^{n\alpha}$ equal to zero and identifying the coefficients, we obtain recurrence relations:

$$\begin{aligned} &a^{n+1} - sd^n + sa^n = 0\ , \\ &d^{n+1} - r\,a^n + d^n + c_1^n\,\Gamma[n\alpha+1] = 0\,, \\ &l^{n+1} - c_2^n\,\Gamma[n\alpha+1] + b\,l^n = 0 \end{aligned} \qquad (4.8)$$

we can obtain a few first terms being calculated:

$$a^0 = M_1\ ,\quad d^0 = M_2\ ,\qquad l^0 = M_3\ .$$

When n=0 we have

$$\begin{aligned} &a^1 = s(M_2 - M_1), \\ &d^1 = rM_1 - M_2 - M_1M_3\,, \\ &l^1 = M_1M_2 - b\,M_3\,. \end{aligned}$$

When n=1 we have

$$\begin{aligned} &a^2 = s(r\,M_1 - M_2 - M_1M_3 - s\ M_2 + s\,M_1), \\ &d^2 = r\,s\,(M_2 - M_1) - r\,M_1 + M_2 + M_1M_3 - {M_1}^2M_2 + b\,M_3M_1 - s\,M_2M_3 + s\,M_3M_1\,, \\ &l^2 = r\,{M_1}^2 - M_1M_2 - {M_1}^2M_3 + s\,{M_2}^2 - s\,M_1M_2 - b\,M_1M_2 + b^2M_3\,. \end{aligned}$$

When n=2 we have

$$\begin{aligned} a^3 &= r\,s^2\,(M_2 - M_1) - r\,s\,M_1 + s\,M_2 + s\,M_1M_3 - s\,{M_1}^2M_2 + s\,b\,M_3M_1 - s^2\,M_2M_3 \\ &\quad + s^{\,2}M_3M_1 - s^2r\,M_1 + s^2\,M_2 + s^2\,M_1M_3 + s^3\,M_2 - s^3M_1\,, \\ d^3 &= r\,s\,(r\,M_1 - M_2 - M_1M_3 - s\,M_2 + s\,M_1) - r\,s\,(M_2 - M_1) + r\ M_1 - M_2 - M_1M_3 \\ &\quad + {M_1}^2M_2 - b\,M_3M_1 + s\,M_2M_3 - s\,M_3M_1 - r\,{M_1}^3 + {M_1}^2M_2 + {M_1}^3M_3 - s\,M_1{M_2}^2 \\ &\quad + s\,{M_1}^2M_2 + b\,{M_1}^2M_2 - b^2M_1M_3 - s\,M_3\,(r\,M_1 - M_2 - M_1M_3 - s\,M_2 + s\,M_1) \\ &\quad - (s\,M_2 - s\,M_1)(M_1M_2 - b\,M_3)\frac{\Gamma(2\alpha+1)}{\Gamma(\alpha+1)^2}\ , \\ l^3 &= r\,s\,M_1\,(M_2 - M_1) - r\,{M_1}^2 + M_1M_2 + {M_1}^2M_3 - M_1({M_1}^2M_2 - b\,M_1M_3) - s\,M_1M_2M_3 \\ &\quad + s\,{M_1}^2M_3 + s\,M_2\,(r\,M_1 - M_2 - M_1M_3 - s\,M_2 + s\,M_1) + s\,(M_2 - M_1)(r\,M_1 - M_2 - M_1\,M_3)\frac{\Gamma(2\alpha+1)}{\Gamma(\alpha+1)^2} \\ &\quad - b\,r\,{M_1}^2 + b\,M_1M_2 + b\,{M_1}^2M_3 - s\,b\,{M_2}^2 + s\,b\,M_1M_2 + b^2\,M_1M_2 - b^3M_3\ . \end{aligned}$$

Compensation from the previous recurrence relations in this series

$$x(t) = \sum_{n=0}^{\infty} a^n\,\frac{t^{n\alpha}}{\Gamma[n\alpha+1]} = a^0 + a^1\,\frac{t^{\alpha}}{\Gamma[\alpha+1]} + a^2\,\frac{t^{2\alpha}}{\Gamma[2\alpha+1]} + a^3\,\frac{t^{3\alpha}}{\Gamma[3\alpha+1]} + a^4\,\frac{t^{4\alpha}}{\Gamma[4\alpha+1]} + \ldots\ldots$$

$$y(t) = \sum_{n=0}^{\infty} d^n\,\frac{t^{n\alpha}}{\Gamma[n\alpha+1]} = d^0 + d^1\,\frac{t^{\alpha}}{\Gamma[\alpha+1]} + d^2\,\frac{t^{2\alpha}}{\Gamma[2\alpha+1]} + d^3\,\frac{t^{3\alpha}}{\Gamma[3\alpha+1]} + d^4\,\frac{t^{4\alpha}}{\Gamma[4\alpha+1]} + \ldots\ldots$$

$$z(t) = \sum_{n=0}^{\infty} l^n\,\frac{t^{n\alpha}}{\Gamma[n\alpha+1]} = l^0 + l^1\,\frac{t^{\alpha}}{\Gamma[\alpha+1]} + l^2\,\frac{t^{2\alpha}}{\Gamma[2\alpha+1]} + l^3\,\frac{t^{3\alpha}}{\Gamma[3\alpha+1]} + l^4\,\frac{t^{4\alpha}}{\Gamma[4\alpha+1]} + \ldots\ldots$$

Therefore:

$$x(t)=M_1+s(M_2-M_1)\frac{t^{\alpha}}{\Gamma[\alpha+1]}+s(rM_1-M_2-M_1M_3-s\ M_2+sM_1)\frac{t^{2\alpha}}{\Gamma[2\alpha+1]}$$
$$+\{rs^2(M_2-M_1)-rsM_1+sM_2+sM_1M_3-sM_1{}^2M_2+sbM_3M_1-s^2M_2M_3$$
$$+s^2M_3M_1-s^2rM_1+s^2M_2+s^2M_1M_3+s^3M_2-s^3M_1\}\frac{t^{3\alpha}}{\Gamma[3\alpha+1]}+....$$

$$y(t)=M_2+\{rM_1-M_2-M_1M_3\}\frac{t^{\alpha}}{\Gamma[\alpha+1]}+\{rs(M_2-M_1)-rM_1+M_2+M_1M_3-M_1{}^2M_2$$
$$+bM_3M_1-sM_2M_3+sM_3M\}\frac{t^{2\alpha}}{\Gamma[2\alpha+1]}+\{rs(rM_1-M_2-M_1M_3-sM_2+sM_1)-rs(M_2-M_1)$$
$$+r\ M_1-M_2-M_1M_3+M_1{}^2M_2-bM_3M_1+sM_2M_3-sM_3M_1-rM_1{}^3+M_1{}^2M_2+M_1{}^3M_3-sM_1M_2{}^2$$
$$+sM_1{}^2M_2+bM_1{}^2M_2-b^2M_1M_3-sM_3(rM_1-M_2-M_1M_3-sM_2+sM_1)$$
$$-(sM_2-sM_1)(M_1M_2-bM_3)\frac{\Gamma(2\alpha+1)}{\Gamma(\alpha+1)^2}\}\frac{t^{3\alpha}}{\Gamma[3\alpha+1]}+.....$$

$$z(t)=M_3+\{M_1M_2-bM_3\}\frac{t^{\alpha}}{\Gamma[\alpha+1]}+\{rM_1{}^2-M_1M_2-M_1{}^2M_3+sM_2{}^2-sM_1M_2-bM_1M_2+b^2M_3\}\frac{t^{2\alpha}}{\Gamma[2\alpha+1]}$$
$$+\{rsM_1(M_2-M_1)-rM_1{}^2+M_1M_2+M_1{}^2M_3-M_1(M_1{}^2M_2-bM_1M_3)-sM_1M_2M_3$$
$$+sM_1{}^2M_3+sM_2(rM_1-M_2-M_1M_3-sM_2+sM_1)+s(M_2-M_1)(rM_1-M_2-M_1\ M_3)\frac{\Gamma(2\alpha+1)}{\Gamma(\alpha+1)^2}$$
$$-brM_1{}^2+bM_1M_2+bM_1{}^2M_3-sbM_2{}^2+sbM_1M_2+b^2\ M_1M_2-b^3M_3\}\frac{t^{3\alpha}}{\Gamma[3\alpha+1]}+.....$$

When $\alpha=1$, then we have the same results with the results of Homotopy perturbation method and Variational iteration method to solve Lorenz system in [6].

5 CONCLUSION

In this paper, The Mittag-Leffler function and its generalizations used to obtain a new method for solving system of nonlinear fractional differential equations (Lorenz system). And compared the results with the results of Homotopy perturbation method (HPM) and Variational iteration method (VIM), the results of HPM and results of VIM in the standard integer order form When $\alpha=1$ in Eq(1.3). The new generalization is based on the Caputo fractional derivative. From the results we seen that this method is a very powerful and efficient technique in finding approximate solutions for wide classes of fractional differential equations.

REFERENCES

[1] R. Barrio, S. Serrano, "A three-parametric study of the Lorenz model," *Physica D* 229, 43–51, 2007.

[2] E. Lorenz, J. Atmos. Sci. 20 (1963) 130.

[3] M. Viana, Math. Intelligencer 22 (2000) 6.

[4] J. Argyris, G. Faust, M. Haase, "An exploration of chaos, in:Texts on Computational Mechanics," VII, North-Holland Publishing Co, Amsterdam, 1994.

[5] C. Sparrow, "The Lorenz equations: Bifurcations, chaos, and strange attractors," in: *Applied Mathematical Sciences*, vol. 41, Springer-Verlag, New York, 1982.

[6] M. MERDAN, "Variational iteration and homotopy perturbation method for solving Lorenz system," BAÜ FBE Dergisi 1, 3-14, 2009.

[7] K.B. Oldham, J. Spanier, The Fractional Calculus, Academic, New York, 1974.

[8] K.S. Miller, B. Ross, "An Introduction to the Fractional Calculus and Fractional Differential Equations," Wiley, New York, 1993.
[9] V. D. Gejji, H. Jafari, "Analysis of a system of nonautonomous fractional differential equations involving Caputo derivatives," *J. Math. Anal. Appl*. 328 (2) 1026–1033, 2007.
[10] A.M.A. El-Sayed, S. Z. Rida, A.A.M. Arafa, "On the Solutions of the generalized reaction-diffusion model for bacteria growth," *Acta Appl. Math*., 110, 1501–1511, 2010.
[11] S. Z. Rida, A.M.A. El-Sayed, A.A.M. Arafa, "On the solutions of time-fractional reaction–diffusion equations," *Commun Nonlinear Sci Numer Simulat* 15, 3847–3854, 2010.
[12] A.M.A. El-Sayed ,S. Z. Rida, A.A.M. Arafa, "Exact Solutions of Some Time- Fractional Biological Population Models by Using Generalized Differential Transform Method," *Int. J. of Math. modeling, simulation and Appl*. Vol. 3, No. 3, 231-239, 2010.
[13] A.M.A. El-Sayed ,S. Z. Rida, A.A.M. Arafa, "On the Solutions of Time-fractional Bacterial Chemotaxis in a Diffusion Gradient Chamber," *Int. J. of Nonlinear Science*, Vol.7, No.4, pp.485-492, 2009.
[14] E. Hairer, G. Wanner, "Solving ordinary differential equations II: stiff and differential–algebraic problems," Springer-Verlag; 1991.
[15] S. Z. Rida, A.A.M. Arafa, "New Method for Solving Linear Fractional Differential Equations," *International Journal of Differential Equations* 2011.
[16] I. Podlubny, Fractional differential equations. New York: Academic Press; 1999.

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Accuracy Assessment of Cloud Reconstruction Approaches using Segmentation

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ABSTRACT: Cloud is the major obstacle to analyze data in the satellite images. The various approaches are used to remove the cloud from the satellite image for further processing. The approaches are in-painting and multi-temporal. But, the algorithm working for these approaches cannot produce the accurate results. So, that the accuracy assessment helps to motivate the increased accuracy result. The main aim of this paper is to analyze the accuracy of in-paint and multi-temporal approach and produce the pros and cons of those approaches. Accuracy assessment helps to obtain degree of truthfulness of the results. There are 'n' numbers of metrics are available to find the accuracy of the result such as analyzing variance, spatial error, probabilistic error etc. In this paper, two approaches are implemented and the results are applied to the segmentation algorithm. Then, the segmentation results are analyzed by using the error matrix. The error matrix have constructed based on the difference between the clusters of the image result. For segmentation the K-Means algorithm is used and for simplicity only two clusters are segmented. Segmentation result will clearly show that the accuracy of the in-paint and multi-temporal approaches. From the result it is evident that the multi-temporal approach produces a better result when compared to the in-painting. Especially, in that multi-temporal the Averaging method produces better accuracy result.

KEYWORDS: Accuracy Assessment, Cloud Reconstruction, Satellite images, Segmentation, K-Means.

1 INTRODUCTION

Satellite images are useful to monitor various changes on earth such as development of urban regions, deforestation, forest fire, and climate changes and so on. But, the major problem with these images is frequent availability of clouds. The extraction of cloud region information is a serious problem but essential step. It is difficult to remove due to various reasons such as illumination, different atmospheric and sensor conditions.

There are three different types of satellite images are available. They are invisible, infrared and water vapor. In that visible satellite images are easy to identify the clouds. In this satellite, the measure of light uses the same wavelengths as human eye. These images can be only viewed during the day time. The clouds are always reflected by the sun light. Thus, the cloud looks brighter when compared to infrared and water vapor images. Thus, in visible satellite images, clouds are brighter in nature, but snow present in it is very difficult to distinguish from clouds. Objects with higher reflective ability to sunlight appear brighter. Object with lower reflective ability to sunlight is darker on satellite images. The infrared satellite images measured temperatures. So, the clouds can infer based on different temperature being measured, whereas in water vapor it is measured based on the humidity of the atmosphere. Some radar satellites are available that do not affected by the cloud

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problems because they operate in the microwave range of the electromagnetic spectrum. These types of images are not suitable to replace on the cloudy region. The radiation emitted in microwave range is very low while in visible range the maximum energy emitted.

The paper is organized as follows. In the next section, the brief explanation of literature review required for developing the proposed scheme. In Section 3, the construction of the proposed cloud masking approaches are discussed. The applications of the proposed family as well as the experimental results are given in Section 4, followed by our main conclusions in Section 5.

2 LITERATURE REVIEW

Chao-Hung Lin, Po-Hung Tsai, Kang-Hua Lai, and Jyun-Yuan Chen [4] discussed about the information cloning. They used multi-temporal satellite images to clone the information for the cloudy region. A threshold based method is used to define the boundaries of the cloud. The geometrically corrected images are used as a reference image in order to clone the information. The major drawback of this method is the lack of accuracy of the information for the replaced cloudy region. Asmala Ahmad and Shaun Quegan [3] proposed two methods for cloud masking. They proposed spectral and Principle Component Assessment (PCA) method for the Moderate Resolution Imaging Spectroradiometer (MODIS) data. In spectral approach, threshold is applied in order to detect clouds. They used two methods to detect clouds such as reflective and thermal bands. In the PCA approach, threshold is applied to the seven principal component is derived from spectral analysis. Based upon the positive and negative value the clouds are detected. The difference between the cloud and land was biggest in PC1 and very small in other PCs. From their Study of cloud detection spectral analysis is relaiable.

Ana Carolina Siravenha, Danilo Sousa, Aline Bispo, and Evaldo Pelaes [1] present the evaluation of two approaches widely in-painting literature, applied for noise removal. One is the nearest neighbor interpolation for the information disseminated by a DCT-based smoothing method. The other method is second order partial differential equations methods. The interpolation process depends on the neighborhood of the pixels labeled as 0 and 3. Michael. J. Wilson and Lazarous Oreopoulos [5] proposed a cloud masking algorithm using Landsat Data Continuity Mission (LDCM). The threshold and "Split–Window" technique will use. Nicolas Champion [7] developed a new algorithm for cloud detection using multi-temporal images by using seed extraction and region growing method. The major drawback of this approach is that false positive cloud detection and this leads to the lack of accuracy in the result.

3 PROPOSED SYSTEM

3.1 IN-PAINTING APPROACH

In-paint approach is the information reconstruction approach in which the same image pixel values are to replace the clouded area. There are various methods are available to in-painting approach by using similar pixel replacement, replacing by using any distance formulae etc,. But, here consider, the image is I1 and the clouded area is C1, then C1 have replaced by summation of I1 except the pixels in C1.

The main advantage of this method is the cloud value cannot be restored again. In distance calculation method, suppose the size of the cloud is large then the cloud pixel value will replace. The major advantage of this proposed method is applicable for the large cloud region.

3.2 MULTI-TEMPORAL APPROACHES

3.2.1 TEMPORAL AVERAGING ALGORITHM

The Temporal averaging algorithm is the type of Multi-temporal approach. The two or three reference images have taken and finding the average of the pixel value. The average pixel values have used to fill the gap. It produces the best result when compared with in-paint method. The result have verified by using the simulated cloud. The clouds have simulated manually to prove that the produced result is working efficiently. In above mentioned algorithms help to fill the data instead of cloud but not accurately.

3.2.2 TEMPORAL CLONING

Temporal Cloning is another Multi-Temporal approach. In this algorithm, the same information which is present in the reference year is used to fill in the gap of cloudy region. This method has very less accuracy when compared to the Multi-temporal averaging method.

3.2.3 SEGMENTATION ALGORITHM

The k-means algorithm is used to segment the cloud free images. The cloud free images are usually used for various process and applications such as segmentation, classification and so on. The K-means algorithm is the type of segmentation algorithm which helps to segment different application. Here two clusters are fixed to obtain the segmentation and the two clusters are referred as k=1 and k=2. Then the mean value of the cluster k=1 and k=2 are obtained to find the differences.

4 RESULTS AND DISCUSSIONS

The main aim is to assess the accuracy of the cloud replaced images by using the Segmentation algorithm. Here the mean value of the cluster is used to analyze the accuracy assessment with the simulated cloud. The Table 1 Shows the error matrix for the multi-temporal information cloning images approaches. The Table 2 Shows the error matrix for the multi-temporal information cloning images approaches. The result shows difference clearly shows the accuracy of the information Cloning is worse when compared to the Multi-temporal Averaging method.

Table 1. Error matrix for the Multi-temporal cloning method using k-means segmentation algorithm

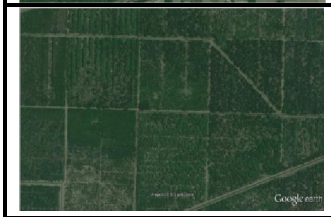
Error matrix	Simulated cloud image		Original image		Difference	
	K=1	K=2	K=1	K=2	K=1	K=2
	52.0940	62.2362	52.1973	62.845	0.1033	0.6088
	58.0486	53.3864	58.9661	52.4649	0.9175	0.9215

Table 2. Error matrix for the Multi-temporal Averaging method using k-means segmentation algorithm

Error matrix	Simulated cloud image		Original image		Difference	
	K=1	K=2	K=1	K=2	K=1	K=2
	52.9532	63.2511	53.1973	62.945	0.2441	0.3061
	58.9921	52.4915	58.9661	52.4649	0.026	0.0266

5 CONCLUSION AND FUTURE WORK

The Multi-temporal approaches are the very famous approach for cloud masking. The major advantages of these approaches are gain accuracy when compared to the in-paint method. In the in-paint method the ground truth information are not presented. Because the information's are collected from the same image itself. So it cannot produce the accurate information. In the averaging method the approximate value are to be replaced in place of the cloudy region. So the approximate values are to be only able to replace. In the cloning method the exact reference image pixel values are replaced. In all the three methods accuracy will not be appropriate in level because there is no analyze of the data. The previous year images are not analyzed whether the information's are increased or decreased. When analyzing the reference image only the quality of the accuracy result will improve.

The Future work will be analyzing the degree of variance between the reference images. With more reference images also the quality of accuracy will improve. So the Efficient Cloud Detection and Removal algorithm will develop for analyzing the percentage of difference between the cloudy images. So that the accuracy level of the cloudy region will improve.

REFERENCES

[1] Ana Carolina Siravenha, Danilo Sousa, Aline Bispo, and Evaldo Pelaes, "Evaluating Inpainting Methods to the Satellite Images Clouds and Shadows Removing", Communications in Computer and Information Science Volume 260, 2011, pp. 56-65.

[2] Anil Z Chitade and Dr. S.K. Katiyar, "Colour Based Image Segmentation Using K-Means clustering*", International Journal of Engineering Science and Technology*, Vol. 2(10), 2010, 5319-5325.

[3] Asmala Ahmad, Shaun Quegan, "Cloud Masking for Remotely Sensed Data using Spectral and Principal Components Analysis", *Engineering, Technology & Applied Science Research*, Vol. 2, No. 3, 2012, 221-225.

[4] Chao-Hung Lin, Po-Hung Tsai, Kang-Hua Lai, and Jyun-Yuan Chen, "Cloud Removal from Multi-temporal Satellite Images Using Information Cloning", IEEE *Transactions on Geoscience and Remote Sensing*, Vol. 51, No. 1, January 2013.

[5] Michael J. Wilson and Lazaros Oreopoulos, "Enhancing a Simple MODIS Cloud Mask Algorithm for the Landsat Data Continuity Mission", *IEEE Transaction On Geoscience And Remote Sensing*. Vol. 51, No. 2, 2013, 0196-2892.

[6] Qingmin Meng, Bruce E. Borders, Chris J. Cieszewski, and Marguerite Madden, "Closest Spectral Fit for Removing Clouds and Cloud Shadows", *Photogrammetric Engineering & Remote Sensing*, Vol. 75, No. 5, pp. 569–576.

[7] Nicolas Champion, "Automatic cloud detection from multi-temporal satellite images: towards the use of pléiades time series", *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Volume XXXIX-B3, 2012 XXII ISPRS Congress, Melbourne, Australia.

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Detection of Exudates for the Diagnosis of Diabetic Retinopathy

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ABSTRACT: Diabetes is a group of metabolic diseases in which a person has high blood sugar. Diabetic Retinopathy (DR) is caused by the abnormalities in the retina due to insufficient insulin in the body. Diabetic Retinopathy affects 80% of all patients who had diabetes for 10 years or more, which can also lead to vision loss. The most primitive sign of Diabetic Retinopathy is Exudates. Exudates in the retina are opacities that result from the escape of plasma and white blood cells from defective blood vessels. Detecting the exudates in an earlier stage can prevent the vision loss. In this paper, an automated algorithm has demonstrated to detect and localize the presence of exudates from low-contrast digital images of retinopathy patients with non-dilated pupils. In this method, first the retinal fundus image is pre-processed. Then, Mask Technique and Score Computation technique is used for segmenting the exudates in the retinal fundus images. This method does not require supervised learning which requires labeled set, may cause human error and it is time consuming process. It can effectively identify the lesions because exudates were clearly distinguished from optic disc and blood vessels. It helps the ophthalmologists apply proper treatments that might eliminate the disease or decrease the severity of it.

KEYWORDS: Diabetic Retinopathy, Exudates, Kirsch Edge detector, Mask Technique, Optic Disc, Score Computation.

1 INTRODUCTION

Diabetic eye disease is a leading cause of low vision and blindness in people of working age in industrialized countries. Approximately 33% of patients with diabetes have signs of diabetic retinopathy. DR is responsible for 1.8 million of the 37 million cases of blindness throughout the world However, according to medical test results, early detection and treatment may prevent more than 95% of the vision reductions that are observed in diabetic patients. DR is progressive dysfunction of the retinal blood vessels caused by chronic hyperglycaemia. Diabetic retinopathy is composed of a characteristic group of lesions found in the retina of individuals having had diabetes for several years.

Exudates are the primary and prevalent indication of diabetic retinopathy. Exudate is a fluid with a high content of protein and cellular debris which has escaped from blood vessels and had been deposited in tissues or on tissue surfaces of an eye. As it progresses, DR can significantly decrease visual acuity. The systematic screening process involves widening the pupil of an eye with chemical solution in order to identify the exudates manually. The various drugs used for mydriasis are amphetamine, tropic amide, atropine, mescaline, cocaine. In addition to diabetic retinopathy, the drugs used for screening process also affect the patients' eye sight. Fig.1.a. shows normal retinal fundus image and Fig.1.b. shows the image containing exudates.

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(a) (b)

Fig. 1. Retinal Images: (a) Normal Fundus image (b) Image showing Exudates

Li Tang et. al. [1] suggested new splat feature classification method to detect hemorrhages. The features were color, spatial location, interactions with neighboring splats, and shape and texture information. It can be obtained by dividing the image into number of segments. Finally, optimal subset of splat features is selected by wrapper approach. Istvan Lazar and Andras Hajdu [2] proposed novel method for detecting the Microaneurysms using directional cross-section profiles of an image. The statistical measures of the feature set such as size, height, and shape of every profile is used in a naïve Bayes classification to eliminate fake candidates. The binary image was obtained at the output side. Balint Antal and Andras Hajdu [3] suggested novel method for identifying the microaneurysms by considering the output of multiple classifiers. It can be detected by improving pre-processed methods and candidate extractors. K. Sai Deepak and J. Sivaswamy [4] introduced motion pattern technique for detecting macular edema. Gaussian and PCA Data Description classifiers were used to extract the exudates. Symmetry measure is used for assessing the severity level.

L. Giancardo et. al. [5] used multiple views of the retinal fundus images for detection and quantitative measurement of the disease. In, Pre-processing stage, the dark microstructures of the macula was enhanced. All the available views were registered and dense pyramidal optical flow is calculated to build a naive height map of the macula. K. Ram et. al. [6] proposed successive clutter rejection method for detecting the Microaneurysyms (MAs). This method has two clutter rejection stages to classify MA from Non-MA. C. Agurto et. al. [7] developed the technique for detection of DR by using instantaneous amplitude and instantaneous frequency characteristics of an image. Keerthi Ram and Jayanthi Sivaswamy [8] proposed Multi-space clustering method to distinguish hard and soft exudates. Alireza Osare et. al. [9] used pattern recognition with machine learning techniques to analyze diabetic retinal images. Akara sopharak [10] used FCM clustering technique for detecting the exudate pixels.

Several algorithms have been developed to automatically identify the exudates which eliminate the needs of human experts. In this project, Mask technique and Score Computation technique is used for classify the exudates from the non-exudates pixels in the retinal images. The fragmented result is then used for validating the severity of the lesions. The demonstrated method is prompt and robust method that can attain high sensitivity and specificity.

2 MATERIALS AND METHODS

2.1.1 IMAGE ACQUISITION

The color fundus images used in this paper were obtained from largest, publicly available dataset MESSIDOR databases. Working images are JPEG format with a size of 2196 X 1958 at 24 bits. These databases includes binary mask for every fundus images.

2.1.2 PRE PROCESSING

The color image was converted into HSV image. The fundus image may having non-uniform illumination, intensity variation and noises. To reduce the effect of such problems, pre-processing was performed on the intensity component of an image. The intensity component of an image was used here to differentiate the bright lesion from other features of the retinal image. Median filter was applied on the image that reduces the blurring of edges of an image and significantly eliminates impulse noise. It suppresses noise without reducing the image sharpness. Contrast enhancement technique evens out the distribution of used gray values and thus makes hidden features of the image more visible. The original input image and preprocessed image are shown in fig.3 and fig.4.

Fig.3. Original Image

Fig. 4. Pre-Processed Image

2.1.3 MASK TECHNIQUE

Optic disc detection is a primary step in automated screening systems for diabetic retinopathy. The OD often serves as a landmark for other fundus features; such as the quite constant distance between the OD and the macula-center (fovea) which can be used as a priori knowledge to help estimating the location of the macula. The OD is the brightest feature of the normal fundus, and it has approximately a circular or vertically slightly oval (elliptical) shape. In colored fundus images, the OD appears as a bright yellowish or white region. In our project, Exudates recognition is the main purpose, it is necessary to remove the optic disc prior to the process. Because OD appears with similar intensity, color and contrast to other features on the retinal image. The optic disc is characterized by the largest high contrast among circular shape areas. While vessels also appear with high contrast, the size of the area is much smaller. So Optic disc is detected and masked. The masked image is shown in fig.5. Mask technique aims at labeling pixels belonging to the Region of Interest (ROI) in the entire image. Pixels outside that ROI are those belonging to the dark surrounding region in the image. Masking process includes the following steps:

- Blur the original image,
- Subtract the blurred image from the original image which is called as mask,
- Add the mask to the original image

Fig.5. Masked Image

2.1.4 SCORE COMPUTATION TECHNIQUE

In our suggested method, exudates were segmented using score computation technique. It can be performed by connected component labeling method which is based on neighborhood approach. The goal of the connected component analysis is to detect the large sized connected foreground region in an image. The pixels that are collectively connected can be clustered into changing or moving objects by analyzing their connectivity. In binary image analysis, the object is extracted using the connected component labeling operation, which consist of assigning a unique label to each maximally connected foreground region of pixels.

The algorithm starts with finding its non-background neighbors. If none of the neighbors is labeled yet, label count is incremented and set it to the current pixel, and also set the label's parent to itself. Move on to the next pixel, this one has a neighbor which is already labeled and assigns the pixel's label to that of the neighbor. This process is continued until none of the neighbors of this pixel is labeled. The label count is incremented and assigns it to the pixel and again setting its parent to itself. When neighbors have different labels, any one of the labels has chosen and set it to the current pixel. By this approach, brighter lesions were obtained which shows both exudates and blood vessel.

2.1.5 REMOVAL OF BLOOD VESSEL

It is necessary to remove the regions that share the exudates with blood vessels. So, contour detection is significant process in this method. Edge detection algorithm was used to remove the blood vessels. Edge detection is the most familiar approach for identifying significant discontinuities in intensity values. The edge detected image is shown in fig.6

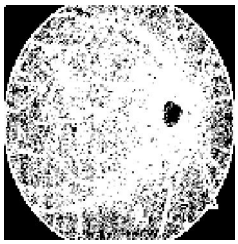

Fig.6. Edge Detected Image

Kirsch edge detection is used to remove the blood vessels by using threshold values. The Kirsch operator is a non-linear edge detector that finds the maximum edge strength in a few predetermined directions. The kirsch edge detector not only defines the presence of edges but also it determines the direction in which the edge moves. The masks of this Kirsch technique are defined by considering a single mask and rotating it to eight main compass directions such as North, Northwest, West, Southwest, South, Southeast, East and Northeast. Blood vessel removed image is shown in fig.7

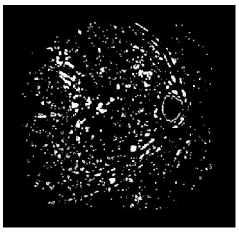

Fig.7. Blood Vessel Removed Image

The Kirsch edge detection algorithm uses a 3×3 table of pixels to store a pixel and its neighbors while calculating the derivatives. The 3×3 table of pixels is called a convolution table, because it moves across the image in a convolution-style algorithm. Kirsch edges try to capture the external edges of the lesion candidate. The average edge outputs under each lesion cluster are calculated and assigned to the lesion in its entirety. Finally, this algorithm provides segmented image which can clearly distinguish the exudates portion from the non-exudates pixels. The resultant image shown in fig.8 was exposed in color which clearly indicates the exudates pixels in the segmented retinal image.

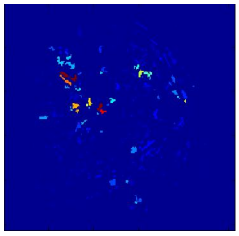

Fig.8. Segmented Image Showing Exudates

3 CONCLUSIONS

The method present in this project is a prompt and efficient method for Exudates detection. The proposed system is a very simple technique which enables the ophthalmologists to detect exudates with very less inspection time. This segmented image shows the location of exudates confirming the disease diabetic retinopathy

REFERENCES

[1] K. Sai Deepak, J. Sivaswamy, "Automatic Assessment of Macular Edema from Colour Retinal Images," *Medical Imaging, IEEE Transactions*, vol. 31, no. 3, pp. 766-776, March 2012.

[2] L. Giancardo, F. Meriaudeau, T. Karnowski, K. Tobin, E. Grisan, P. Favaro, A. Ruggeri, and E. Chaum, "Textureless macula swelling detection with multiple retinal fundus images," *IEEE Trans. Biomed. Eng.*, vol. 58, no. 3, pp. 795–799, March 2011.

[3] K. Ram, G. D. Joshi, J. Sivaswamy, "A Successive Clutter-Rejection Based Approach for Early Detection of Diabetic Retinopathy," *IEEE Transactions on Biomedical Engineering,* Vol.58, no. 3, March 2011.

[4] C. Agurto, V. Murray, E. Barriga, S. Murillo, M. Pattichis, H. Davis, S. Russell, M. Abramoff, and P. Soliz, "Multiscale AM-FM methods for diabetic retinopathy lesion detection," *Medical Imaging, IEEE Transactions*, vol. 29, no. 2, pp. 502 –512, Feb. 2010.

[5] K. Ram and J. Sivaswamy, "Multi-space Clustering for segmentation of Exudates in Retinal Colour Photographs", *31st Annual International Conference of the IEEE EMBS,USA*, pp. 1437-1440, September 2009.

[6] Alireza Osare et al., "A Computational–Intelligence Based Approach for Detection of Exudates in Diabetic Retinopathy Images", *IEEE Transactions on Information Technology in Biomedicine*. Vol. 13. no. 4, pp. 535-545, July 2009.

[7] Akara Sopharek et al., "Automatic exudates detection for diabetic retinopathy Screening", 10.2306/*Science asia*1513-1874.2009. 35.080, pp. 80-88, Feb 2009.

[8] Akara sopharak, Matthew N. Dailey, Bunyarit Uyyanonvara, Sarah Barman, Tom Williamson Khine thet New and Yin Aye Moe, "Machine learning approach to automatic Exudates detection in retinal images from diabetics patients", *Journal of Modern Optics*, pp. 1-17, Jan. 2008.

[9] M. Niemeijer, Michael D. Abràmoff, Bram van Ginneken, "Segmentation of the Optic Disc, Macula and Vascular Arch in Fundus Photographs," *IEEE Transactions On Medical Imaging*, Vol. 26, no.1, Jan. 2007.

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Literature Review of Automatic Multiple Documents Text Summarization

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ABSTRACT: For the blessing of World Wide Web, the corpus of online information is gigantic in its volume. Search engines have been developed such as Google, AltaVista, Yahoo, etc., to retrieve specific information from this huge amount of data. But the outcome of search engine is unable to provide expected result as the quantity of information is increasing enormously day by day and the findings are abundant. So, the automatic text summarization is demanded for salient information retrieval. Automatic text summarization is a system of summarizing text by computer where a text is given to the computer as input and the output is a shorter and less redundant form of the original text. An informative précis is very much helpful in our daily life to save valuable time. Research was first started naively on single document abridgement but recently information is found from various sources about a single topic in different website, journal, newspaper, text book, etc., for which multi-document summarization is required. In this paper, automatic multiple documents text summarization task is addressed and different procedure of various researchers are discussed. Various techniques are compared here that have done for multi-document summarization. Some promising approaches are indicated here and particular concentration is dedicated to describe different methods from raw level to similar like human experts, so that in future one can get significant instruction for further analysis.

KEYWORDS: World Wide Web, search engine, information retrieval, document abridgement, human expert.

1 INTRODUCTION

The narration of automatic i.e. computerized abstraction began 60 years ago, as implementation of automatic text summarizer is often cited in the oldest publication in 1958 by H. P. Luhn [1]. The goal of automatic text summarization is to condense the given text to its essential contents, based upon user's choice of brevity. In this system, the summary is generated by machine to draw the most significant information in a shorter form of the source text, while still keeping its principal semantic content and helps the user to quickly understand large volumes of information. On the basis of methodology or techniques that are used for summarization, approaches can be divided into two broad groups – extraction and abstraction. Reformulation of contents is done while abstraction and the important sentences of original document are picked up in extraction. Extraction needs no background knowledge and this is domain independent, where abstraction is domain dependent in nature and requires human knowledge and is specific goal oriented [2]. Summarization task can be classified into two types [3]: 1) single document text summarization, 2) multi-document text summarization. After 2002, the single-document summarization task was approximately dropped [4]. In multi-document summarization, several key points are involved, such as reducing each document, incorporating all document's significant idea, compare the ideas found from each, ordering sentences come from different sources keeping the logical and grammatical structure right.

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A range of procedures that employee document abstraction, such as neural networks, semantic graphs, fuzzy logic etc. are incorporated on the study on finding significant portion of text. The objective of this paper is to present a comprehensive literature review on automatic multi-document summarization using natural language processing and explore the trends of passage abstraction.

The rest of the paper is organized as follows. Section 2 briefly explains multi-document summarization. Section 3 presents a comprehensive literature review about different procedures on automatic multiple documents summarization. Section 4 turns conclusion with a brief about this paper.

2 MULTI-DOCUMENT TEXT SUMMARIZATION

Simply, multi-document text summarization means to retrieve salient information about a topic from various sources. Given a set of documents D = (D1, D2,…,Dn) on a topic T, the task of multi-document summarization is to identify a set of model units (S1,S2,…,Sn). The model units can be sentences, phrases or some generated semantically correct language units carrying some useful information. Then significant sentences are extracted from each model units and re-organized them to get multi-documents' summary. Process flow of multi-document summarization can be depicted as fig. 1.

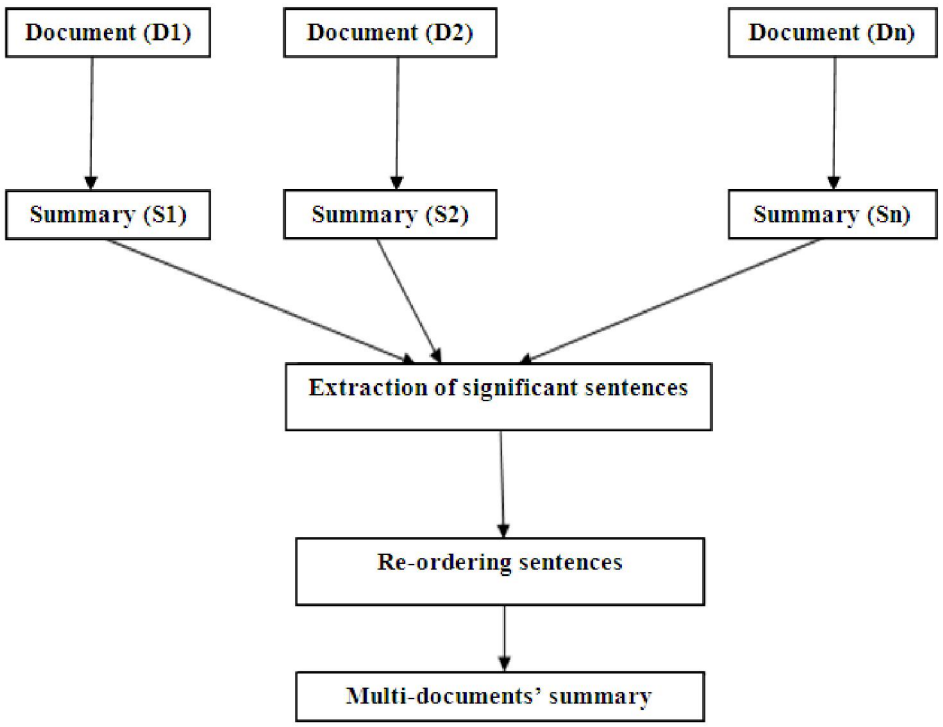

Fig. 1. Process flow of multiple-documents text summarization

3 REVIEW ON AUTOMATIC MULTIPLE DOCUMENTS TEXT SUMMARIZATION

Research on single document summarization has turned into its golden age and much more complicated to the era of multi-document summarization. Various methods are available for retrieval of information from diversified source. Many techniques have been developed from the very beginning of the thinking of multiple documents summarization to this time of modern science. In this paper, the discussed methods are grouped into five categories.

3.1 TERM FREQUENCY BASED METHOD

Salton [5] in 1989 introduced TF-IDF or term-frequency inverse-document-frequency model, where the score of a term in the document is the ratio of the quantity of terms in that document to the frequency of the quantity of documents containing that terms. The significance of term evaluation is given by the principle TFI X IDFI, where TFI is the frequency of term I in the document and IDFI is the inverted frequency of documents in which that term occurs. By computing pertinence of terms in the sentence, consequently sentences can be scored for illustration.

Jun'ichi Fukumoto [6] in 2004 offered a multi-document summarization technique that applied very simple strategy to generate abstract using TF/IDF based sentence extraction for single document summarization and use of single document summarization for multi-document. Their system automatically classifies a document set into three types using information of high frequency nouns and named entity: (a) one topic type, (b) multi-topic type, and (c) others. In the first type, the second document shows additional information or subsequent event of the first document, and so on for the following documents. In the second type, documents describe the same event type such as a set of traffic accidents. The third type of documents is related each other but not classified into the first two types. For summarization, at first sentences are extracted from each document based on TF/IDF, sentence position and weighing using intention type, such as “request”, “obligation” and “necessary” etc., of a sentence. In the second step unnecessary parts of sentences are eliminated. Then extracted sentences are sorted in the original order in a document to generate condensed version of each single document and send them for document set type classification. After that all the extracted sentences are segmented into clauses and removed the repeated clauses and the rest of the clauses are sorted for generating expected summary. The task of document set type classification is a commendable effort in this research, but the mechanism used here for summarization is mostly based on single document abstraction.

You Ouyang et al [7] in 2009 introduced a novel hierarchical summarization approach which is able to integrate a range of objectives of multi-document abstraction. Human summarization concept is depicted here in such a way that man may start with finding the core topic in a document set and write something about this core topic. Next he may go to find sub-topic and sub-sub-topics and so on. Motivated by this experience, a hierarchical approach is offered here to mimic the behavior of human summarizer. The procedure includes two phases such as:

(i) Word hierarchical representation: Before constructing the hierarchical representation unnecessary concepts are removed from the document set where concepts are represented as terms of words. Two types of words are selected, i.e. query-relevance and topic-specificity and the identified keywords are sorted by their frequency. After that point-wise mutual information (PMI), is a measure of association used in information theory, is used to identify the subsumption between words and high PMI is regarded as significant. Using the identified relations, a top-down tree is constructed.

(ii) Summarization based on hierarchical representation: In this step sentences are selected through an iterative algorithm which follows a general to specific order. Words that are in the top level of the tree are regarded as the core concept. The algorithm moves to down level words through the subsumption relations between the words and new sentences are added except redundant sentences until the whole summary is generated.

Vikrant Gupta et al [8] in 2012 presented a new statistical approach to automatic summarization based on the Kernel of the source text called KernelSum (KERNEL SUMMarizer). Using simple statistical measures, Kernel is identified as the most significant passage of the source text. It serves as the guideline to choose the other sentences for summary. The procedure proposed here is composed with the following functional components: i) Text pre-processor works on converting the HTML or Word Documents to plain text, ii) Sentence separator divide the sentences based on some rules like ending point such as a dot and a space etc. iii) Word separator detaches the words through some criteria like a space, iv) Stop-words eliminator eradicates the regular English words like ‘a, an, the, of form…’, v) Word-frequency calculator computes the number of times a word appears in the document after removing stop-words, vi) Scoring algorithm estimate the score of each sentence by using the TF-ISF (Term Frequency - Inverse Sentence Frequency), vii) Ranking algorithm counts rank of every sentence according to the scores, location, length, heading sentence etc. viii) Summarizing part picked the sentences from the ranked list and concatenated to produce the expected brief of the input document. Final extract have been evaluated under the light of Kernel preservation and textuality and found 90% of the extracts have been judged to totally or partially preserve the gist, textuality was also highly graded: 85% of them were totally or partially coherent and cohesive.

3.2 GRAPH BASED METHOD

Inderjeet Mani et al [9] in 1997 represented topic through a set of entry nodes in the graph, along with edges corresponding to the semantic relations between items. The algorithm used here applies a spreading activation technique to discover nodes related to the core theme. The nodes whose meanings are equivalent to topic terms are treated as entry points into the graph and called activating node. Weight of nodes is an exponentially decaying function of activating node’s weight and the distance between nodes. Weight of a neighbor node is calculated as a function of link weight and activating node weight. Consecutively the method finds neighbor of starting nodes and accumulate the activating nodes to the output until getting threshold number of output nodes.

In 2004 Rada Mihalcea et al [10] proposed an algorithm named TextRank using graph based method in the ground of natural language processing. A vertex is added for each sentence in the text to construct a graph. Link between vertices are set up using sentence similarity relation. This relation is based on content overlapping by which a score is generated for each vertex. After applying the iterative procedure consequently vertices are sorted by their scores, and then top scored sentences are chosen to construct abstract.

Junlin Zhang et al [11] in 2005 stated that multi-document extractive summarization depends on the notion of sentence centrality to recognize the most significant sentences in a document. A new approach under the hub-authority framework has been introduced here that unites the text content with some cues such as "cue phrase", "sentence length" and "first sentence" and investigates the sub-topics in the multi-documents by conveying the features of these sub-topics into graph-based sentence ranking algorithms. Old graph-based method is developed here with two essential different points: (i) unites the text content with some characteristics such as cue phrase, length of sentences and position. (ii) discovers the sub-topics with graph-based sentence ranking algorithms. Then the summary is generated according to the sentence ranking score of all sentences. The provided method was evaluated on DUC 2004 data and proved that the design of combining the exterior and interior features under the Hub/Authority framework is an effective graph-ranking schema in multi-document generic text abstraction.

Xiaojun Wan [12] in 2008 explored a graph-based ranking algorithm for multi-document summarization under the assumption that all the sentences are indistinguishable. Document impact on summarization performance is invented here with document-based graph model to incorporate the document-level information and the sentence-to-document relationship into the graph-based ranking process. Basic graph-based model is essentially a way of deciding the importance of a vertex within a graph based on global information recursively drawn from a one-layer link graph of sentences. The document-based graph model is integrated here to examine the document impact by exploring document importance and the sentence-to-document correlation into the sentence ranking process. This is a two-link graph including both sentences and documents. It is assumed that the sentences which belong to an important document, highly correlated with the document, will be more likely to be chosen into the summary.

Kokil Jaidka et al [13] in 2010 invented a novel summarization technique to generate literature review of research paper that mimics the characteristics of human literature reviews. An analysis has been carried out here to understand the human strategies of information selection and recapitulation. Some significant questions were thought before designing the procedure such as: i) where do researchers select information from? ii) what type of information do they select? iii) how do they fulfill the functions of a literature review? The novel approaches in this system would mainly be in the information selection and integration stage to select information from different semantic levels, and the rhetorical function implementation stage where the literature review will be drafted. In this proposed procedure three types of discourse structure are defined. For sentence-level, XML schema is constructed to define the valid XML document structure used to represent the structure of a literature review, including the expected elements and their hierarchical relationships. For clause-level and intra-clause-level, a graphical representation of rhetorical relations is represented as a tree structure between the constituent clauses of text. A number of strategies applied to select salient parts from this XML or graphical tree structure to produce a comparative literature review, such as: a) Correlation between the candidate topic and source content, b) Semantic similarity measures, c) Relative information gain ratios of information with respect to the surrounding text.

3.3 TIME BASED METHOD

McKeown et al [14] in 1995 presented a natural language processing system that summarizes a series of news articles on the same event using empirical analysis. Length of summaries varies on the basis of the available resources of text. The proposed system here named SUMMONS (SUMMarizing Online NewS articles) that summarize full text input using templates formed by the message understanding systems developed under the ARPA human language technology program [15]. Their research focused on techniques to summarize how the trends of an event changes over time, using various points of view over the same event or series of events. Input to SUMMONS is a set of templates, where each template represents the information extracted from one or more sources by a message understanding system. It first groups messages jointly, identifies commonalities between them, and notes how the discourse influences wording by setting realization flags. The departure point is in the stage of identifying what information to include and how to group it together.

Xiaojun Wan et al [16] in 2007 unveiled TimedTextRank algorithm as an enhancement of graph based ranking process namely TextRank for multi document summarization and incorporated a new temporal dimension. A proclamation has been made that for an evolving topic, recent documents are usually more important than earlier documents because of the

availability of novel information. The TextRank procedure makes use of the relationships between sentences and chooses sentences according to the "vote" or "recommendations" from their neighboring sentences, which is similar to PageRank and HITS. An affinity graph is generated at first to reveal the relationships among all sentences in the document set. Now the vote is casted for each node in a way that the votes cast from new documents are attached more importance than the votes cast from the sentences in old documents. By this way the informativeness score is calculated to select sentences for generating summary.

3.4 SENTENCE CO-RELATION BASED METHOD

S. Hariharan et al [17] in 2012 proposed enhancements on two graphical methods namely- LexRank (threshold) and LexRank (continuous) offered by Erkan and Radev [18]. LexRank and Continuous LexRank techniques are developed based on modification of the most popular page ranking algorithms designed for web link analysis. A link between two sentences is considered as a vote cast from one sentence to the other sentence. The score of a sentence is determined by the votes that are casted for it and the scores of the sentences casting these votes. A document can be considered as a network of sentences those are associated with each other. Cosine similarity has been used to discover similarity between two couple of sentences and to assess the relevance between sentences. Proposed enhancements in this paper are discounting technique and position weight factor. Discounting method envisages that once a sentence is selected then the next sentence is selected based on the contributions made by the remaining n-1 sentences only. So, the chance for repetition of information in the succeeding sentences is minimized, and the summary will be cohesive and meaningful. In the graph based approach, importance to position of the sentence can be given in a way by giving preference to sentences that occurs earlier out of two documents considered. For instance, first sentence in a document of 5 sentences will get a weight of 1/5 = .20 and in a document of 10 sentences will get a weight of 1/10 = .10. Now the node will be extracted from graph based on casted votes, scores, position, weight, etc. to get the abstract.

Tiedan Zhu et al [19] in 2012 in their paper proposed the logical closeness criterion to measure the similarity between two sentences through which extracted sentences for summarization can be chronologically ordered. In multi-document summarization, sentences are selected from various documents differ with single document summarization. So a strategy to arrange the order of sentences is demanded. This publication also gave a brief review about the others work on sentence ordering and offered an improved procedure. This research emphasized on logical-closeness rather than topical-closeness which is based on synonymy and not strong enough to measure the coherence of sentences. To assess logical-closeness following techniques are applied,

(i) Notation Definition: the arrow '→' and the sentence-chain. For two sentences A and B, a notation is defined A→B to represent that A and B are adjacent where A precedes B. Multiple sentences are represented as chain with arrow.

(ii) Definition of Logical-closeness: logical-closeness means the closeness in meanings. Sometime two sentences have no topical-closeness but coherent in sense.

(iii) Measure of Logical-closeness: If sentence A is similar with the adjacent sentences of B and vice versa then sentences A and B are coherent. By this way coherency with each other is calculated.

Finally more adjacent sentences are picked up in a chain to produce the logical summary.

3.5 CLUSTERING BASED METHOD

Jade Goldstein et al [20] in 2000 presented a method for text extraction approach to multi-document summarization that builds on single-document summarization methods by using supplementary available information about the document set and relationships between the documents. Here they identified four minimum requirements for multi-document summarization: (a) clustering- the ability to cluster similar documents and passages to find related information, (b) coverage- the ability to find and extract the main points across documents, (c) anti redundancy- the ability to minimize redundancy between passages in the summary, (d) summary cohesion criteria- the ability to combine text passages in a useful manner for the reader. The proposed procedure emphasized on "relevant novelty" which is a metric for minimizing redundancy and maximizing both relevance and diversity. The method works as follows: (i) Segment the documents into passages, and index them, (ii) Identify the passages relevant to the query using cosine similarity with a threshold below which the passages are discarded, (iii) Using "relevant novelty" metric, depending on the desired length of summary, select a number of passages, (iv) Resemble the selected passages into a summary document.

Judith D. Schlesinger et al [21] in 2008 proposed a multi-document summarization technique that combines Clustering, Linguistics and Statistics for Summarization and named it CLASSY. It uses linguistic trimming and statistical methods to

produce generic summaries for both single and clusters of documents. CLASSY has cut a good figure in the Document Understanding Conference (DUC) evaluations and Multi lingual (English and machine translated/original version of Arabic document) Summarization Evaluations (MSE). The proposed method used trimming rules to shrink sentences, identify sentences and organize the chosen sentences for the final summary. Here the thought was to design a multi-lingual summarization technique. CLASSY structural design made up of five steps: preparation of raw texts, trimming of sentences, scoring, redundancy elimination and sentence organizing. This method can also be used for machine translated edition of Arabic document as well as English document. The trimming method is truly dependent on language and the quality of summarization very much depends on the translation quality of machine.

Xiaojun Wan et al [22] in 2008 presented a summarization procedure using cluster-based link analysis. This paper described about Markov Random Walk model which exploited for multi-document summarization by making use of the link relationships between sentences in the document set. Two models were proposed here to incorporate the cluster-level information into the process of sentence ranking. The first model is the Cluster-based Conditional Markov Random Walk Model (ClusterCMRW), which incorporates the cluster-level information into the link graph. The second model is the Cluster-based HITS Model (ClusterHITS), which considers the clusters and sentences as hubs and authorities in the HITS algorithm. Both models are based on link analysis techniques. The overall summarization framework consists of the following three steps:

(i) Theme cluster detection: By using clustering algorithm this method detect theme cluster from the document set.

(ii) Sentence score computation: This step aims to compute the saliency scores of the sentences in the document set by using either the ClusterCMRW model or the ClusterHITS model to incorporate the cluster-level information.

(iii) Summary extraction: In the final step, redundancy is removed and high scored sentences are chosen as summary sentences.

Nitin Agarwal et al [23] in 2011 presented an unsupervised approach called SciSumm for multi-document summarization of scientific articles. Using the context of the co-citation in the source article, the system produces a query by which it can generate a summary in a query-oriented fashion. In this proposed method SciSumm has four principal modules that are central to the functionality of the system. i) TextTilling module: This module used to obtains tiles of text relevant to the citation context using TextTilling algorithm [24]. Those text tiles are used as the basic unit for summary. ii) Clustering module: Frequent Term based text clustering algorithm [25] is used to generate labeled clusters using the text tiles extracted from the co-cited paper. iii) Ranking module: The clusters are ordered according to relevance with respect to the generated query using ranking module. iv) Summary presentation module: This module is used to display the ranked clusters obtained from the ranking module.

4 COMPARISON AMONG THE TECHNIQUES

At a glance comparison among the techniques of multi document text summarization has been shown in table 1:

Table 1. Comparison Among the Techniques of Multiple documents Text Summarization

#	Researcher(s), Year, Reference	Category	Basis of procedure
1	G. Salton, 1989, [5]	Term frequency based method	The significance of term evaluation is given by the principle TFI X IDFI, where TFI is the frequency of term I in the document and IDFI is the inverted frequency of documents in which that term occurs.
2	Jun'ichi Fukumoto, 2004, [6]	Term frequency based method	This method applied very simple strategy to generate abstract using TF/IDF based sentence extraction for single document summarization and use of single document summarization for multi-document.
3	You Ouyang, 2009, [7]	Term frequency based method	The procedure includes two phases such as: word hierarchical representation on the basis of most frequent terms in top of hierarchy and summarization based on hierarchical representation.

4	Mr.Vikrant Gupta, 2012, [8]	Term frequency based method	Using simple statistical measures, Kernel is identified as the most significant passage of the source text that contains most frequent terms. It serves as the guideline to choose the other sentences for summary.
5	Inderjeet Mani, 1997, [9]	Graph based method	The algorithm used here applies a spreading activation technique to discover nodes related to the core theme. Consecutively the method finds neighbor of starting nodes and accumulate the activating nodes to the output.
6	Rada Mihalcea, 2004, [10]	Graph based method	A vertex is added for each sentence and link between vertices are set up using sentence similarity relation. Then top scored sentences are chosen to construct abstract.
7	Junlin Zhang, 2005, [11]	Graph based method	A new approach under the hub-authority framework has been introduced here that unites the text content with some cues and investigates the sub-topics into graph-based sentence ranking algorithm for generating expected output.
8	Xiaojun Wan, 2008, [12]	Graph based method	This is a two-link graph including both sentences and documents. It is assumed that the sentences which belong to an important document, highly correlated with the document, will be more likely to be chosen into the summary.
9	Kokil Jaidka, 2010, [13]	Graph based method	XML schema is constructed to define the valid XML document structure used to represent the structure of a literature review. Then a number of strategies applied to select salient parts from this XML or graphical tree structure to produce a comparative literature review.
10	Kathleen McKeown, 1995, [14]	Time based method	This method focused on techniques to summarize how the trends of an event changes over time, using various points of view over the same event or series of events.
11	Xiaojun Wan, 2007, [16]	Time based method	Here the enhancement of TextRank is unveiled named TimedTextRank with incorporating time dimension. This is based on the proclamation that for an evolving topic, recent documents are usually more important than earlier documents.
12	Shanmugasundaram Hariharan, 2012, [17]	Sentence co-relation based method	A link between two sentences is considered as a vote cast from one sentence to the other sentence. Sentences will be extracted based on casted votes, scores, position etc. to get the abstract.
13	Tiedan Zhu, 2012, [19]	Sentence co-relation based method	This research emphasized on logical-closeness rather than topical-closeness which is based on synonymy and not strong enough to measure the coherence of sentences.
14	Jade Goldstein, 2000, [20]	Clustering based method	Using clustering, coverage, anti redundancy and summery cohesion criteria the proposed procedure emphasized on “relevant novelty” which is a metric for minimizing redundancy and maximizing both relevance and diversity.

15	Judith D. Schlesinger, 2008, [21]	Clustering based method	This method combines Clustering, Linguistics and Statistics for Summarization and named it CLASSY. Structural design made up of five steps: preparation of raw texts, trimming of sentences, scoring, redundancy elimination and sentence organizing.
16	Xiaojun Wan, 2008, [22]	Clustering based method	Two models were proposed here in the process of sentence ranking. One is to incorporate the cluster-level information into the link graph. Second is to consider the clusters and sentences as hubs and authorities in the HITS algorithm for scoring sentences.
17	Nitin Agarwal, 2011, [23]	Clustering based method	This technique generates a summary in a query-oriented fashion with an unsupervised approach called SciSumm. Here the proposed method has four principal modules: text tilling, clustering, ranking and summery presentation.

5 CONCLUSION

In this paper, concepts of multiple documents text summarization are reviewed that categorize different approaches in this ground. This literature review explore the recent trend in summarization system that comes from novice procedure to this time of computer, where natural language processing is used to generate the summary resemble with human expert. Almost all the techniques found for summarization presumed that the documents of correlated topic will be submitted for abstraction. Though Fukumoto J. in 2004 classified given documents into three types, in third type it was assumed that all the documents have association with each other [6]. There is hardly any research found yet to categorize the presented documents with similarity measurement before summarizing. We have faith that the study on multi-document summarization system is a productive region for further research. Around 17 papers have been discussed here and various key topics from other historical publication relevant with text summarization have been analyzed here from 1988 to 2012. There exist some other techniques similar with those described in this paper, the discussion of which has not been included here as it will be a large corpus. But it is expected that any researchers can get help from this literature review for better understanding of different types of procedure on multi-document summarization. Anyone can also get direction for better perception of the diversified sorts of abstraction, which will help to construct new procedure for next generation.

REFERENCES

[1] Hans P. Luhn, "The Automatic Creation of Literature Abstracts," *IBM Journal of Research and Development*, vol. 2, no. 2, pp. 159-165, 1958.

[2] B. Cretu, Z. Chen, T. Uchimoto and K. Miya, "Automatic Summarization Based on Sentence Extraction: A Statistical Approach," *International Journal of Applied Electromagnetics and Mechanics*, IOS Press, vol. 13, no. 1-4, pp. 19-23, 2002.

[3] S. Suneetha, "Automatic Text Summarization: The Current State of the art," *International Journal of Science and Advanced Technology* (ISSN 2221-8386), vol. 1, no. 9, pp. 283-293, 2011.

[4] Krysta M. Svore, Lucy Vanderwende and Christopher J.C. Burges, "Enhancing Single-document Summarization by Combining RankNet and Third-party Sources," Proceedings of the Joint Conference on Empirical Methods in Natural Language Processing and Computational Natural Language Learning, pp. 448–457, 2007.

[5] G. Salton, "Automatic Text Processing: the transformation, analysis, and retrieval of information by computer," Addison-Wesley Publishing Company, USA, 1989.

[6] Jun'ichi Fukumoto, "Multi-Document Summarization Using Document Set Type Classification," Proceedings of NTCIR- 4, Tokyo, pp. 412-416, 2004.

[7] You Ouyang, Wenji Li and Qin Lu, "An Integrated Multi-document Summarization Approach based on Word Hierarchical Representation," Proceedings of the ACL-IJCNLP Conference Short Papers, Suntec, Singapore, pp. 113–116, 2009.

[8] Mr.Vikrant Gupta, Ms Priya Chauhan, Dr. Sohan Garg, Mrs. Anita Borude and Prof. Shobha Krishnan, "An Statistical Tool for Multi-Document Summarization," *International Journal of Scientific and Research Publications* (ISSN 2250-3153), vol. 2, issue 5, 2012.

[9] Inderjeet Mani and Eric Bloedorn, "Multi-document summarization by graph search and matching," AAAI/IAAI, vol. cmp-lg/9712004, pp. 622-628, 1997.
[10] Rada Mihalcea and Paul Tarau, "Text-rank: Bringing Order into Texts," Proceeding of the Conference on Empirical Methods in Natural Language Processing, Barcelona, Spain, 2004.
[11] Junlin Zhang, Le Sun and Quan Zhou, "A Cue-Based Hub-Authority Approach for Multi-Document Text Summarization," Proceedings of NLP-KE'05, IEEE, pp. 642-645, 2005.
[12] Xiaojun Wan, "An Exploration of Document Impact on Graph-Based Multi-Document Summarization," Proceedings of the Conference on Empirical Methods in Natural Language Processing, Association for Computational Linguistics, Honolulu, Hawaii, pp. 755-762. 2008.
[13] Kokil Jaidka, "Multidocument Summarization of Information Science Research Papers," Bulletin of IEEE Technical Committee on Digital Libraries: JCDL/ICADL Doctoral Consortium Issue, vol. 6, issue 2, 2010.
[14] Kathleen McKeown and Dragomir R. Radev, "Generating Summaries of Multiple News Articles," Proceedings of the 18th annual international ACM SIGIR conference on Research and development in information retrieval, Seattle, Washington, pp. 74–82, 1995.
[15] Message Understanding Conference (MUC). Proceedings of the Fourth Message Understanding Conference (MUC- 4). DARPA Software and Intelligent Systems Technology Office, 1992.
[16] Xiaojun Wan, "TimedTextRank: Adding the Temporal Dimension to Multi-Document Summarization," Proceedings of the 30th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval, Amsterdam, pp. 867- 868, 2007.
[17] Shanmugasundaram Hariharan, Thirunavukarasu Ramkumar and Rengaramanujam Srinivasan, "Enhanced Graph Based Approach for Multi Document Summarization," *The International Arab Journal of Information Technology*, 2012. [Online] Available: www.ccis2k.org/iajit/PDF/vol.10,no.4/4460-11.pdf (March 11, 2013)
[18] G. Erkan and D. Radev, "LexRank: Graph-based Lexical Centrality as Salience in Text Summarization," *Journal of Artificial Intelligence Research*, vol. 22, pp. 457-479, 2004.
[19] Tiedan Zhu and Xinxin Zhao, "An Improved Approach to Sentence Ordering For Multi-document Summarization," IACSIT Hong Kong Conferences, IACSIT Press, Singapore, vol. 25, pp. 29-33, 2012.
[20] Jade Goldstein, Vibhu Mittal, Mark Kantrowitz and Jaime Carbonell, "Multi-Document Summarization by Sentence Extraction," ANLP/NAACL Workshops. Association for Computational Linguistics, Morristown, *New Jersey*, pp. 40-48, 2000.
[21] Judith D. Schlesinger, Dianne P. O'Leary and John M. Conroy, "Arabic/English Multi-document Summarization with CLASSY - The Past and the Future," Proceedings of the 9th international conference on Computational linguistics and intelligent text processing, Haifa, Israel, pp. 568–581, 2008.
[22] Xiaojun Wan and Jianwu Yang, "Multi-Document Summarization Using Cluster-based Link Analysis," Proceedings of the 31st annual international ACM SIGIR conference on Research and development in information retrieval, Singapore, pp. 299-306, 2008.
[23] Nitin Agarwal, Gvr Kiran, Ravi Shankar Reddy and Carolyn Penstein Ros´e, "Towards Multi-Document Summarization of Scientific Articles:Making Interesting Comparisons with SciSumm," Proceedings of the Workshop on Automatic Summarization for Different Genres, Media, and Languages, Portland, Oregon, pp. 8–15, 2011.
[24] Marti A. Hearst, "TextTiling: Segmenting Text into Multi-paragraph Subtopic Passages," Computational Linguistics, vol. 23, no. 1, pp. 33-64, 1997.
[25] Florian Beil, Martin Ester and Xiaowei Xu, "Frequent Term-Based Text Clustering," Proceedings of the eighth ACM SIGKDD international conference on Knowledge discovery and data mining, Edmonton, Alberta, Canada, pp. 436-442, 2002.

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Estimates of the Variations in ECOST for Radial Distribution Systems using Analytical Techniques

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ABSTRACT: This paper analyzes different analytical techniques to evaluate the expected cost at the load points and the system. The analytical techniques vary in their complexity and the data utilized during the evaluation. The information obtained by using those techniques which is useful to utilities for the better investment in the system. The collection of the additional data may result in higher investment and operational costs for the utilities. The variation in the expected cost value using these different techniques may be used in determining the level of accuracy the utility may want and hence invest in the system. The variation in the results using these techniques may provide some indication of whether the application of more complex techniques and hence the additional investment costs can be justified**.**This paper estimates the variations in ECOST which is obtained from the results using the various analytical techniques. In this paper the techniques are divided into seven separate cases. The data requirement of the events and interruption costs increases with the increase in complexity of these techniques. This results in more accurate evaluation of ECOST. However, utilities may face huge investment and operation costs to collect the additional data. The variation in the results using these techniques may give indication of whether the application of complex techniques and hence additional investment costs can be justified.

KEYWORDS: Expected customer interruption cost (ECOST), customer damage function (CDF), composite CDF, sector CDF, system CCDF.

1 INTRODUCTION

An electric power system is required to supply electricity to customers with reasonable continuity and adequacy and as economically as possible. The system reliability can be increased with an increase in investment in the planning and operating Phases by improving the existing system and development of new infrastructure. However, over-investment can result in non-economic operation of the power system such as higher operating costs which must be reflected in the tariff structure. The finite economic constraint will be infringed even though the system itself may have less failures and hence better supply. The other end is under-investment in the system which will have the opposite effects. It is evident that the continuity and economic constraints can compete. Power system reliability analysis can help determine the balance between economy and continuity and provide the customers with an economical and reliable supply of electricity [1]. The investments related to the reliability of the electric system need to be evaluated in terms of their cost/benefit implications. This form of analysis is referred to as reliability cost/worth analysis and it helps to determine the balance between investment and reliability of the system.

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There have been many techniques and suitable criteria developed for better power system reliability evaluation over the last few decades. Canadian customer service continuity statistics compiled by utilities show that approximately 80% of the total customer interruptions are due to the result of failures in the distribution system [3]. A highly reliable generation and transmission system may still result in poor energy supply to the customers if the distribution system is unreliable. Therefore, distribution system reliability evaluation is important to ensure appropriate system reliability levels and to provide effective information for regulatory bodies to set proper benchmarks in the deregulated environment. Quantitative reliability assessment is an important aspect in distribution system planning and operation. Analysis of past performance and prediction of future performance are two crucial factors of distribution system reliability evaluation. Various analytical and simulation techniques have been developed for reliability assessment of distribution system [4]. A simple distribution system can be represented by a mathematical model and the expected values of the reliability indices can be calculated using analytical techniques.

2 RBTS DISTRIBUTION SYSTEM ANALYSIS

The test system used in this research is taken from the Roy Billinton Test System (RBTS). The example system shown in Figure 1 is used to illustrate the proposed methodology. It is a part of the Roy Billinton Test System (RBTS) and represents a typical urban distribution system.

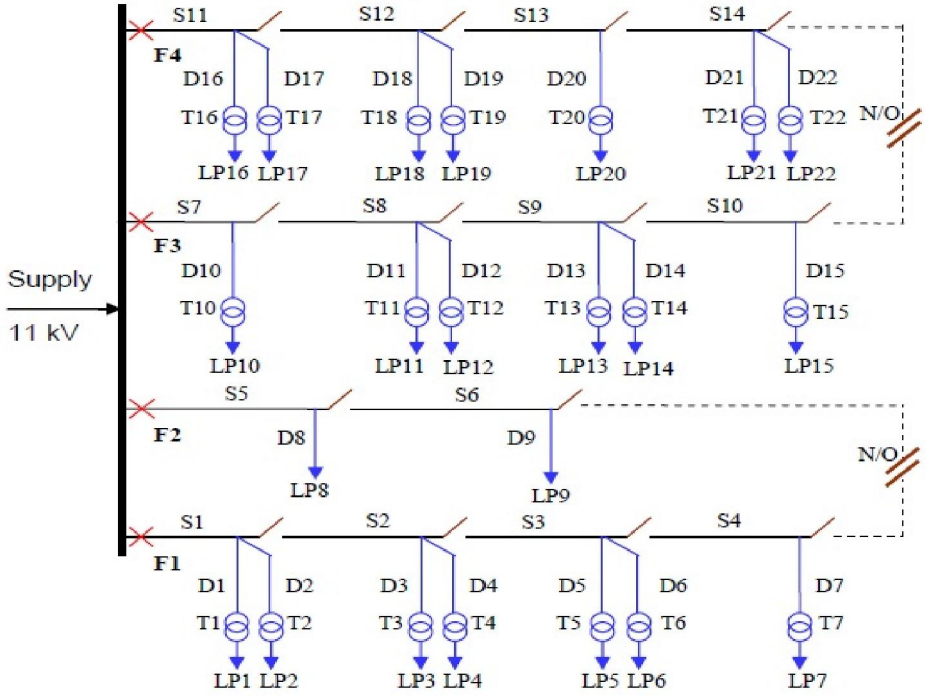

Fig. 1. Representative urban distribution system

3 CUSTOMER DAMAGE FUNCTION

Customer interruption costs provide a good perspective on the reliability of the power system. Customer interruption costs can be represented by customer damage functions (CDF). The CDF can be determined for a group of customers belonging to particular standardized industrial classifications (SIC) [1]. In these cases, the customer damage functions are referred to as individual customer damage functions (ICDF). All the customer costs of a given sector combined result in the sector customer damage function (SCDF).The sector CDFs used in paper are shown as demand normalized values (Rs/kW) in Table1 [1].

Table 1. Sector interruption cost estimates (CDF) in (Rs/kW)

User sector	1min	20min	1hr	4hr	8hr
Residential	0.001	0.09	0.5	4.9	15.7
Commercial	0.381	2.97	8.6	31	83
Small user	4.778	9.88	21	69	119
Institutional	0.044	0.37	1.5	6.6	26

3.1 COMPOSITE CUSTOMER DAMAGE FUNCTION

A composite customer damage function (CCDF) is created by aggregating the sector CDF data. Table 2 shows the load composition based on annual peak demand for Bus 6 of the Roy Billinton Test System (RBTS) used in this paper. It is assumed that there is proportional distribution of load curtailment across all the sectors shown in Table 1.

Table 2. Load composition for the system based on annual peak demand

User Sector	Sector Peak(MW)	Sector peak (%)
Residential	7.25	36.25
Commercial	3.75	18.74
Small user	3.5	17.49
Institutional	5.50	27.50
Total	20.00	100

Table 3 shows the CCDF obtained for the system from the sector CDF using the load composition for the system from Table 2.

Table 3. System CCDF and sector CDF (Rs/kW)

User sector	1 min	20 min	60 min	240 min	480 min
Residential	0.001	0.09	0.48	4.91	15.6
commercial	0.381	2.96	8.55	31.3	83.0
small user	4.77	9.87	21.06	68.83	119.
institutional	0.04	0.36	1.49	6.55	26.0
CCDF	0.92	2.43	5.90	21.6	49.4

Fig.2. shows each sector CDF along with the system CCDF

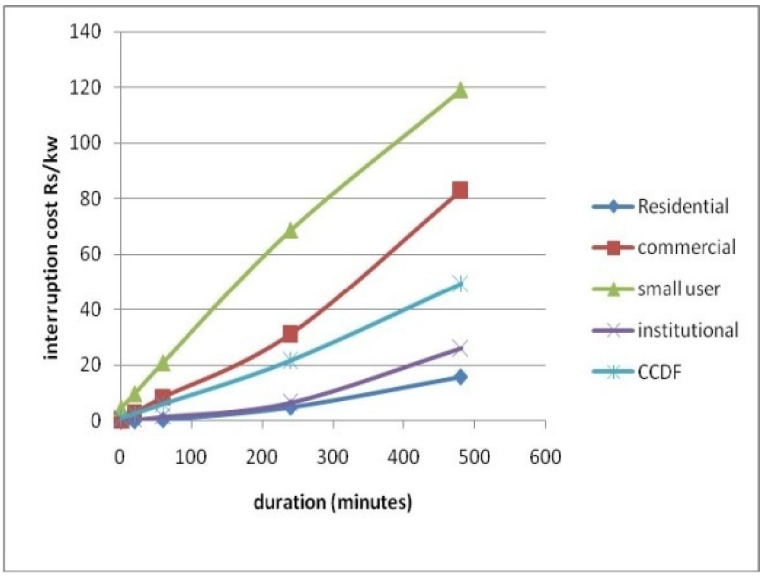

Fig. 2. Sector CDFs and System CCDF

Similarly, the Feeder CCDF can be obtained from sector CDF by using the load composition in each individual feeder. Feeder 1,3and 4 of Bus 6 contain residential, commercial and institutional sector customers. Feeder 2 contains small user sector customers. Table 4 shows the load composition by percentage at each of these feeders.

Table 4. Load composition by percentage for each feeder of Bus 6

User Sector	F1(%)	F2(%)	F3(%)	F4(%)
Residential	0.43	0	0.49	0.39
Commercial	0.25	0	0.14	0.27
Small user	0	1	0	0
Institutional	0.30	0	0.36	0.33

Table 5 shows the Feeder CCDF for each of the feeders of Bus 6 obtained using Tables 3 and Table 4.

Table 5. Feeder CCDF (Rs/kW)

CCDF	1 min	20 min	60 min	240 min	480 min
F1	0.12	0.99	3.07	12.9	37.8
F 2	4.77	9.87	21.0	68.8	119.1
F 3	0.07	0.66	2.16	9.86	30.3
F4	0.12	0.95	2.86	10.8	31.1

4 VARIATION IN ECOST USING ANALYTICAL TECHNIQUES

The distribution system is represented as a mathematical model for analytical techniques to be applied. Most analytical techniques are based on failure mode and effect analysis (FMEA). The analytical techniques utilize different data to calculate the ECOST at the load points and in the total system. These various techniques are analyzed on a case by case basis. The results are then compared to determine the variation in the expected customer cost values. Expected values are obtained using the analytical techniques. The respective sector CDF and CCDF used are shown in Table 3.The expected customer cost values are obtained at the system and individual load point levels.

4.1 ANALYTICAL TECHNIQUES

Technique 1

In which the expected system interruption cost ECOST can be determined by using the SAIFI for the system, the total peak load of the system and the cost associated with CAIDI using the system CCDF. Table 6 shows the ECOST for this technique.

Table 6. Total expected cost using technique 1

	SAIFI (int/cust)	$CCDF_{CAIDI}$ (Rs/kW)	ECOST (kRs/yr)
System	0.24	16.85	83.65

Applying a CAIDI of 3.084 hours, the equivalent customer interruption cost using the system CCDF is 16.85 Rs/kW. Thus, the ECOST for the system is 83.65 kRs/yr.

Technique 2

This technique is modification of the above mentioned technique 1. In which the ECOST can be determined by calculating the ECOST of each feeder (CAIDI).Finally the system ECOST can be obtained by summation of ECOST of each feeder. Table 7 shows the ECOST for this technique.

Table 7. Total expected cost using the technique 2

Feeder	SAIFI (int/cust)	$CCDF_{CAIDI}$ (Rs/kW)	ECOST (kRs/Yr)
1	0.24	9.17	13.49
2	0.13	66.08	32.32
3	0.24	7.068	8.91
4	0.24	9.48	12.94
Total			67.67

It can be seen that the ECOST for the system decreases to 67.67kRs/yr. Consideration of the ECOST at the feeder levels using the corresponding SAIFI and peak load gives a more accurate estimate of the ECOST at the system level.

Technique 3:

In which the ECOST at a particular load point was calculated using the system CCDF. The summation of ECOST of all the load points gives the system ECOST. Fig 3 shows the ECOST at each load point using system CCDF. The system ECOST is equal to 48.65 kRs/yr. It can be seen that the size of the peak load at the load point, position of the load point in the system and the operating scheme of the layout to that load point, i.e. the presence of disconnects, breakers, alternate supply significantly affects the load point expected costs.

The ECOST for the entire system is the summation of all the load point costs and is equal to 48.65 kRs/yr. This is a decrease of 28.10% from the ECOST calculated in Case 2 and a decrease of 41.844% from Case 1.

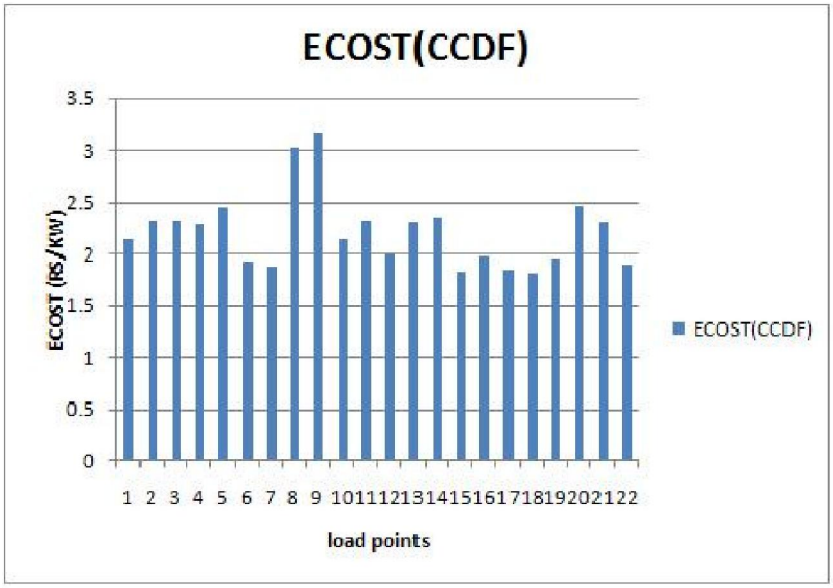

Fig. 3. Calculation of the load point ECOST using the system CCDF

Technique 4

In which the ECOST at a patirticular load point was calculated using the sector CDF. The summation of the ECOST of all the load points gives the system ECOST. Fig 4 shows the ECOST at each load point using sector CDF. The system ECOST is equal to 46.92 kRs/yr.

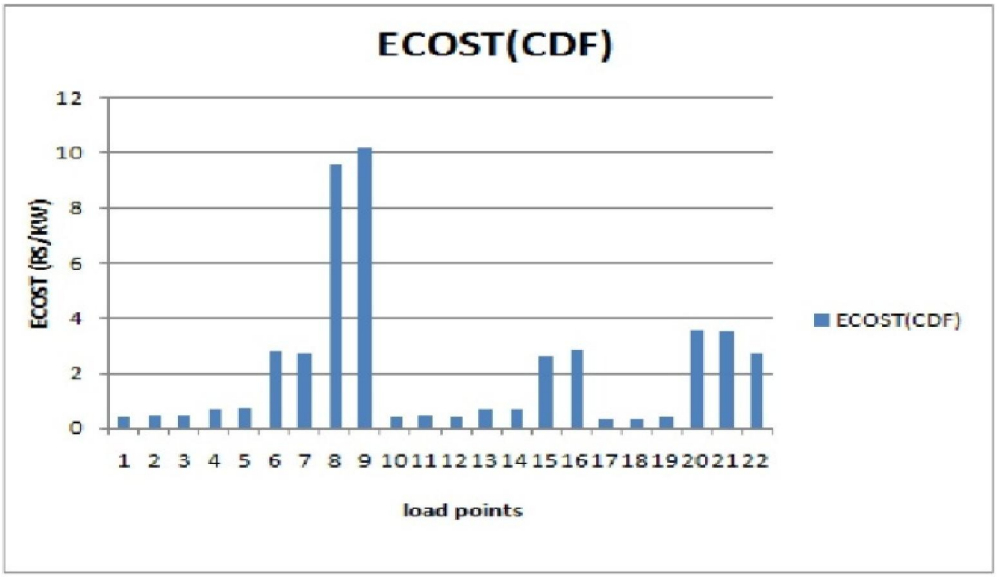

Fig. 4. Calculation of load point ECOST using sector CDF

The total expected cost is 46.92 kRs/yr which is a decrease of 3.5% from the ECOST value calculated in Case 3. The differences between these two values obtained using system CCDF and sector CDF is shown graphically by comparing the load point ECOST values in Fig 5.

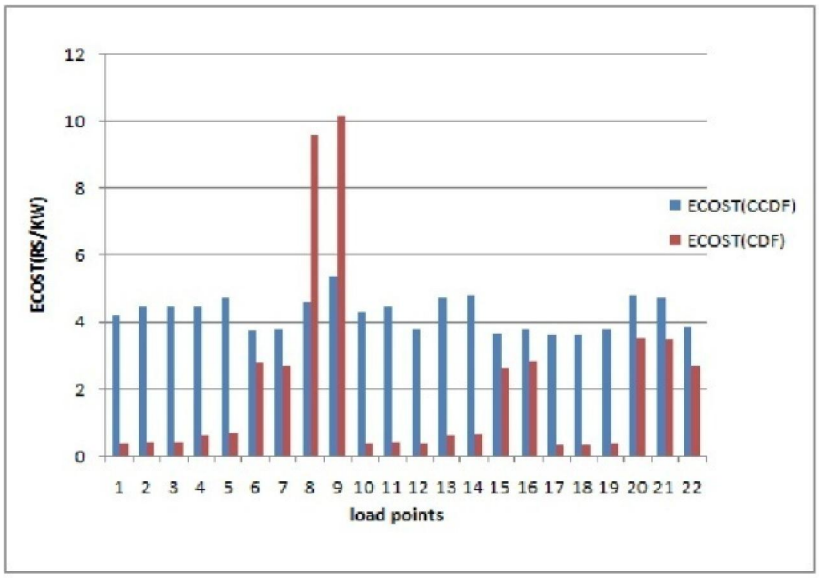

Fig. 5. Comparison of load point ECOST calculated using system CCDF and sector CDF

Fig. 5 shows that the type of customer at the load points and the proportion of the sectors in the system need to be considered when applying the system CCDF to calculate the expected cost. The customers at load points whose sector CDF are much higher than the rest of the sectors will have lower load point ECOST values while the rest might have a higher load point ECOST when the system CCDF is used. This is due to the assumption of proportional distribution of all load curtailments across all sectors while aggregating the sector CDFs to create the system CCDF.

Technique 5

In which the ECOST of a system can be calculated by using the concept of transferring of loads. The total ECOST in this case is equals to 59.02 KRs/yr. Table 8 shows the ECOST for this technique.

Table 8. ECOST technique 5

FEEDER	CDF (Rs/kW)	ECOST (KRs/yr)
1	3.18	31.81
2	3.09	8.79
3	4.53	2.72
4	3.06	15.69
system		59.029

Technique 6

In which the ECOST at a particular feeder was calculated using the feeder CCDF. The summation of the ECOST of all the feeders gives the system ECOST. The system ECOST is equals to 136.14 kRs/yr. Table 9 shows the total ECOST obtained from feeder CCDF.

Table 9. ECOST by technique 6

Feeder	CCDF (Rs/kW)	ECOST (kRs/yr)
1	9.21	7.26
2	66.08	39.71
3	6.98	32.53
4	9.51	56.63
Total		136.14

Technique 7

The entire system is considered as a single load and the system ECOST is calculated directly. The system ECOST obtained by this technique is equals to 1095.39 kRs/yr. Table 10 shows the ECOST by this technique.

Table 10. ECOST by technique7

	CDF (Rs/kW)	ECOST (kRs/yr)
System	16.903	1095.39

5 CONCLUSION

This paper introduces various analytical techniques to evaluate the expected cost at the load points and the system. These techniques require general data which usually are available from most utilities. These technique are, therefore, more realistic for most utilities to estimate the customer interruption costs. The results obtained using the various analytical techniques which shows variation in ECOST using different approaches. The ECOST at a patirticular load point was calculated using the sector CDF and summation of the ECOST of all the load points gives the system ECOST.Which gives more accurate value of ECOST compared to other techniques.

REFERENCES

[1] R. Billinton and R.N. Allan, “Reliability Evaluation of Power Systems”, Second Edition, Plenum Press, New York, 1996.
[2] L. Goel and R. Billinton, “Determination of Reliability Worth for Distribution System Planning”, IEEE Transactions on Power Delivery, Vol. 9, No. 3, July 1994.
[3] Canadian Electricity Association, “2000 Annual Service Continuity Report on Distribution System Performance in Canadian Electrical Utilities”, May 2001.
[4] Roy Billinton and Peng Wang, “Distribution System Reliability Cost/Worth Analysis Using Analytical and Sequential Simulation Techniques”, IEEE Transactions on Power Systems, Vol. 13, No. 4, November 1998.
[5] R. Billinton, S. Kumar, N. Chowdhury, K. Chu, K. Debnath, L. Goel, E. Khan, P. Kos, G. Nourbakhsh, J. Oteng-Adjei, “A reliability Test System for Educational Purposes – Basic Data”, IEEE Transactions on Power Systems, Vol. 4, No. 3, August 1989 .
[6] C. Bhargava, P.S.R. Murty and S. Bharath sree vatsav “Reliability Analysis of Distribution Automation using Interval and Affine Arithmetic.” IACSIT Press Singapore 2011.
[7] C. Bhargava, P.S.R. Murthy and k.Alekhya “ Assessment of Reliability for Distribution Feeders on the Basis of Cost Analysis.” Bonfring International Journal of Power Systems and Integrated Circuits, Vol. 1, Special Issue, December 2011
[8] R. Billinton, J. Oteng-Adjei and R. Ghajar, “Comparison of Two Alternate Methods to Establish an Interrupted Energy Assessment Rate”, IEEE Transactions on Power Apparatus and Systems, August 1987, pp. 751-757.

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Fault Diagnosis in Process Control Valve Using Artificial Neural Network

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ABSTRACT: As modern process industries become more complex, the importance to detect and identify the faulty operation of pneumatic process control valves is increasing rapidly. The prior detection of faults leads to avoiding the system shutdown, breakdown, raw material damage and etc. The proposed approach for fault diagnosis comprises of two processes such as fault detection and fault isolation. In fault diagnosis, the difference between the system outputs and model outputs called as residuals are used to detect and isolate the faults. But in the control valve it is not an easy process due to inherent nonlinearity. The particular values of five measurable quantities from the valve are depend on the commonly occurring faults such as Incorrect supply pressure, Diaphragm leakage and Actuator vent blockage. The correlations between these parameters from the fault values for each operating condition are learned by a multilayer BP Neural Network. The parameter consideration is done through the committee of Development and Application of Methods for Actuator Diagnosis in Industrial Control Systems (DAMADICS). The simulation results using MATLab prove that BP neural network has the ability to detect and identify various magnitudes of the faults and can isolate multiple faults. In addition, it is observed that the network has the ability to estimate fault levels not seen by the network during training.

KEYWORDS: BP, Control Valve, DAMADICS, Fault Diagnosis, Neural Network, MATLab.

1 INTRODUCTION

A common element in modem process industries is the pneumatic process control valve, which is used to control the flow of a liquid, gas or slurry. Failures in these valves due to some abnormality operating conditions give rise to disturbances in the system process. The result is process output deviate from required output and some time unscheduled process shut down. The increasing complexity of process industries and the needed to reduce the overall production costs leads to development of suitable techniques for detecting and assigning causes to valve failures [1].

A number of techniques for fault detection and identification (FDI) have been developed and can be applied to process control valves. In general, FDI techniques follow some measureable parameters related to the performance of the system. When the parameters deviate from their original values, it is assumed that a fault occurred in the valve. If the dependent parameters are carefully selected then that is enough to identify each fault. The design of an effective FDI system requires: (i) a method for obtaining fault dependent parameters related to the system performance, and (ii) a decision process that identifies the specific operating condition related to a particular set of dependent parameters [1].

There are a number of papers that propose different techniques for the fault detection. Beard (1971) & Jones (1973) proposed Beard-Jones Fault Detection Filter based on Observer-based fault detection scheme [2]. Clark & Fosth & Walton, (1975) developed Luenberger Observers based on residual generation scheme [3]. Rank (1987) & Isermann (1991) & Basseville and Nikiforov (1993) proposed Classical fault diagnosis but this method is theoretical only [4]. Cordier et al., (2000) & (de Kleer and Kurien, 2003) implemented Model-Based Diagnosis (MBD) but exact model of complex system is difficult [5].

To build highly efficient, timely and accurate fault diagnosis systems which ensure production safety has become focus research in control field. Modern methods to solve FDI problems in systems with inherent dynamics can be classified into

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three broad categories. The first being a model based techniques. But developing mathematical models for complex systems or for nonlinear systems is difficult, so that model-based scheme has some disadvantage. Furthermore even make a model; the model should be validated by means of experimental method. This method is not suitable for practical complex system. The third class method is to use neural network as fault classifiers to solve FDI problems. This paper investigates a BP neural network to diagnose faults in the process control valve using MATLab by proper selection of dependent parameters [6].

2 PNEUMATIC CONTROL VALVE

The most common final control element in the process control industries is the control valve. The control valve manipulates a flowing fluid, such as gas, steam, water, or chemical compounds, to compensate for the load disturbance and keep the regulated process variable as close as possible to the desired set point.

A pneumatic servo-actuated industrial control valve, which is used as test bed of the fault detection approach proposed in this paper. The internal structure of pneumatic control valve, is shown in Fig. 1.

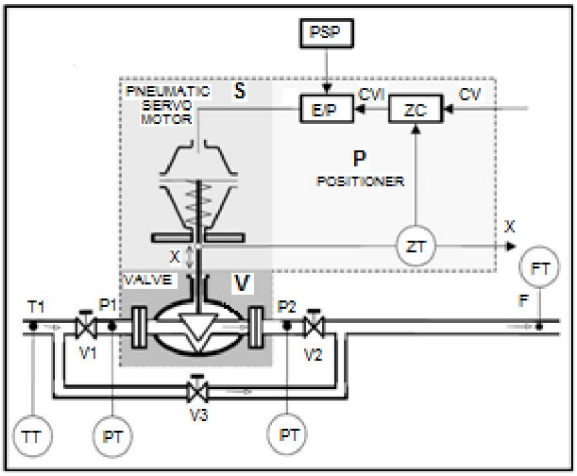

Fig. 1. Internal structure of pneumatic control valve

2.1 ACTUATOR COMPONENTS

The pneumatic control valve includes three parts: spring-and diaphragm pneumatic servo-motor, positioner, and valve, as shown in Fig. 1.

2.1.1 SPRING-AND-DIAPHRAGM PNEUMATIC SERVOMOTOR

Spring-and-diaphragm pneumatic servomotor is a compressible (air) fluid powered device in which the fluid acts upon the flexible diaphragm, to provide linear motion of the servomotor stem.

2.1.2 POSITIONER

Eliminate the control-valve-stem miss-positions produced by the external or internal sources such as friction, pressure unbalance, and hydrodynamic forces.

2.1.3 VALVE

To prevent, allow and/or limit the flow of fluids through control systems. Changing the state of the control valve is accomplished by a servomotor [7].

2.2 INTERNAL PARAMETERS OF ACTUATOR

S -Pneumatic servo-motor

V -Control valve

P -Positioner

ZC -Position P Controller (internal loop)

E/P -Electro-Pneumatic Transmitter

2.2.1 ADDITIONAL EXTERNAL COMPONENTS

V1 -Cut-Off Valve

V2 -Cut-Off Valve

V3 -By-Pass Valve

PSP -Positioner Supply Pressure

PT -Pressure Transmitter

FT -Volume Flow Rate Transmitter

TT -Temperature Transmitter

2.2.2 SET OF BASIC MEASURED PHYSICAL VALUES

CV -External (Flow or Level) Controller Output

F -Flow Sensor Measurement

P1 -Valve Input Pressure

P2 -Valve Output Pressure

T1 -Liquid Temperature

X -Rod Displacement

3 CONTROL VALVE FAULTS

DAMADICS committee is concerning on the development of pneumatic control valve fault detection and isolation (FDI) algorithms [6].The main goal of DAMADICS benchmarks is the creation of well defined, repeatable single actuator faults. For this purpose the set of actuator faults was identified [8].

DAMADICS predefined the 19 types of faults which are going to be occurring in the pneumatic valve during the process [9]. The faults of control valve are classified into four following groups: Control valve faults; Pneumatic servo-motor faults; Positioner faults; General faults/external faults. Mostly, single actuator faults are observed in industrial practice whereas multiple faults rarely occur. When fault is occurring, dependent parameters will be vary from the normal condition. So these parameters are sufficient to characterize the changes in the performance of the actuator due to the occurrence of the faults under investigation [6].

3.1 FAULT CONSIDERED FOR DIAGNOSIS

In real time application several faults may occur in pneumatic control valve. Three commonly occurring faults are

- Incorrect supply pressure
- Actuator vent blockage
- Diaphragm leakage

These faults are going to be diagnosed by the Neural Network methods.

3.2 DEPENDENT PARAMETERS CONSIDERED FOR DIAGNOSIS

The following five parameters are considered to identify the above three faults which are approved by the DAMADICS [8].

- Valve Input Pressure (kPa)
- Valve Output Pressure (kPa)
- Flow Sensor Measurement (m3/h)
- Rod Displacement (%)
- External (Flow or Level) Controller Output (%)

4 ARTIFICIAL NEURAL NETWORK TECHNIQUE

Neural networks are an information processing systems formed by interconnecting simple processing units called neurons. Each neuron is an independent processing unit that modifies the input based on the weight which is assigned by training of neural network.

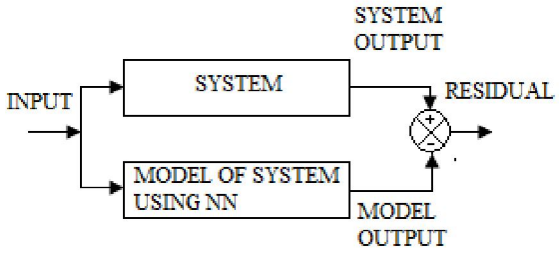

Fig. 2. Residual generation using neural network

Neural networks are applied in FDI systems for both detection and isolation. For the detection part, the normal behavior of the objective system is modeled using a neural network [10]. Residual signals are generated by comparing the output of the neural network with the output of the objective system as shown in the Fig. 2.

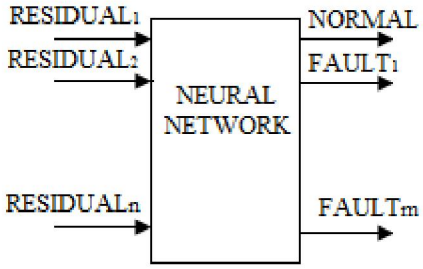

Fig. 3. Residual mapping into a normal or faulty class

For the isolation part, a neural network is used to perform the classification of the residuals into the corresponding classes of faults as shown in the Fig. 3.

4.1 NETWORK STRUCTURE

A feed-forward network has a layered structure. Each layer consists of neurons which receive their input from neurons from a layer directly below and send their output to neurons in a layer directly above the neuron. The Ni inputs are fed into the first layer of $N_{h,1}$ hidden neurons. The input neurons are merely 'fan-out' neurons; no processing takes place in these neurons. The activation of a hidden neuron is a function F_i of the weighted inputs plus a bias. The activation function shown in Eq. (1) is used in hidden neurons.

$$F_i = \log sig(code) \tag{1}$$

$$\begin{Bmatrix} Error\ \ signal\ \ from \\ past\ \ hidden\ neuron \end{Bmatrix} = F_i\left(\begin{pmatrix} weighted \\ inputs \end{pmatrix} + bias\right) \tag{2}$$

The output of the hidden neurons is distributed over the next layer of $N_{h,2}$ hidden neurons, until the last layer of hidden neurons, of which the outputs are fed into a layer of No output neurons as shown in Fig. 4 and the Eq. (2) gives the output of each and every hidden layer [11].

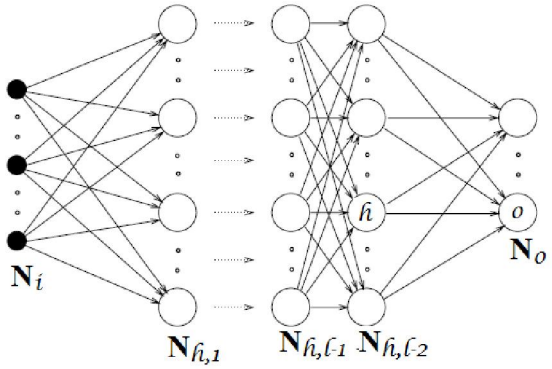

Fig. 4. A multi-layer feed-forward network with l layers of neurons

The size of the output layer grows as the number of fault classification increases. The input layer contains five nodes, one node corresponds to each available dependent parameters. The neurons in the hidden layer are adjustable. Since the network does not contain any feedback loops, its output can be calculated as an explicit function of the network inputs and the network weights [12].The two linear output neurons estimate the type of the fault.

4.2 NETWORK TRAINING

The training of neural network creates the nonlinear correlation between the values of the dependent parameters and the respective operating condition of the process. This is done by adjusting weights of the network so that the error between the required output (the actual operating condition) and the network output (the estimated operating condition) for all sets of training data is minimized. A weight adjustment is performed by trainscg ( ). It is a network training function that updates weight and bias values according to the scaled conjugate gradient method.

The feed-forward backpropagation network training function shown in Eq. (3) is used to train the network.

$$net = \begin{Bmatrix} newff(PR,[nhid\ \ nout],\{'\tan sig''\log sig'\}, \\ 'trainscg','learngdm','mse') \end{Bmatrix}; \tag{3}$$

So the weights were adjusted to minimise the network error over the entire set of training data. Training was terminated when the overall network error fall below 0.001, or the total number of weight corrections (epochs) exceeded 1000.

5 RESULTS

The real time data measured under normal and abnormal condition of pneumatic control using data acquisition is given to BPN algorithm. Totally 1000 data are collected under various operating conditions including no fault condition. Two hidden layers are given for calculation and back-propagation of the error. The Table 1 shows the output of network.

Table 1. Results of Neural Network

S. No.	Parameters	Network Output
1	No. of training data	750
2	No. of checking data	250
3	Training error	0.00098381
4	Classification error	0.0034
5	Computational Time	4.5084

Network performance was attained at epoch 105 and the plot was shown in the Fig. 5.

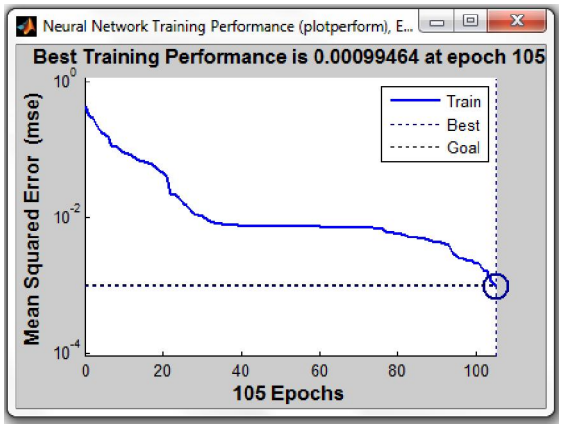

Fig. 5. Network performance plot

The linear regression of targets relative to outputs was shown in the Fig. 6.

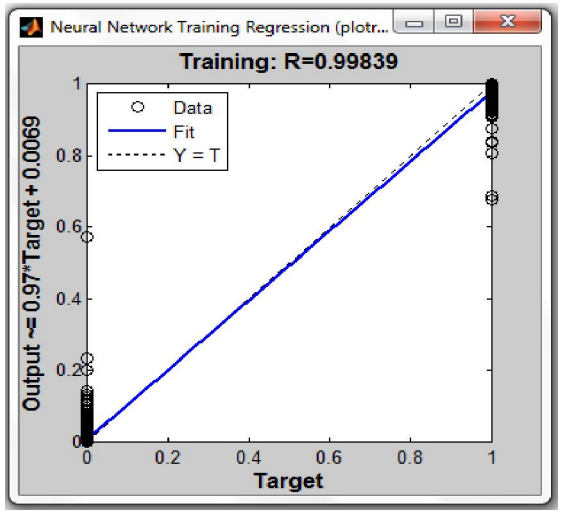

Fig. 6. Linear regression of targets relative to outputs plot

From the analysis of various plots and network output the BP neural network has the perfect ability to diagnosis control valve faults.

6 CONCLUSION

In this paper a BP neural-network based scheme for detection and identification of pneumatic control valve faults was proposed. The specific values of five parameters were observed to depend upon the particular type of fault. For each operating condition, the dependent parameters changed its state which is learned by a multilayer feed-forward neural network with the goal of successfully detecting and identifying the faults. The simulation results proved that the trained neural network has the capability to detect and identify the various magnitudes of the faults with better performance.

REFERENCES

[1] M. Karpenko, N. Sepehri "A Neural Network Based Fault Detection And Identification Scheme For Pneumatic Process Control Valves" *Proceedings of the 2001 IEEE International symposium on Computational Intelligence in Robotics and Automation*, pp. 166-171, July 29 –Augest 1 2001.

[2] Beard R V: Failure *accommodation in linear system through selfreorganization*, PhD thesis, MIT, Massachusetts, USA, pp. 21-25, 1971.

[3] Clark RN, Fosth DC and Walton WM, "Detecting instrument malfunctions in control systems," *IEEE Transactions on Aerospace and Electronic Systems AES-11*, pp. 465-473, 1975.

[4] Basseville M and Nikiforov I: Detection of abrupt changes: theory and application, Information and System Science. Prentice Hall, New York, pp. 56-78, 1993.

[5] Cordier MO, Dague P, Dumas M, Levy F, Montmain J, Staroswiecki M and Traves-Massuyes L , " AI and automatic control approaches of modelbased diagnosis: Links and underlying hypothesis," *IEEE Proceedings of the 4th IFAC Symposium SAFEPROCESS'00*, Budapest, Hungary, vol. 1, pp. 274- 279,2000.

[6] Fukai Deng, Erqing Zhang, Qunli Shang, Shan-en Yu and Yifang He, "Application of BP Neural Network in Faults Diagnosis of Process Valve Actuator," *Lecture Notes in Electrical Engineering, Volume 107, Computer, Informatics, Cybernetics and Applications,* Part 8, pp. 793-801,2012.

[7] DAMADICS Benchmark Definition, Warsaw University of Technology, Institute of Automatic Control and Robotics Team with cooperation with UPC, Preliminary, ver. 1.0 March 17, pp. 01-20, 2002.

[8] Michał Bartyś: How to build a benchmark problem for FDI evaluation, DAMADICS Vacation School Technical University of Lisbon, pp. 01-15, August 31- September1 2001.

[9] Michał Bartyś, Michał Syfert: Using Damadics Actuator Benchmark Library (DABLib), Final, ver. 1.22, pp. 01-20, April 26, 2002.

[10] Vasile Palade, Cosmin Danut Bocaniala and Lakhmi Jain (Eds): Computational Intelligence in Fault Diagnosis, Springer-Verlag London Limited, pp. 01-37, 2006.

[11] Ben Krose and Patrick van der Smagt: An Introduction to Neural Networks, The University of Amsterdam, Eighth edition, pp. 33-38, November 1996.

[12] Marcu T, Mirea L, Frank P.M, "Development of dynamic neural networks with application to observer-based fault detection and isolation," *International Journal of Applied Mathematics and Computer Science*, pp. 547-570, 1999.

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Detection of Heart Diseases by Mathematical Artificial Intelligence Algorithm Using Phonocardiogram Signals

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ABSTRACT: An artificial intelligence (AI) algorithm has been developed using Mathematical formula to diagnose heart disease from Phonocardiogram (PCG) signals. Auscultation, the technique of listening to heart sounds with a stethoscope can be used as a primary detection technique for detecting heart disorders for the past years. But now the Phonocardiogram, the digital recording of heart sounds is becoming very popular technique as it is relatively inexpensive. Four amplitude parameters of the PCG signal are extracted by using filter technique and are used as input. PCG signals for three types of heart diseases such as Tachycardia, Bradycardia and Atrial fibrillation were used in this paper to test the accuracy. These disease types that affect the electrical system of heart are known as arrhythmias, cause the heart to beat very fast (Tachycardia) or very slow (Bradycardia), or unexpectedly (Atrial fibrillation). After the signals are filtered and the parameters are extracted, the parameters are fed to the AI algorithm. Classifications of heart diseases are carried using the AI algorithm by comparing the extracted parameters. Here comparison is done using Min Max method. The developed mathematical artificial intelligence algorithm is implemented in MATLab using Simulink and the simulation results proved that the developed algorithm has been shown to be a powerful technique in detection of heart diseases using PCG signals.

KEYWORDS: Artificial intelligence, Atrial fibrillation, Bradycardia, Heart, MATLab, Phonocardiogram signals, Tachycardia.

1 INTRODUCTION

Cardiac auscultation is the foremost basic analysis tool used to evaluate the function of the heart [1]. Electrocardiography (ECG) test is varied if the heart sound from the Phonocardiogram (PCG) shows any abnormalities. Heart sounds has the advantage of being heard and seen on the screen, which gives a higher level of the accuracy of the basic diagnosis. Even, because of noise and human misinterpretation, diagnosis may not be as accurate as we desired. Diagnosis accuracy can be substantially improved if an artificial intelligence machine is used to provide potential diagnoses using some parameters of the heart sound signals. Such process is expected to reduce mortality rate and cost of care [2].

There are a number of papers that propose different techniques for the extraction of parameters from the heart sounds and classify those using different techniques. In the late 1980 Mohamed and Raafat implemented a mathematical model to the heart sounds and murmurs by a finite number of parameters [3]. In this case, parameters were derived based on the linear prediction of the cardiac cycle frames, where classification was carried out based on the minimum distance between the parameters of the measured pattern and the reference patterns. Patil and Kumaraswamy presented an intelligent technique for heart attack based on Data Mining and Artificial Neural Network [4]. In this method, the parameters that are important to the heart attack are computed by K-means clustering algorithm.

A novel method of separating the heart sounds using homomorphic filtering and parameter extraction from wavelet coefficients are classified using GAL (Grow and Learn) algorithm [5].

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Reed et al. [5] analyze the heart sounds for symptom detection, where heart sounds were separated and transformed using wavelet decomposition. [6].

Yaghouby et al. presented Heart rate variability (HRV) based classification of arrhythmia. This is based on both the General Discriminant Analysis (GDA) and the Multi-Layer Perceptron (MLP) method [7].

In this paper, a new AI mathematical algorithm is developed and the input parameters to the algorithm are extracted from the PCG signals. PCG signals from many human subjects are collected and the diseases are classified using a comparison algorithm to assess the diagnosis predictability. Among these subjects, few are diagnosed with tachycardia (disease-1), remaining is diagnosed with bradycardia (disease-2) and Atrial fibrillation (disease-3).

2 MECHANISMS FOR HEART SOUND PRODUCTION

The human heart has four chambers, two upper chambers are called atrial and two lower chambers are called ventricles as shown in Fig. 1.

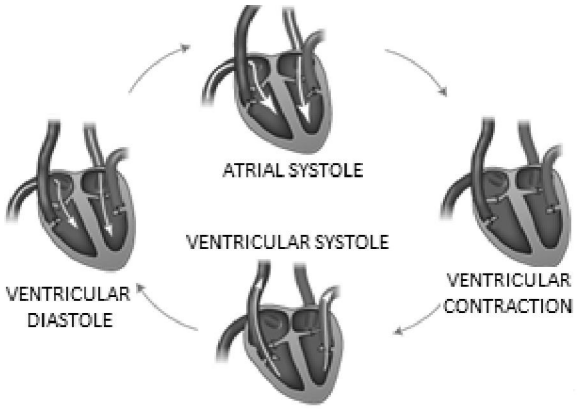

Fig. 1. Mechanism of creation of heart sound

There are valves located between the atrial and ventricles of a heart, and also between the ventricles and the major arteries. These valves open and close periodically to permit blood flow in only one direction. Two sounds are normally produced due to blood flow through the heart valves during each cardiac cycle as shown in Fig. 2.The sound S1 called “lubb” and S2 called “dupp”.

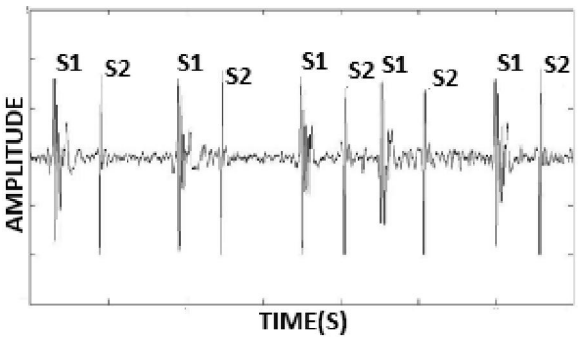

Fig. 2. Waveform of S1 heart sound lubb and S2 heart sound dupp

3 PHONOCARDIOGRAPHY

Diagnostic technique that creates a graphic record called Phonocardiogram (PCG) of the sounds and murmurs produced by the heart as shown in Fig. 3 [8].

The heart sounds are produced by mechanical events, as follows:

A. Valvular events - Vibrations caused mostly by closing of valves and a lesser intensity vibration is produced by opening of the heart valves [8].

B. Muscular events - Vibrations of the myocardium due to contraction of valves

C. Vascular events - The sudden distension of the arterial walls causes vibration due to ejection of blood [8].

D. Acceleration/Deceleration of the blood flow in the heart produces vibration [8].

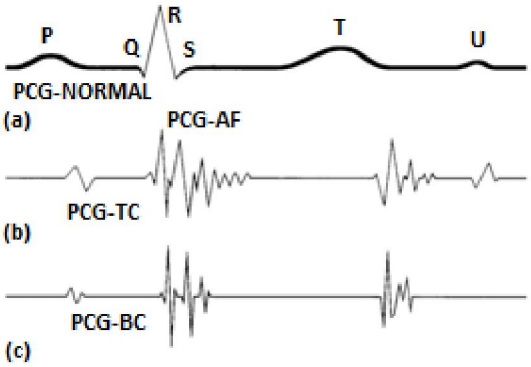

Fig. 3. (a) The PCG Signals for normal human (b) The PCG Signals for Tachycardia and Atrial Fibrillation disease (c) The PCG Signals for Bradycardia disease

4 HEART DISEASES

The term "Heart Diseases" refers to diseases occurred in the heart and also in the blood flow system within the heart. There are more than 50 different types, the most common type that affects the electrical system is known as arrhythmias. They can cause the heart to beat very fast (Tachycardia) or very slow (Bradycardia), or unexpectedly (Atrial fibrillation) as shown in Fig. 3. These kinds of heart disease include the following types:

- Tachycardia
- Bradycardia
- Atrial Fibrillation
- Premature Atrial Contractions (PAC), also called as premature atrial complexes
- Atrial flutter etc. [9].

4.1 TACHYCARDIA

Heart rate that exceeds the normal beat range is called tachycardia. A heart rate exceeds 100 beats per minute is usually accepted as tachycardia as shown in Fig.4.

Fig. 4. ECG showing tachycardia with a heart rate of 100 beats per minute

Even though, tachycardia can be dangerous depending on the heart rate speed and type of rhythm. Tachycardia derived from the Greek words tachys (accelerated or rapid) and kardia (of the heart).

4.2 BRADYCARDIA

The resting heart rate of fewer than 60 beats per minute is called bradycardia, even though it is no symptomatic until the rate drops below 50 beats per minute as shown in Fig.5. It may produce cardiac arrest in some cases; because those have bradycardia may be not able to pump required oxygen to their hearts. It sometimes results in lacking of strength, briefness of breath, and if severe cause death.

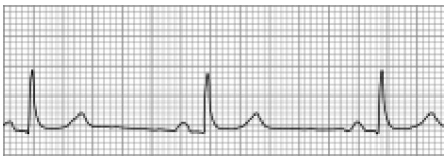

Fig. 5. Fig. 5. ECG showing bradycardia with a heart rate of about 50 beats per minute

4.3 ATRIAL FIBRILLATION

Atrial fibrillation or flutter is a one type of unexpected heart beat rate in which the heart sounds is very fast and irregular.

5 SIMULATION USING MATLAB

In this paper, a new mathematical AI algorithm was developed using MATLab, where new parameters are extracted from the PCG signals and are used as input to the algorithms.

5.1 PARAMETERS CONSIDERED

The P,Q,R,S amplitude values from the PCG signal are considered as input parameters as shown in Fig. 3.

5.2 PARAMETER EXTRACTION

The parameters are extracted from PCG signal using Butterworth filter and many signal processing elements. The PCG signal is processed by filter and peak values of the signal are detected by MinMax Mask.

5.3 ATRIAL FIBRILLATION DETECTION ALGORITHM

Since an irregular rhythm of the QRS complexes is the major parameter of AF. The R–R interval (RRI), defined as the interval of neighboring QRS complexes, is an ideal parameter to identify AF. This paper uses two different algorithms for AF detection.

5.3.1 ALGORITHM I

Step 1: Detection of R waves and marking of R peaks.

Step 2: Calculation of RRI (the duration of adjoined Rpeaks).

Step 3: Calculation of the variation of consecutive RRI (ΔRRI).

Step 4: Activation of the alarm system when ΔRRI >150 ms occurs twice within each 6 s of computation.

5.3.2 ALGORITHM II

Step 1: Detection of R waves and marking of R peaks.

Step 2: Calculation of RRI (the duration of adjoined R peaks).

Step 3: Calculation of the variation of consecutive RRI (ΔRRI).

Step 4: Calculation of the SD of RRI (RRIstd) in each 6-s recording.

Step 5: Activation of the alarm system when ΔRRI >150 ms occurs twice and RRIstd > 60 ms within 6 s of computation.

The simulation for atrial fibrillation was shown in Fig. 6.

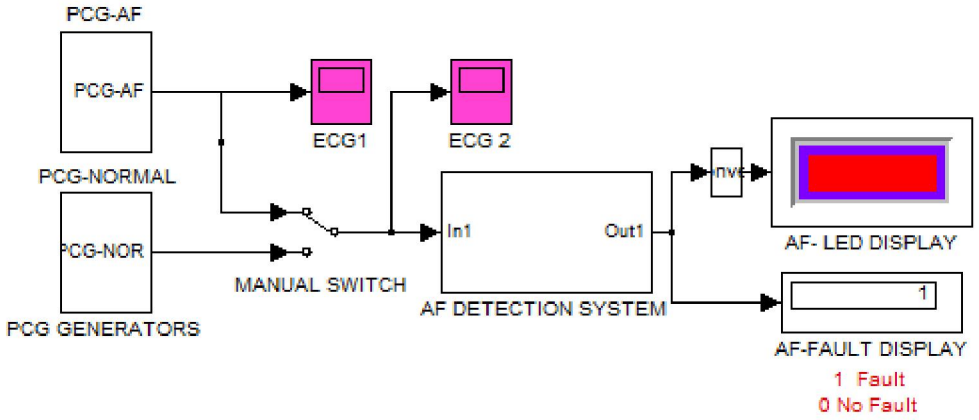

Fig. 6. Simulation of Atrial Fibrillation (AF) heart disease detection

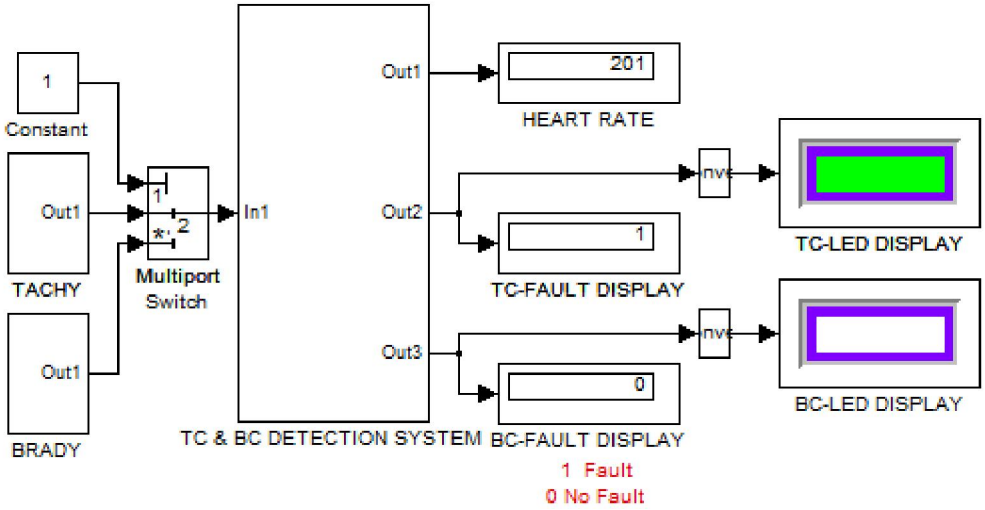

Fig. 7. Simulation of Tachycardia(TC) and Bradycardia(BC) heart disease detection

5.4 TACHYCARDIA DETECTION

For this disease the AF detection algorithm was used by considering only the peak value without considering the time phenomenon ,that find tachycardia when the heart beats goes too fast. The simulation for tachycardia was shown in Fig. 7.

5.5 BRADYCARDIA DETECTION

For this disease the AF detection algorithm was used by considering only the peak value without considering the time phenomenon, that find bradycardia when the heart beats goes too slowly. The simulation for bradycardia was shown in Fig. 7.

6 RESULTS

The three different colours in the simulation a result indicates three different diseases occurred in the heart and white colour indicate normal condition of heart as shown in the Table 1.

Table 1. Simulation Results

S. No.	Disease	Fault Display Value	LED Display Colour
1	Tachycardia	0 (Normal Condition)	Green
		1 (Disease)	White
2	Bradycardia	0 (Normal Condition)	Blue
		1 (Disease)	White
3	Atrial Fibrillation	0 (Normal Condition)	Red
		1 (Disease)	White

7 CONCLUSION

This paper proposes the preprocessing of heart sound signal from many human objects with disease in simulation. Among these human objects, few are diagnosed with tachycardia (disease-1), remaining is diagnosed with bradycardia (disease-2) and Atrial fibrillation (disease-3). Four independent parameters related to the PCG signals are extracted. These parameters are fed as inputs to AI algorithm. The result shows that the new AI algorithm finds the diseases perfectly and simulation also verifies the same.

REFERENCES

[1] S. S. Tripathy, "System for diagnosing valvular heart disease using heart sounds," Master's Thesis, India, 2005.
[2] Ibrahim Abdel-Motaleb and Rohit Akula, "Artificial Intelligence Algorithm for Heart Disease Diagnosis using Phonocardiogram Signals," IEEE transaction on biomedical engineering, Vol. 51, NO. 7, pp. 1196-1202, 2012.
[3] A. S. A. Mohamed and H. M. Raafat, "Recognition of heart sounds and murmurs for cardiac diagnosis," In Proceedings of 9th International Conference on Pattern Recognition, pp. 133-145, 1988.
[4] S. B .Patil and Y. S. Kumaraswamy, "Intelligent and Effective Heart Attack Prediction System Using Data Mining and Artificial Neural Network," European Journal of Scientific Research, ISSN 1450-216X Vol.31 No.4. pp. 642-656, 2009.
[5] C. N. Gupta, Ramaswamy Palaniappan, Sundaram Swaminathan and Shankar M. Krishnan ,"Neural Network Classification of Homomorphic Segmented Heart Sounds, " Applied Soft Computing 7, pp. 286–297, 2007.
[6] T. R. Reed , N. E Reed and P. Fritzson, "The Analysis of Heart Sounds for Symptom Detection and Machine-Aided Diagnosis," In Proceedings of the 4th International EUROSIM conference, pp. 01-06, 2001.
[7] F. Yaghouby, A. Ayatollahi and R. Soleimani, "Classification of Cardiac Abnormalities Using Reduced Features of Heart Rate Variability Signal," World Applied Sciences Journal 6, pp. 1547-1554, 2009.
[8] "Heart Sounds. Phonocardiography" [Online] Available: www.fiziologie.ro/engleza/Practicals_Semester_1/Practicals%20CV%204.pdf (April 2013)
[9] "Heart Articles" [Online] Available: http://heart.emedtv.com/heart_diseases/heart_diseases.html (April 2013)

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Étude des propriétés hydriques (porosité et conductivité hydraulique saturée) de l'aquifère du quaternaire d'Abidjan (Côte d'Ivoire)

[Study of Hydraulic properties (porosity and saturated hydraulic conductivity) of the quaternary aquifer of Abidjan (Côte d'Ivoire)]

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ABSTRACT: The hydraulic properties of the soil are important parameters in hydrogeology. They allow knowing the characteristics and functioning of aquifers. But their determination is costly and difficult on large sites such as the quaternary aquifer of Abidjan. The objective is to know the hydraulic properties of the aquifer of Abidjan through the study of the porosity and the prediction of saturated hydraulic conductivity by the modified Kozeny Carman's model. The predicted conductivities are compared to those measured in situ by the double rings infiltrability method. The work showed that the porosities ranging from 0.25 to 0.42 while the hydraulic conductivities from 2.10^{-5} to 5.10^{-5} m/s. The quaternary aquifer of Abidjan is composed of coarse sand of the marine cordon and medium sand of the lagoon depressions. The coarse sands are found in the southern part of the aquifer while the medium sands in the north part. The application of the modified Kozeny Carman model showed that the predicted conductivities are close to those measured in situ. This model can be used to predict the hydraulic conductivity of the sands of the quaternary aquifer. The model has the merit of using the basic physical properties of the soil easily accessible. It could therefore be applied to other sandy aquifers along of whole eburneo basin of the West Africa.

KEYWORDS: Abidjan aquifer, saturated hydraulic conductivity, modified Kozeny Carman model, Quaternary groundwater, physical property of soil.

RESUME: Les propriétés hydriques des sols sont des paramètres importants en hydrogéologie pour la connaissance des caractéristiques et du fonctionnement des aquifères. Mais leur détermination notamment la mesure de la conductivité hydraulique est couteuse et difficile sur des sites étendus comme l'aquifère du quaternaire d'Abidjan. L'objectif est de connaître les propriétés hydriques de l'aquifère d'Abidjan à travers l'étude de la porosité et la prédiction de la conductivité hydraulique saturée par le modèle de Kozeny Caman modifié. Les conductivités prédites sont comparées à celles mesurées in situ par la méthode d'infiltrabilité à double anneaux. Les travaux ont montré que les porosités varient de 0.25 à 0.42 tandis que la conductivité de 2.10^{-5} à 5.10^{-5} m/s. L'aquifère du quaternaire d'Abidjan est constitué de sables grossiers des cordons marins et les sables moyens des dépressions fluivio-lagunaires. Les sables grossiers se trouvent au sud de l'aquifère et les sables moyens au nord. L'application du modèle de Kozeny Carman modifié a montré que les conductivités prédites sont proches de celles mesurées in situ. Ce modèle peut être utilisé pour prédire la conductivité hydraulique de ces sables. Il a le

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mérite d'utiliser les propriétés physiques de base du sol facilement accessibles. Il pourrait donc s'appliquer sur les aquifères sableux de tout le bassin eburneo-nigerian qui borde toute l'Afrique de l'ouest.

MOTS-CLEFS: Aquifère d'Abidjan, conductivité hydraulique saturée, Modèle de Kozeny Carman modifié, nappe du quaternaire, propriété physique des sols.

1 INTRODUCTION

Les zones côtières d'Afrique sont très sollicitées par l'homme. Elles permettent une ouverture sur le monde à travers de grands ports et regroupent les plus grandes villes notamment Ouest africaines. Ce sont des zones humides propices à l'habitation et aux activités agricoles [6], [7]. Elles regroupent les grands aquifères du continent. Ces aquifères sont sujets à la pollution anthropogéniques [5], [13], [32], [38]. Leur fonctionnement n'est toujours pas connu. Ce qui rend difficile la mise en place de programmes de gestion pour la préservation de la ressource eau qui se raréfie de plus en plus sur le continent.

L'aquifère du quaternaire situé au sud de la grande métropole d'Abidjan fait partie de ces aquifères. C'est un aquifère dont la nappe affleure par endroit. Il est équipé de puisards et de puits et l'eau est utilisée comme eau de boisson pour une frange de la population. Les études réalisées ont montré une forte pollution anthropique [12], [2]. Ce qui provoque des épidémies récurrentes liées aux maladies hydriques. L'étude de la dynamique de l'aquifère du quaternaire d'Abidjan pours définir un plan de protection nécessite la connaissance des propriétés hydriques notamment la conductivité hydraulique.

La conductivité hydraulique (ks) est une propriété importante de l'aquifère [15]. Sa connaissance est essentielle à la modélisation de l'écoulement de l'eau et au transfert de solutés [15], [15]. Lorsque l'aquifère est très étendu comme l'aquifère du quaternaire d'Abidjan, la connaissance de la conductivité hydraulique sur l'ensemble du système est nécessaire pour comprendre son fonctionnement à partir d'un modèle. Plusieurs méthodes d'estimation de la conductivité hydraulique existent. Les méthodes expérimentales de laboratoire sont appliquées au laboratoire sur des échantillons de sol prélevés et transportés. Des écarts de mesure sont observés sur les résultats de mesure en fonction du protocole de mesure appliqué [20]. En plus, le déplacement du matériau de son point de prélèvement peut modifier les résultats de mesure au laboratoire.

Les méthodes expérimentales in situ ont le mérite de prendre en compte l'environnement du matériau pendant la mesure de la conductivité hydraulique [23], [21]. Mais ces méthodes sont onéreuses et demandent beaucoup de temps quand les sites sont étendus [27].

Plusieurs méthodes de prédictions de la conductivité hydraulique ont été développées. Ainsi, des méthodes de prédiction basées sur la connaissance de la taille des grains de sol ont été testées [33], [3], [16], [19], [28], [20]. D'autres méthodes de prédiction basées sur la connaissance des paramètres physiques de base des matériaux ont été développées [26], [40], [37], [4], [30]. Ces méthodes utilisent des paramètres physiques des sols facilement accessibles et ont été discutées par [9], [39].

L'objectif de cette étude est de déterminer les propriétés hydriques (porosité et conductivité hydraulique) de l'aquifère du quaternaire d'Abidjan. Il s'agit de tester le modèle de Kozeny Carman modifié pour prédire la conductivité hydraulique (ks). Le modèle de Kozeny Carman utilise des paramètres physiques de base (indice de vide e, coefficient d'uniformité Cu, D_{10}, D_{60}) des matériaux pour la détermination de la conductivité hydraulique.

2 MATERIELS ET METHODE

2.1 PRESENTATION DU SITE D'ETUDE

L'aquifère du quaternaire d'Abidjan est situé entre les latitudes 5°12'5''Nord et 5°20'15''Nord et les longitudes 4°4'57''Ouest et 3°43'19''Ouest. C'est un étendu de sable [11]. Cet étendu de sable forme l'aquifère du quaternaire d'Abidjan et fait partie du bassin sédimentaire côtier de Côte d'Ivoire et du grand bassin éburnéo-nigérian. Il s'étend sur une superficie d'environ 253 km^2 et est limité au sud par l'Océan Atlantique et la lagune Ouladine, au Nord par la lagune Ebrié, à l'Est par la lagune Potou et la lagune Ouladine et à l'Ouest par la lagune Ebrié et le Canal de Vridi [12] (figure 1).

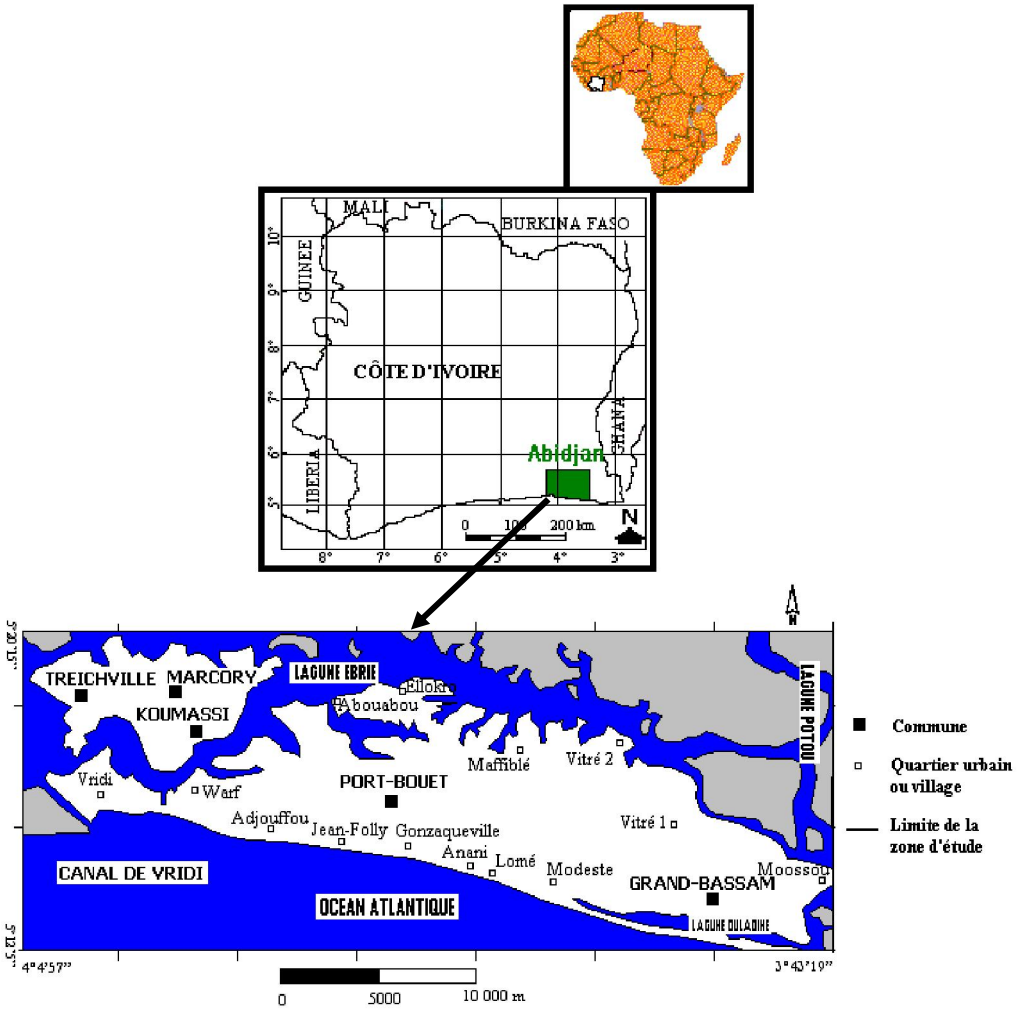

Fig. 1. Situation géographique du site d'étude

2.2 PRELEVEMENT

51 échantillons de sable ont été prélevés sur l'ensemble du site. Les points de prélèvement sont présentés dans la figure 2.

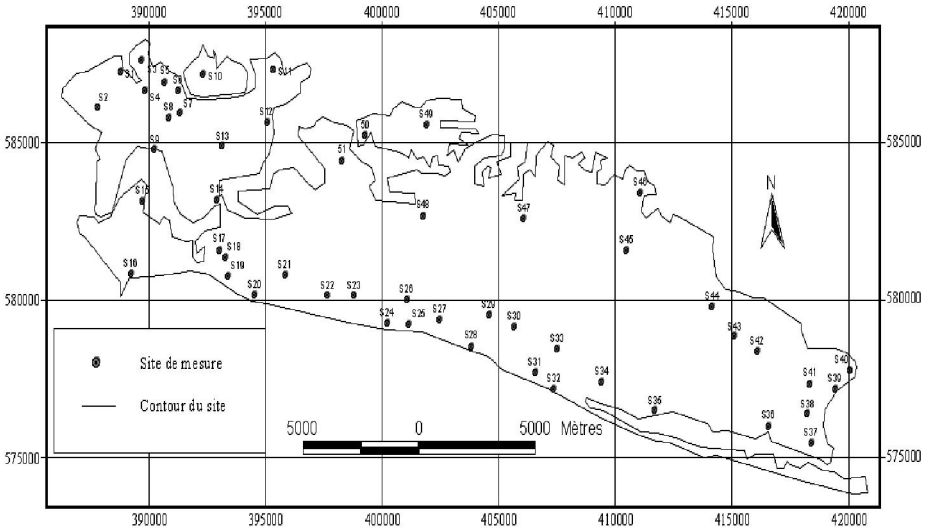

Fig. 2. Points d'échantillonnage de sol et de mesure de conductivité hydraulique (ks)

2.3 MESURE DE LA POROSITE ET ANALYSE GRANULOMETRIQUE

Au niveau de ces 51 points d'échantillonnage des mesures de conductivités hydrauliques ont été faites à partir de l'infiltromètre à double anneaux. Les porosités ont été mesurées et des analyses granulométriques ont été faites. Pour préparer l'échantillon de sable, les échantillons sont pesés, lavés à l'eau douce et séchés à l'étuve à 105°C. La matière organique contenue dans cet échantillon est éliminée avec l'eau oxygénée à 30 %.

Pour la mesure de la porosité n, un volume V de l'échantillon séché est prélevé. L'échantillon séché a été immergé dans un volume d'eau (Ve) pendant une journée. Le volume des pores est égal au volume d'eau Ve moins le volume (Vre) de l'eau restante après la saturation totale de l'échantillon [14], [20]. La porosité a été calculée en utilisant l'équation suivante :

$$n = \frac{V_e - V_r}{V}$$

Les analyses granulométriques sont faites à partir des fractions de 100 g d'échantillon séché puis tamisée. L'échantillon est placé au sommet d'une série de 16 tamis AFNOR superposés dans l'ordre des mailles de tailles décroissantes. Les dimensions des mailles sont comprises entre 63 µm et 5 mm. Le refus de chaque tamis est pesé après agitation. On en déduit le pourcentage en poids de chaque classe dimensionnelle par rapport à l'échantillon de départ. Les courbes granulométriques sont faites à partir des pourcentages cumulés en masse d'échantillon de sable passant les différentes mailles du tamis. Les diamètres D_{10} et D_{60} sont déterminés sur les courbes granulométriques obtenues.

2.4 MESURE IN SITU DE KS

La conductivité hydraulique saturée est déterminée par la méthode d'infiltrabilité à double anneaux. Cette méthode a déjà été utilisée par [24] et [25] pour la détermination de la conductivité hydraulique des sols non saturés. La méthode d'infiltrabilité à double anneau est basée sur la détermination de la vitesse verticale d'un flux d'eau à travers un sol à partir de la loi de Darcy. Pour la mesure in situ, on enfonce de 50 cm dans le sol le cylindre métallique central de l'infiltromètre, sur lequel on pose le vase de Mariotte. Celui-ci maintient le niveau de l'eau constant à une certaine hauteur au dessus de la surface du sol. Après la stabilisation de la vitesse, le volume d'eau V infiltré pendant un temps t est mesuré. Connaissant le débit q d'infiltration, on applique la loi de Darcy, l'infiltration se faisant suivant la surface S égale à la section du cylindre et le gradient hydraulique égale à 1. La conductivité hydraulique est déterminée à partir de la fonction.

$$K_s = \frac{v}{st}$$

ks la conductivité hydraulique (m.s-1) ; V volume d'eau infiltrée (m^3); S la section du cylindre (m^2) et t le temps (s).

2.5 MODELE DE KOZENY CARMAN MODIFIE

Sur la base de la méthode de Kozeny-Carman, [29], [30] ont développé un modèle d'estimation de la conductivité hydraulique saturée. Ce modèle est tiré de la relation proposée par [4]. Ces derniers ont introduit un paramètre qui est la tortuosité qui est une fonction de l'indice des vides. L'équation générale s'écrit :

$$K_s = C_{KCM} \frac{\gamma_w}{\mu_w} \frac{e^{3+x}}{1+e} \frac{1}{\varphi_s^2 S_m^2}$$

avec C_{KCM} constante, γ_w le poids volumique de l'eau $\left[ML^{-2}T^{-2}\right]$, μ_w la viscosité de l'eau $\left[ML^{-1}T^{-1}\right]$, e l'indice des vide [-] calculé à partir de la porosité n mesurée comme suit :

$$e = \frac{n}{1-n}$$

x=2 est un facteur qui tient compte de la tortuosité, φ_s masse volumique de l'eau $\left[ML^{-3}\right]$et S_m la surface spécifique massique $\left[L^2M^{-1}\right]$.

Selon Kovac's (1981) la surface spécifique S_m peut s'écrire :

$$S_m = \frac{\alpha}{\varphi_s D_h}$$

avec α est un facteur de forme, $1/\alpha^2$ =1 et D_h le diamètre équivalent [L].

Selon [40], on peut écrire

$$D_h = C_u^{1/6} D_{10}$$

La forme finale de l'équation peut s'écrire pour des sols peu plastiques en tenant compte des paramètres géotechniques comme suit [30] :

$$K_s = C_g \frac{\gamma_w}{\mu_w} \frac{e^{3+x}}{1+e} C_u^{1/3} D_{10}^2$$

C_g =0.1, $\gamma_w = 10\,KN/m^3$, $\mu_w = 10^{-3}\,Pa.s$, D_{10} en m, Cu : coefficient d'uniformité et K_s en m/s.

3 RESULTATS

Les courbes granulométriques des 51 échantillons de sable ont permis de déterminer les diamètres D_{10} et D_{60}. Les indices de vide e calculés à partir des porosités n mesurées, les diamètres D_{10} et D_{60} obtenus et les coefficients d'uniformité Cu et les ks calculés sont mentionnés dans le tableau 1.

Tableau 1. Propriété physique de sol et conductivité hydraulique saturée

Points	n	e	$D_{10}.10^{-2}$ (m)	$D_{60}.10^{-2}$ (m)	Cu	Ks(m/s) prédites
S1	0,29	0,40	0,020	0,060	3,00	4,22E-05
S2	0,30	0,43	0,040	0,070	1,75	1,98E-04
S3	0,32	0,48	0,020	0,060	3,00	9,86E-05
S4	0,29	0,40	0,018	0,043	2,43	3,01E-05
S5	0,30	0,43	0,020	0,060	3,00	5,84E-05
S6	0,31	0,43	0,024	0,050	2,08	7,56E-05
S7	0,31	0,45	0,023	0,060	2,61	8,87E-05
S8	0,27	0,36	0,025	0,058	2,32	3,86E-05
S9	0,20	0,35	0,020	0,048	2,38	2,08E-05
S10	0,26	0,35	0,029	0,050	1,72	3,80E-05
S11	0,23	0,30	0,020	0,051	2,55	1,02E-05
S12	0,28	0,39	0,021	0,050	2,38	3,77E-05
S13	0,29	0,41	0,021	0,052	2,48	4,72E-05
S14	0,30	0,43	0,023	0,055	2,39	7,16E-05
S15	0,30	0,43	0,021	0,050	2,38	5,96E-05
S16	0,26	0,40	0,021	0,050	2,40	4,24E-05
S17	0,27	0,50	0,029	0,050	1,72	2,10E-04
S18	0,34	0,52	0,029	0,054	1,86	2,58E-04
S19	0,36	0,57	0,030	0,060	2,03	4,22E-04
S20	0,31	0,44	0,028	0,060	2,14	1,14E-04
S21	0,31	0,44	0,039	0,070	1,79	2,17E-04
S22	0,25	0,30	0,030	0,065	2,17	2,18E-05
S23	0,26	0,60	0,030	0,060	2,00	5,51E-04
S24	0,38	0,70	0,060	0,100	1,67	4,22E-03
S25	0,39	0,54	0,058	0,090	1,55	1,16E-03
S26	0,30	0,35	0,050	0,100	2,00	1,23E-04
S27	0,37	0,58	0,057	0,090	1,58	1,60E-03
S28	0,35	0,50	0,050	0,080	1,60	6,09E-04
S29	0,42	0,70	0,050	0,100	2,00	3,11E-03
S30	0,36	0,56	0,030	0,067	2,23	4,15E-04
S31	0,42	0,73	0,021	0,060	2,86	7,34E-04

S32	0,42	0,70	0,050	0,080	1,60	2,89E-03
S33	0,36	0,56	0,040	0,077	1,93	7,17E-04
S34	0,39	0,64	0,050	0,093	1,86	2,00E-03
S35	0,40	0,67	0,050	0,100	2,00	2,49E-03
S36	0,26	0,34	0,025	0,040	1,60	2,56E-05
S37	0,31	0,46	0,022	0,059	2,68	9,13E-05
S38	0,31	0,45	0,020	0,041	2,05	6,19E-05
S39	0,33	0,49	0,021	0,055	2,62	1,10E-04
S40	0,35	0,54	0,022	0,061	2,77	2,10E-04
S41	0,32	0,47	0,025	0,060	2,45	1,33E-04
S42	0,31	0,44	0,023	0,055	2,39	8,10E-05
S43	0,27	0,37	0,035	0,075	2,14	7,98E-05
S44	0,30	0,40	0,020	0,050	2,50	3,97E-05
S45	0,35	0,50	0,019	0,050	2,63	1,04E-04
S46	0,32	0,48	0,035	0,085	2,43	2,82E-04
S47	0,30	0,43	0,029	0,039	1,33	9,35E-05
S48	0,29	0,41	0,029	0,041	1,41	7,79E-05
S49	0,29	0,41	0,023	0,055	2,39	5,84E-05
S50	0,29	0,42	0,024	0,056	2,33	6,75E-05
S51	0,26	0,35	0,060	0,100	1,67	1,62E-04

Les porosités sont comprises entre 20 et 45%. Les coefficients d'uniformité calculés à partir des diamètres D_{10} et D_{60} sont compris entre 1 et 3. Les conductivités hydrauliques prédites sont comparées à celles mesurées in situ par la méthode d'infiltrabilité à double anneaux dans la figure 3.

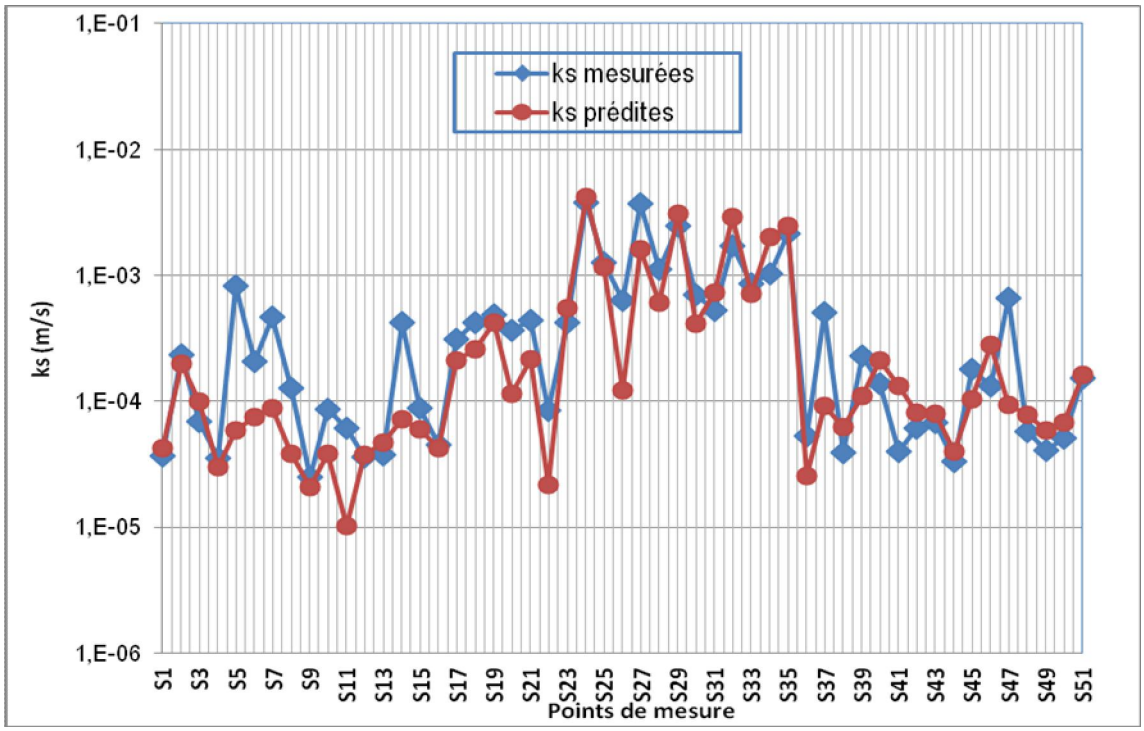

Fig. 3. Comparaison entre les valeurs de ks prédites et celles mesurées

Les conductivités hydrauliques sont comprises entre 10^{-2} et 10^{-5} m/s. Les valeurs de ks prédites sont inférieures à celles mesurées. Mais les écarts ne sont pas importants. De façon générale, les valeurs de ks mesurées sont proches de celles prédites.

Les conductivités hydrauliques mesurées ont permis d'établir une carte de répartition des conductivités sur le site dans la figure 4.

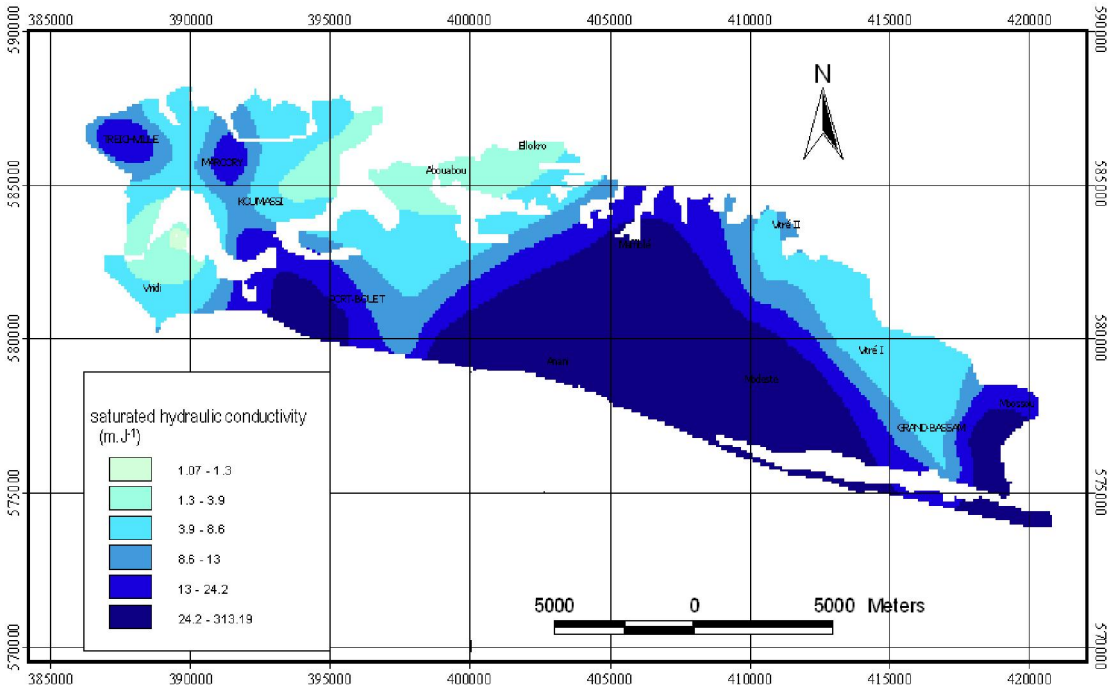

Fig. 4. Carte de distribution de la conductivité hydraulique saturée

La carte de distribution des conductivités hydrauliques montre que les conductivités hydrauliques sont élevées dans la partie sud en bordure de la mer. Elle évolue de façon décroissante vers le nord.

4 DISCUSSION

Les porosités des sables de l'aquifère du quaternaire d'Abidjan mesurées ont des valeurs comprises entre 0.20 et 0.45. Sur l'échelle des valeurs définies, ce sont des moyens et grossiers [17], [8]. Ces sables grossiers des cordons marins et moyens des dépressions fluivio-lagunaires ont été décrits par Delor et al. (1992). Ils ont été déposés tout le long du littoral Ouest africain pendant les derniers épisodes de transgression et de régression qui datent du quaternaire [1]. Ces dépôts forment le bassin éburneo-nigerian [36] et ont donné naissance à des aquifères qui bordent toute l'Afrique de l'ouest.

Les conductivités hydrauliques mesurées varient de 10^{-2} -10^{-3} m/s pour les sables grossiers et de 10^{-4} – 10^{-5} m/s pour les sables moyens. Ces résultats sont proches de ceux mesurés par [1] et [35].

La carte de distribution des conductivités hydrauliques établie montre que les sables marins plus grossiers se trouvent tout le long de l'océan atlantique tandis que les sables moyens des dépressions fluivio-lagunaires se trouvent au nord tout au long des lagunes. Plusieurs facteurs expliquent cette classification. Les sables marins déposés subissent une influence des vents marins qui entrainent les particules les plus légères vers le nord. Il y a aussi les cours d'eaux qui apportent de fines particules de sable et d'argile le long des lagunes où ils se jettent notamment en période de crue [31].

De façon générale, les valeurs de conductivités hydrauliques mesurées in situ sont proches de celles prédites par le modèle de Kozeny Carman modifiée. Ces résultats confirment celles de [30]. Dans les conditions d''application du modèle ($0,35 \leq e \leq 1,26$), $1 \leq Cu \leq 227$), le modèle de kozeny Carman, modifié peut être utilisé pour prédire des conductivités hydrauliques saturées des sols granulaires tels que des sables de l'aquifère du quaternaire d'Abidjan.

La tendance générale qui tend à une sous estimation des conductivités hydrauliques prédites par le modèle par rapport à celles mesurées s'explique par le fait que la zone d'étude est habitée. Les sables subissent une influence de l'activité humaine. Ils subissent une compaction par endroit due aux travaux d'aménagement. Les travaux ont montré que la compaction des matériaux modifie leurs conductivités hydrauliques [34], [18]. Mais les effets de la compaction sont, contrairement aux argiles, moins perceptibles dans nos travaux parce que les sables sont des matériaux moins compressibles. Le modèle de Kozeny Carman modifié basé sur l'utilisation des propriétés géotechniques de base pour la prédiction de la conductivité hydraulique ne prend pas en compte l'effet de la compaction.

5 CONCLUSION

L'étude des propriétés hydriques de l'aquifère du quaternaire d'Abidjan a montré que l'aquifère est constitué de sables grossiers des cordons marins au sud et les sables moyens des dépressions fluivio-lagunaires au nord. Ces deux types de sables ont des porosités comprises entre 0.20 et 0.45 et des conductivités hydrauliques qui varient entre 10^{-2} et 10^{-5} m/s. L'application du modèle de Kozeny Carman modifié montre que ce modèle peut être utilisé pour prédire les conductivités hydrauliques. Ce modèle a le mérite d'utiliser des propriétés physiques de base (porosité et diamètres D_{10} et D_{60}) qui sont des paramètres facilement accessibles. La concordance entre les conductivités hydrauliques mesurées et celles prédites montre que l'application de ce modèle peut s'étendre à une évaluation de la conductivité hydraulique de tous les aquifères du bassin eburnéo-nigérian qui bordent toute l'Afrique de l'Ouest. C'est une méthode complémentaire aux méthodes in situ qui permettra d'avoir des données sur les caractéristiques et les propriétés hydriques de ces aquifères pour comprendre leur fonctionnement et mieux les protéger contre la pollution anthropogénique.

REFERENCES

[1] N. Aghui et J. Biémi, "Bassin sédimentaire de Côte d'Ivoire: Géologie et hydrogéologie des nappes de la région d'Abidjan et risque de contamination", *Annales Univ. Côte d'Ivoire*, Série c : 331-347, 1984.

[2] K.E. Ahoussi, N. Soro, G. Soro, T. Lasm, M. Oga et S.P. Zadé, "Groundwater pollution in Africa biggest towns: case of the town of Abidjan (Côte d'Ivoire)", Eur*. J .Sci. Res*., 20: 302-316, 2008.

[3] L.R. Ahuja, J.W. Naney, R.E. Green, and D.R. Nielsen, "Macroporosity to characterize spatial variability of hydraulic conductivity and effects on land management", *Soil Science Society of America Journal* 48, 699–702, 1984.

[4] M. Aubertin, B. Bussière, R.P Chapuis, "Hydraulic conductivity of homogenized tailings from hard rock mines", *Canadian Geotechnical Journal*, 33: 470–482, 1996.

[5] Baba-Moussa A., 1994. "Etude de la pollution bactériologique de la nappe phréatique à partir d'une latrine en Afrique subtropicale. Th. Doct, Ecole Polytech. Fédérale Lausanne, 247 p.

[6] Benoit G., "Environnement et développement en Méditerranée – Les perspectives du Plan Bleu", Futuribles, 321, 11-46, 2006.

[7] H. Bithin, V. Hrikrishna, D. Anibrban, "Modelling and control of saltwater intrusion in a costal aquifer of Andhra Pradesh, India", *Journal of hydro-environment Research*, Vol. 3 (3):148-159, 2009.

[8] G. Castany, "Hydrogéologie, principes et méthodes 2e cycle", Ed. *Dumond* Paris, 236 p.

[9] R.P. Chapuis, and I. Montour, "Evaluation de l'équation de Kozeny–Carman pour prédire la conductivité hydraulique", Proceedings, 45ie`me Conférence Canadienne de Géotechnique. Toronto, Ontario, 78-1–78-10, 1992.

[10] R.P. Chapuis, M. Aubertin, on the use of the Kozeny-Carman's equation to predict the hydraulic conductivity of soils", *Canadian Geotechnical Journal*, 40, n°. 3: 6, 1998, 2003.

[11] C. Delor, I. Diaby, Y. Siméon, B. Yao, J.P Tastet, M. Vidal, J.P Chiron, A. Dommanget, Notice explicative de la carte Géologique de la Côte d'Ivoire à 1/200000, Feuille Grand-Bassam", Mémoire de la Direction de la Géologie de Côte d'Ivoire, n°4, Abidjan, Côte d'Ivoire, 30 p, 1992.

[12] G.A Douagui, "Évaluation de la vulnérabilité à la pollution de la nappe du Quaternaire du secteur Canal de Vridi-Grand-bassam par la méthode Drastic", *Mém. DEA, Univ. Abobo-Adjamé*, 69 p, 2005.

[13] B.C.E Egboka et F.C. Ezeonu, "Nitrate et nitrite pollution and contamination in parts of SE Nigeria", *Water Resources*, 2: 101-110, 1990.

[14] C.W. Fetter, "Applied Hydrogeology". Prentice-Hall, Englewood Cliffs, NJ, USA, 2001.

[15] N. Fodor, R. Sandor, T. Orfanus, L. Lichner, K. Rajkai. "Evaluation method dependency of measured saturated hydraulic conductivity", *Geoderma*, Vol. 165 (1) : 60-68, 2011.

[16] Franzmeier D.P, "Estimating of hydraulic conductivity from effective porosity data for some Indiana soils", *Soil Science Society of America Journal*, Vol: 1801-1803, 1991.

[17] L. W. Gelhar, C. Welty, K. T. Rehfeldt, "A critical review of data on field scale dispersion in aquifers", *Water Resources*, 28: 1955-1974, 1992.
[18] L. Hsueh-Yu, "A method to estimate hydraulic conductivity from bulk geochemical compositions", *Environ. Geol*, Vol 51: 1029–1041, 2007.
[19] J.D. Jabro, "Estimating of saturared hydraulic conductivity of soils from particule size distribution and bulk density data", *Journal of the American Society of Agricultural Engineers*, Vol, 35 2:557-560, 1992.
[20] C. Jae-Yeol, H. Se-Yeong, K. Hyoung-Soo, K.Eun-Joung, Y. Kyounghee, L. Jeong-Hwan, "Estimating hydraulic conductivity using grain-size analyses, aquifer tests, and numerical modeling in a riverside alluvial system in South Korea", *Hydrogeology Journal,* vol. 16 : 1129–1143, 2008.
[21] J. Ross, M. Ozbek, F. G. Pinder, "Hydraulic Conductivity Estimation via Fuzzy Analysis of Grain Size Data", *Mathematical Geology*, vol. 39: 765–780, 2007.
[22] J.R.P Jourda, K.J Kouamé, M.B Saley, B.H Kouadio, Y.S Oga, S. Deh, "Contamination of Abidjan aquifer by sewage: an assessment of extent and strategies for protection. In: Xu Y. and USHER B. (Eds): Groundwater pollution in Africa, *Taylor et Francis/Balkema, Leiden*, 291-300, 2006.
[23] A. Klute and C. Dirksen, "Hydraulic conductivity and diffusivity: laboratory methods, Methods of Soil Analysis. Part 1. Physical and Mineralogical Methods", in: A. Klute, Editor, (2nd ed.), Madison, pp. 687–732, 1986.
[24] K. Koffi, "Contribution à l'étude des processus couplés hydrogéochimiques dans les stocks de déchets miniers: le cas du site de Carnoules (Gard, France)", Th. Doct. unique, Univ. Montpellier II, 161 p, 2004.
[25] K.I. Kouamé, "Pollution physico -chimique des eaux dans la zone de la décharge d'Akouédo et analyse du risque de contamination de la nappe d'Abidjan par un modèle de simulation des écoulements et du transport des polluants", Th. Doct. Unique, Univ. Abobo-Adjamé, 206 p, 2007.
[26] Kovac's, G. 1981. "Seepage Hydraulics", *Elsevier Science* Publishers, Amsterdam.
[27] M. M. Mahmoud, "A geostatistical approach to optimize the determination of saturated hydraulic conductivity for large-scale subsurface drainage design in Egypt", *Agricultural water Management*, Vol. 42 (3) : 291-312, 2000..
[28] F.D. Masch and K.J. Denny, "Grain size distribution and its effect on the permeability of unconsolidated sands", Water *Resources Research,* 2(4), 665–677, 1966.
[29] M. Mbonimpa, M. Aubertin, R.P. Chapuis, B. Bussière, "Développement de fonctions hydriques utilisant les propriétés géotechniques de base", 1st Joint IAH-CNC-CGS *Groundwater Specialty Conf.*, p. 343-350, 2000.
[30] M. Mbonimpa, M. Aubertin, R.P. Chapuis, B. Bussière, "Practical pedotransfer functions for estimating the saturated hydraulic conductivity", *Geotechnical and Geological Engineering*, 20: 235–259, 2002.
[31] Y.M.S. Oga, "Ressources en eaux souterraines de la région du Grand-Abidjan (Cote d'Ivoire): approches hydrochimique et isotopique", Th. Doct., Univ. Paris XI ORSAY; 211 p, 1998.
[32] B. Ousmane, A. Daddy, T. Margueron, A. Boubacar et Z. Garba, "Groundwater contamination in the Niamey urban area, Niger", In: Y.Xu and B.USHER (Eds): Groundwater pollution in Africa, *Taylor § Francis/Balkema, Leiden*, 169-179, 2006.
[33] R.G Shepherd, "Correlations of permeability and grain size", *Ground Water,* 27(5), 633–638, 1989.
[34] E.Takeo, J.A Rwaichi, N. Takako, O.Yoshio, C. Abhijit "Correlation of hydraulic conductivity of clay–sand compacted specimens with clay properties", *Applied Clay Science*, vol. 26 : 3-12, 2004.
[35] S.A. Tapsoba, "Etude géologique et hydrogéologique du bassin sédimentaire de la Côte d'Ivoire: recharge et qualité des eaux dans l'aquifère côtier (région de Jacqueville) ", *Mém. DEA, Univ. Cheik Anta Diop*, 65p, 1990.
[36] J.P Tastet, "Environnements sédimentaires et structuraux quaternaires du littoral du golfe de Guinée, Côte d'Ivoire, Togo, Bénin", *Th. Doct. d'Etat, Univ. Bordeau I*, 181 p, 1979.
[37] O. Tieje, and V. Hennings, "Accuracy of the saturated hydraulic conductivity prediction by pedotransfer functions compared to the variability within FAO textural classes", *Geoderma*, 69:71-84, 1996.
[38] G.Tredoux et A.S. Talma, "Nitrate pollution of groundwater in southern Africa. In: Xu Y. and USHER B. (Eds): Groundwater pollution in Africa", *Taylor et Francis/Balkema,Leiden*, 15-36, 2006.
[39] K.O. Uma, B.C.E Bgboka, K. M. "Onuoha, New statistical grain size method for evaluating the hydraulic conductivity of sandy aquifers", *Journal of Hydrology* 108:343–366, 1989
[40] M. Vuković, A. Soro, "Hydraulics and water wells: theory and application", *Water Resources* Publications, Highlands Ranch, CO, USA, 1992.

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Inverse Interpolation: The Rate of Enzymatic Reaction based Finite differences, Formulas for obtaining intermediate values of Temperature, Substrate Concentration, Enzyme Concentration and their Estimation of Errors

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ABSTRACT: Inverse interpolation is the process of finding the values of the argument corresponding to a given value of the function when the latter is intermediate between two tabulated values. The finite differences are differences between the values of the function or the difference between the past differences. Finite differences are forward difference, backward difference and divide difference. Temperature, concentration of substrate, concentration of enzyme and other factors are affected the rate of enzymatic reaction. The concentration of substrate is the limiting factor, as the substrate concentration increases, the Enzyme reaction rate increases. Assuming a sufficient concentration of substrate is available, increasing Enzyme concentration will increase the rate of enzymatic reaction. Temperature, concentration of substrate and concentration of enzyme are increased the rate of enzymatic reaction at a limit which is called optimum limit. On the basis of this concept mathematical functions are defined. These mathematical functions are worked in "n" limit. Take the rate of enzymatic reaction is independent variable for finite differences, formulas and their estimation of errors. These formulas are used to obtaining intermediate values of Temperature, substrate concentration and enzyme concentration. If the point lies in the upper half then used forward difference interpolation. If the point lies in the lower half then used backward difference interpolation. When the interval is not equally spaced then used divide difference interpolation.

KEYWORDS: Inverse interpolation, Finite differences, Estimation of Errors, Rate of enzymatic reaction.

1 INTRODUCTION

The rate of enzymatic reaction is affected by Temperature, concentration of substrate, concentration of enzyme and other factors [1]. The rise in Temperature accelerates an Enzyme reaction but at the same time causes inactivation of the protein. At certain Temperature known as the optimum Temperature the activity is maximum [2]. The concentration of substrate is the limiting factor, as the substrate concentration increases, the Enzyme reaction rate increases. Assuming a sufficient concentration of substrate is available, increasing Enzyme concentration will increase the enzymatic reaction rate. Temperature, concentration of substrate and concentration of enzyme are increased the rate of enzymatic reaction at a limit which is called optimum limit [1]-[3]. The finite differences are differences between the values of the function or the difference between the past differences. Finite differences are forward difference, backward difference and divide difference [4]-[15]. Inverse interpolation is the process of finding the values of the argument corresponding to a given value of the function when the latter is intermediate between two tabulated values [16][17].

2 INVERSE INTERPOLATION

Let $y = f(x)$ be a function where y is dependent variable and x is independent variable. The technique of determining the values of x corresponding to the value of y from the set of tabulated values, is known as inverse

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interpolation [16][17]. In enzymatic reaction, Temperature, concentration of substrate and concentration of enzyme are worked in n limit which are defined three mathematical functions:

$$V^T = f(T)$$
$$V^S = f(S)$$
$$V^E = f(E)$$

Where T is the temperature, S is the concentration of substrate, E is the concentration of enzyme, V^T is the rate of enzymatic reaction with temperature, V^S is the rate of enzymatic reaction with concentration of substrate, V^E is the rate of enzymatic reaction with concentration of enzyme. And other factors are be constant in each functions [1]-[3]. In above mathematical functions, we take the rate of enzymatic reaction is Independent variable. Temperature, concentration of substrate and concentration of enzyme are being dependent variable for inverse interpolation.

3 FORWARD DIFFERENCE OF TEMPERATURE

If $(V_0^T, T_0), (V_1^T, T_1), (V_2^T, T_2) \ldots\ldots\ldots (V_n^T, T_n)$ denoted the values of the inverse function then $T_1 - T_0$, $T_2 - T_1$, $T_3 - T_2, T_4 - T_3, \ldots\ldots\ldots\ldots T_n - T_{n-1}$ are called the forward differences of T [18]. These differences are denoted as $\Delta T_0, \Delta T_1, \Delta T_2, \Delta T_3, \ldots\ldots\ldots \Delta T_{n-1}$ therefore

$\Delta T_0 = T_1 - T_0$,

$\Delta T_1 = T_2 - T_1$,

$\Delta T_2 = T_3 - T_2$,

$\Delta T_3 = T_4 - T_3$,:

:

:

:

:

$\Delta T_{n-1} = T_n - T_{n-1}$

Where Δ is called the forward difference operator, and $\Delta T_0, \Delta T_1\ \Delta T_2\ \Delta T_3 \ldots\ldots\ldots \Delta T_{n-1}$ are called first order forward differences. The differences of the first order difference are called second order forward differences and are denoted as $\Delta^2 T_0, \Delta^2 T_1, \Delta^2 T_2, \Delta^2 T_3, \ldots$ etc.

$\Delta^2 T_0 = \Delta T_1 - \Delta T_0$

$\Delta^2 T_1 = \Delta T_2 - \Delta T_1$

$\Delta^2 T_2 = \Delta T_3 - \Delta T_2$

$\Delta^2 T_3 = \Delta T_4 - \Delta T_3$

In general, the first order forward difference at the i^{th} point is

$\Delta T_i = T_{i+1} - T_i$

And the order forward difference at the point is

$\Delta^j T_i = \Delta^{j-1} T_{i+1} - \Delta^{j-1} T_i$

3.1 FORMULA FOR FORWARD DIFFERENCE INTERPOLATION

If $f(a), f(a+h), \ldots\ldots\ldots, f(a+nh)$ are be values of inverse function then

$V^T = a, a+h, ..., a+nh$

Let $f(V^T)$ be a polynomial of degree n and let

$$f(V^T) = A_0 + A_1(V^T - a) + A_2(V^T - a)(V^T - a - h) + A_3(V^T - a)(V^T - a - h)(V^T - a - 2h) + \ldots\ldots\ldots + A_n[(V^T - a)(V^T - a - h)\ldots\{V^T - a - (n-1)h\}] \quad (1)$$

Where $A_0, A_1 \ldots\ldots\ldots A_n$ all are constants [19].

Putting $V^T = a$ in equation (1), we got:

$$f(a) = A_0 \quad (2)$$

Again putting $V^T = a + h$ in equation (1), we got:

$$f(a+h) = A_0 + A_1 h$$
$$A_1 h = f(a+h) - A_0$$
$$= f(a+h) - f(a)$$
$$= \Delta f(a)$$

$$A_1 = \frac{\Delta f(a)}{h} \quad (3)$$

Again putting $V^T = a + 2h$ in equation (1), we got:

$$f(a+2h) = A_0 + A_1(2h) + A_2(2h)(h) = A_0 + 2hA_1 + A_0 + 2h^2 A_2$$ [from equation (2) and(3)]

Or $2h^2 A_2 = f(a+2h) - A_0 - 2hA_1$

$$= f(a+2h) - f(a) - 2\Delta f(a)$$
$$= f(a+2h) - f(a) - 2\{f(a+h) - f(a)\}$$
$$= f(a+2h) - 2\{f(a+h) + f(a)\}$$
$$= \Delta^2 f(a)$$

$$\therefore A_2 = \frac{1}{2h^2}\Delta^2 f(a)$$

Or $A_2 = \frac{1}{2!h^2}\Delta^2 f(a)$ (4)

Similarly $A_3 = \frac{1}{3!h^3}\Delta^3 f(a)$ (5)

:

:

Proceeding in similar way, we got: $A_n = \frac{1}{n!h^n}\Delta^n f(a)$ (6)

substituting the values of $A_0, A_1, A_2, \ldots\ldots, A_n$ in equation (1), we got:

$$f(V) = f(a) + \frac{\Delta f(a)}{h}(V^T - a) + \frac{\Delta^2 f(a)}{2!h^2}(V^T - a)(V^T - a - h) + \ldots\ldots + \frac{\Delta^n f(a)}{n!h^n}(V^T - a)(V^T - a - h)\ldots\{V^T - a - (n-1)h\} \quad (7)$$

Now let: $V^T = a + hu$

$$\therefore V^T - a = hu$$

$$V^T - a - h = (u-1)h$$

$$V^T - a - 2h = (u-2)h$$

$$\vdots$$

$$\vdots$$

$$\vdots$$

$$\vdots$$

$$V^T - a - (n-1)h = \{u - (n-1)\}h$$

Putting these values in equation (7), we got:

$$f(a+hu) = f(a) + \frac{\Delta f(a)}{h}(uh) + \frac{\Delta^2 f(a)}{2!h^2}(uh)(u-1)h + \ldots\ldots\ldots\ldots + \frac{\Delta^n f(a)}{n!h^n}(uh)(u-1)h\ldots\{u-(n-1)h\}$$

Simplifying, we got:

$$f(a+hu) = f(a) + u\Delta f(a) + \frac{\Delta^2 f(a)}{2!}\{u(u-1)\} + \ldots\ldots + \frac{\Delta^n f(a)}{n!}(u)(u-1)\ldots\{u-(n-1)\} \quad (8)$$

Also we know that

$$u^{(m)} = u(u-1)(u-2)\ldots\ldots\ldots\{u-(m-1)\} \quad (9)$$

From equation (8) and (9), we have:

$$f(a+hu) = f(a) + \Delta f(a)\frac{u^{(1)}}{1!} + \Delta^2 f(a)\frac{u^{(2)}}{2!} + \Delta^3 f(a)\frac{u^{(3)}}{3!} + \ldots\ldots + \Delta^n f(a)\frac{u^{(n)}}{n!} \quad (10)$$

3.1.1 ESTIMATION OF ERROR

If inverse function defined by $(n+1)$ points $(V_0^T, T_0), (V_1^T, T_1)\ldots\ldots\ldots(V_n^T, T_n)$. When $V_0^T, V_1^T, V_2^T, V_3^T \ldots\ldots\ldots\ldots V_n^T$ are equally spaced with interval h and this function is continuous and differentiable $(n+1)$ times.

The function be approximated by a polynomial $P_n(V^T)$ of degree not exceeding a such that

$$P_n(V_i^T) = T_i \qquad [\text{Where } i = 0,1,2,3\ldots\ldots\ldots n] \quad (11)$$

Since the expression $f(V^T) - P_n(V^T)$ vanishes for $V^T = V_0^T, V_1^T, V_2^T, V_3^T \ldots\ldots\ldots\ldots V_n^T$,

We put $$f(V^T) - P_n(V^T) = K\varphi(V^T) \quad (12)$$

Where $$\varphi(V^T) = (V^T - V_0^T)(V^T - V_1^T).....(V^T - V_n^T) \quad (13)$$

And K is to be determined in such a way that equation (12) holds for any intermediate values of V^T, say $V^T - V'^T$ [where $V_0^T \le V'^T \le V_n^T$].

Therefore from equation (12),

$$K = \frac{f(V'^T) - P(V'^T)}{\varphi(V'^T)} \quad (14)$$

Now we construct a function $f(V^T)$ such that

$$f(V_0^T) = f(V_1^T) - P_n(V^T) - K\varphi(V^T)$$

Where K is given by equation (14).

It is clear that

$$f(V_0^T) = f(V_1^T) = f(V_2^T) = f(V_3^T) = ...f(V_n^T) = f(V'^T) = 0 \quad (15)$$

Let $f(V^T)$ vanishes (n+2) times in the interval $V_0^T \le V^T \le V_n^T$; consequently, by the repeated application of Rolle's Theorem [20] [21], $f'(V^T)$ must vanish $(n+1)$ times, $f''(V^T)$ must vanish n times etc in the interval $V_0^T \le V^T \le V_n^T$.

Particularly, $f^{(n+1)}(V^T)$ must vanish once in the interval $V_0^T \le V^T \le V_n^T$. Let this point be $V^T = W$, $V_0^T < W < V_n^T$.

Now differentiating equation (15) $(n+1)$ times with respect to V^T and putting $V^T = W$, we got:

$$f^{(n+1)}(W) - K(n+1)! = 0$$

Or $$K = \frac{f^{(n+1)}(W)}{(n+1)!} \quad (16)$$

Putting this value of K in equation (14), we got:

$$\frac{f^{(n+1)}(W)}{(n+1)!} = \frac{f(V'^T) - P_n(V'^T)}{\varphi(V'^T)}$$

Or $$f(V'^T) - P_n(V'^T) = \frac{f^{(n+1)}(W)}{(n+1)!}\varphi(V'^T) \quad , \qquad V_0^T < W < V_n^T$$

Since V'^T is arbitrary therefore on dropping the prime on V'^T we got:

$$f(V^T) - P_n(V^T) = \frac{f^{(n+1)}(W)}{(n+1)!}\varphi(V^T), \quad V_0^T < W < T_n^T \quad (17)$$

Now we use Taylor's theorem [22] [23]:

$$f(W+h) = f(W) + hf'(W) + \frac{h^2}{2!}f''(W) + ...+ \frac{h^n}{n!}f^n(W) + ... \quad (18)$$

Neglecting the terms containing second and higher powers of h in equation (18), we got:

$$f(W+h) = f(W) + hf'(W)$$

Or $$f'(W) = \frac{f(W+h) - f(W)}{h} \qquad (19)$$

Or $$f'(W) = \frac{1}{h}\Delta f(W) \qquad [\because \Delta f(V^T + h) f(V^T)]$$

$$Df(W) = \frac{1}{h}\Delta f(W) \qquad [\because D = \frac{d}{dW}]$$

$$D = \frac{1}{h}\Delta \qquad \text{[Because } f(W) \text{ is arbitrary]}$$

$$\therefore D^{n+1} = \frac{1}{h^{n+1}}\Delta^{n+1}$$

From equation (19), we got:

$$f^{(n+1)}(W) = \frac{1}{h^{(n+1)}}\Delta^{(n+1)} f(W)$$

Putting the values of $f^{(n+1)}(W)$ in equation (17), we got:

$$f(V^T) - P_n(V^T) = \left[\frac{\varphi(V^T)}{(n+1)!}\right]\left[\frac{1}{h^{(n+1)}}\Delta^{(n+1)} f(W)\right]$$

$$f(V^T) - P_n(V^T) = \left[\frac{(V^T - V_0^T)(V^T - V_1^T)(V^T - V_2^T)....(V^T - V_0^T)}{(n+1)!}\right]\left[\frac{1}{h^{(n+1)}}\Delta^{(n+1)} f(W)\right] \qquad (20)$$

Then

$V^T - V_0^T = h\beta$

$V^T - V_1^T = V^T - (V_0^T - h) = (V^T - V_0^T) - h = (h\beta - h) = h(\beta - 1)$

Similarly $V^T - V_2^T = h(\beta - 2)$

:

:

:

Similarly $V^T - V_n^T = h(\beta - n)$

Putting these values in equation (20), we got:

$$f(V^T) - P_n(V^T) = \left[\frac{(h\beta)\{h(\beta-1)\}\{h(\beta-2)\}\{h(\beta-3)\}.....\{(\beta-n)\}}{(n+1)!}\right]\left[\frac{1}{h^{(n+1)}}\Delta^{(n+1)} f(W)\right]$$

This is mathematical expression for estimation of error, if the point lies in the lower half.

4 BACKWARD DIFFERENCE OF TEMPERATURE

If $(V_0^T, T_0), (V_1^T, T_1), (V_2^T, T_2) \ldots\ldots\ldots (V_n^T, T_n)$ denoted the values of the inverse function then $T_1 - T_0$, $T_2 - T_1$, $T_3 - T_2$, $T_4 - T_3$, $\ldots\ldots\ldots\ldots T_n - T_{n-1}$ are called the backward differences of T [18]. These differences are denoted as $\nabla T_1, \nabla T_2, \nabla T_3, \ldots\ldots\ldots \nabla T_{n-1}$ therefore

$$\Delta T_1 = T_1 - T_0$$

$$\Delta T_2 = T_2 - T_1,$$

$$\Delta T_3 = T_3 - T_2,$$

$$\Delta T_4 = T_4 - T_3,$$

$$\vdots$$

$$\Delta T_n = T_n - T_{n-1}$$

Where ∇ is called the backward difference operator, and ∇T_1 ∇T_2, ∇T_3, $\ldots\ldots\ldots$, ∇T_{n-1} are called first order backward differences. The differences of the first order difference are called second order backward differences and are denoted as, $\nabla^2 T_2, \nabla^2 T_3, \nabla^2 T_4, \nabla^2 T_5$ … .etc.

$$\nabla^2 T_2 = \nabla T_2 - \nabla T_1$$

$$\nabla^2 T_3 = \nabla T_3 - \nabla T_2$$

$$\nabla^2 T_4 = \nabla T_4 - \nabla T_3$$

$$\nabla^2 T_5 = \nabla T_5 - \nabla T_4$$

In general, the first order forward difference at the i^{th} point is

$$\nabla T_i = T_i - T_{i-1}$$

And the order forward difference at the point is

$$\nabla^j T_i = \nabla^{j-1} T_i - \nabla^{j-1} T_{i-1}$$

4.1 FORMULA FOR BACKWARD DIFFERENCE INTERPOLATION

If $f(k), f(k+h), \ldots\ldots\ldots, f(k+nh)$ are be values of inverse function then

$$V^T = k, k+h, \ldots\ldots, k+nh$$

Let $f(V^T)$ be a polynomial of degree n and let

$$\begin{aligned} f(V^T) = {} & K_0 + K_1(V^T - k - nh) + K_2(V^T - k - nh)\{V^T - K(n-1)h\} \\ & + K_3(V^T - k - nh)\{V^T - k - (n-1)h\} \\ & \{V^T - k - (n-2)h\} + \quad \ldots\ldots\ldots \\ & + K_n[(V^T - k - nh)\{V^T - k - (n-1)h\} \ldots\ldots (V^T - k - h) \end{aligned} \tag{21}$$

Where $K_0, K_1, K_2, \ldots\ldots\ldots K_n$ all are constants [19].

Putting $V^T = k + nh$ in equation (21), we got:

$$f(k+nh) = K_0 \tag{22}$$

Again putting $V = k + (n-1)h$ in equation (21), we got:

$$f\{k+(n-1)h\} = K_0 + K_1 h$$
$$K_1 h = K_0 - f\{k+(n-1)h\}$$
$$= f(k+nh) - f\{k+(n-1)h\}$$
$$= \Delta f(k+nh)$$
$$K_1 = \frac{\Delta f(k+nh)}{h} \tag{23}$$

Again putting $V^T = k + (n-2)h$ in equation (21), we got:

$$f\{k+(n-2)h\} = K_0 + K_1(-2h) + K_2(-2h)(-h)$$
$$2h^2 K_2 = f\{K+(n-2)h\} - K_0 - 2hK_1$$

Or $2h^2 K_2 = f\{k+(n-2)h\} - f(k+nh) + 2\nabla f(k+nh)$ [from eq.(22) and(23)]

$$= f\{k+(n-2)h\} - f(k+nh) + 2[\{f(k+nh)\} - f\{k+(n-1)h\}]$$
$$= f\{k+(n-2)h\} - f(k+nh) - 2f\{k+(n-1)h\}$$
$$= f(k+nh) - 2[f\{k+(n-1)h\} + f(k)]$$
$$= \Delta^2 f(k+nh)$$

$$\therefore K_2 = \frac{1}{2h^2}\Delta^2 f(k)$$

Or $$K_2 = \frac{1}{2!h^2}\Delta^2 f(k=nh) \tag{24}$$

Similarly $$K_3 = \frac{1}{3!h^3}\Delta^3 f(k+nh) \tag{25}$$

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Proceeding in similar way, we got: $K_n = \frac{1}{n!h^n}\Delta^n f(k+nh)$ (26)

substituting the values of $K_0, K_1, K_2, \ldots\ldots\ldots, K_n$ in equation (21), we got:

$$f(V^T) = f(k+nh) + \frac{\Delta f(k)}{h}(V^T - k - nh)$$
$$+ \frac{\Delta^2 f(k+nh)}{2!h^2}(V^T - k - nh)\{V^T - k - (n-1)h\} + \ldots\ldots \tag{27}$$
$$+ \frac{\Delta^n f(k+nh)}{n!h^n}(V^T - k - nh)\{V^T - k - (n-1)h\}..(V^T - k - n)$$

Now let: $V^T = k + nh + hu$

$$\therefore V^T - k = nh + hu$$

$$V^T - k - (n-1)h = (u+1)h$$

$$V^T - k - (n-2)h = (u+2)h$$

$$\vdots$$

$$\vdots$$

$$\vdots$$

$$\vdots$$

$$V^T - k - h = \{u + (n-1)\}h$$

Putting these values in equation (27), we got:

$$f(k+nh+hu) = f(k+nh) + \frac{\Delta f(k+nh)}{h}(uh) + \frac{\Delta^2 f(k+nh)}{2!h^2}(uh)(u+1)h + \ldots..$$

$$+ \frac{\Delta^n f(k+nh)}{n!h^n}(uh)(u+1)h.....\{u+(n-1)h\}$$

Simplifying, we got:

$$f(k+nh+hu) = f(k+nh) + u\Delta f(k+nh) + \frac{\Delta^2 f(k+nh)}{2!}\{u(u+1)\} + \ldots.$$

$$+ \frac{\Delta^n f(k+nh)}{n!}(u)(u+1)....\{u+(n-1)\} \quad (28)$$

4.1.1 ESTIMATION OF ERROR

If inverse function defined by $(n+1)$ points $(V_0^T, T_0), (V_1^T, T_1)\ldots\ldots\ldots(V_n^S, T_n)$. When $V_0^T, V_1^T, V_2^T, V_3^T \ldots\ldots\ldots V_n^T$ are equally spaced with interval h and this function is continuous and differentiable $(n+1)$ times.

The function be approximated by a polynomial $P_n(V^T)$ of degree not exceeding a such that

$$P_n(V_i^T) = E_i \qquad [\text{Where } i = 1,2,3\ldots\ldots\ldots.n] \quad (29)$$

Since the expression $f(V^T) - P_n(V^T)$ vanishes for $V^T = V_0^T, V_1^T, V_2^T, V_3^T \ldots\ldots\ldots V_n^T$,

We put $f(V^T) - P_n(V^T) = K\varphi(V^T)$ (30)

Where $\varphi_1(V^T) = (V^T - V_n^T)(V^T - V_{n-1}^T)\ldots\ldots\ldots\ldots(V^T - V_0^T)$ (31)

And K is to be determined in such a way that equation (30) holds for any intermediate values of V^T, say $V^T - V'^T$ [where $V_0^T \le V'^T \le V_n^T$].

Therefore from equation (30),

$$K = \frac{f(V'^T) - P_n(V'^T)}{\varphi_1(V'^T)} \quad (32)$$

Now we construct a function $f(V^T)$ such that: $f(V_0^T) = f(V_1^T) - P_n(V^T) - K\varphi_1(V^T)$

Where K is given by equation (32).

It is clear that

$$f(V_0^T) = f(V_1^T) = f(V_2^T) = f(V_3^T) = ...f(V_n^T) = f(V'^T) = 0 \quad (33)$$

Let $f(V^T)$ vanishes (n+2) times in the interval $V_0^T \le V^T \le V_n^T$; consequently, by the repeated application of Rolle's Theorem [20] [21], $f'(V^T)$ must vanish $(n+1)$ times, $f''(V^T)$ must vanish n times etc in the interval $V_0^T \le V^T \le V_n^T$.

Particularly, $f^{(n+1)}(V^T)$ must vanish once in the interval $V_0^T \le V^T \le V_n^T$. Let this point be $V^T = W$, $V_0^T < W < V_n^T$.

Now differentiating equation (15) $(n+1)$ times with respect to V^T and putting $V^T = W$, we got:

$$f^{(n+1)}(W) - K(n+1)! = 0$$

Or
$$K = \frac{f^{(n+1)}(W)}{(n+1)!} \quad (34)$$

Putting this value of K in equation (32), we got:

$$\frac{f^{(n+1)}(W)}{(n+1)!} = \frac{f(V'^T) - P_n(V'^T)}{\varphi_1(V'^T)}$$

Or
$$f(V'^T) - P_n(V'^T) = \frac{f^{(n+1)}(W)}{(n+1)!}\varphi_1(V'^T), \qquad V_0^T < W < V_n^T$$

Since V'^T is arbitrary therefore on dropping the prime on V'^T we got:

$$f(V^T) - P_n(V^T) = \frac{f^{(n+1)}(W)}{(n+1)!}\varphi_1(V^T), \quad V_0^T < W < V_n^T \quad (35)$$

Now we use Taylor's theorem [22] [23]:

$$f(W+h) = f(W) + hf'(W) + \frac{h^2}{2!}f''(W) + ... + \frac{h^n}{n!}f^n(W) + ... \quad (36)$$

Neglecting the terms containing second and higher powers of h in equation (18), we got:

$$f(W+h) = f(W) + hf'(W)$$

Or
$$f'(W) = \frac{f(W+h) - f(W)}{h} \quad (37)$$

Or
$$f'(W) = \frac{1}{h}\Delta f(W) \qquad [\because \Delta f(W) = f(W+h) - f(W)]$$

$$Df(W) = \frac{1}{h}\Delta f(W) \qquad [\because D = \frac{d}{dW}]$$

$$D = \frac{1}{h}\Delta \qquad \text{[Because } f(W) \text{ is arbitrary]}$$

$$\therefore D^{n+1} = \frac{1}{h^{n+1}}\Delta^{n+1}$$

From equation (37), we got: $f^{(n+1)}(W) = \frac{1}{h^{(n+1)}}\Delta^{(n+1)} f(W)$

Putting the values of $f^{(n+1)}(Y)$ in equation (35), we got:

$$f(V^T) - P_n(V^T) = \left[\frac{\varphi_1(V^T)}{(n+1)!}\right]\left[\frac{1}{h^{(n+1)}}\Delta^{(n+1)} f(W)\right]$$

$$f(V^T) - P_n(V^T) = \left[\frac{(V^T - V_0^T)(V^T - V_1^T)(V^T - V_2^T)...(V^T - V_0^T)}{(n+1)!}\right]\left[\frac{1}{h^{(n+1)}}\Delta^{(n+1)} f(W)\right] \quad (38)$$

If $\frac{V^T - V_n^T}{h} = \beta$

Then

$$V^T - V_n^T = h\beta$$

$$V^T - V_{n-1}^T = V^T - (V_n^T - h) = (V^T - V_n^T) + h = (h\beta + h) = h(\beta + 1)$$

Similarly $V^T - V_{n-2}^T = h(\beta + 2)$

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Similarly $V^T - V_0^T = h(\beta + n)$

Putting these values in equation (38), we got:

$$f(V^T) - P_n(V^T) = \left[\frac{(h\beta)\{h(\beta+1)\}\{h(\beta+2)\}\{h(\beta+3)\}.....\{(\beta+n)\}}{(n+1)!}\right]\left[\frac{1}{h^{(n+1)}}\Delta^{(n+1)} f(W)\right]$$

OR

$$f(V^T) - P_n(V^T) = \left[\frac{\beta(\beta+1)(\beta+2)(\beta+3).....(\beta+n)}{(n+1)!}\right]\left[\Delta^{(n+1)} f(W)\right]$$

This is mathematical expression for estimation of error, if the point lies in the lower half.

5 DIVIDE DIFFERENCE OF TEMPERATURE

If $(V_0^T, T_0), (V_1^T, T_1).....(V_n^T, T_n)$ denoted the values of the inverse function where V^T is the rate of enzymatic reaction with Temperature then $\frac{T_1 - T_0}{V_1^T - V_0^T}$ $\frac{T_2 - T_1}{V_2^T - V_1^T}$, $\frac{T_3 - T_2}{V_3^T - V_2^T}$, $\frac{T_4 - T_3}{V_4^T - V_3^T}$,..... $\frac{T_n - T_{n-1}}{V_n^T - V_{n-1}^T}$,are called the divide differences of T. These differences are denoted as $\Delta_d T_0$ $\Delta_d T_1$, $\Delta_d T_2$, $\Delta_d T_3$,..... $\Delta_d T_{n-1}$ therefore

$$\Delta_d T_0 = \frac{T_1 - T_0}{V_1^T - V_0^T}$$

$$\Delta_d T_1 = \frac{T_2 - T_1}{V_2^T - V_1^T},$$

$$\Delta_d T_2 = \frac{T_3 - T_2}{V_3^T - V_2^T},$$

$$\Delta_d T_3 = \frac{T_4 - T_3}{V_4^T - V_3^T},$$

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$$\Delta_d T_{n-1} = \frac{T_n - T_{n-1}}{V_n^T - V_{n-1}^T}$$

Where Δ_d is called the divide difference operator, and $\Delta_d T_0 \ \ \Delta_d T_1 \ \Delta_d T_2 \ \Delta_d T_3$ ..... $\Delta_d T_{n-1}$ are called first order divide differences. The differences of the first order difference are called second order divide differences and are denoted as $\Delta^2{}_d T_0 \ \Delta_d^2 T_1, \Delta_d^2 T_2, \Delta_d^2 T_3$,... etc.

$$\Delta_d^2 T_0 = \frac{\Delta_d T_1 - \Delta_d T_0}{V_2^T - V_0^T}$$

$$\Delta_d^2 T_1 = \frac{\Delta_d T_2 - \Delta_d T_1}{V_3^T - V_1^T}$$

$$\Delta_d^2 T_2 = \frac{\Delta_d T_3 - \Delta_d T_2}{V_4^T - V_2^T}$$

$$\Delta_d^2 T_3 = \frac{\Delta_d T_4 - \Delta_d T_3}{V_5^T - V_3^T}$$

In general, the first order divide difference at the i^{th} point is

$$\Delta_d T_i = \frac{T_{i+1} - T_i}{V_{i+1}^T - V_i^T}$$

And the order divide difference at the point is

$$\Delta^j T_i = \frac{\Delta^{j-1} T_{i+1} - \Delta^{j-1} T_i}{V_{i+j}^T - V_i^T}$$

$$\Delta^j T_i = \frac{\Delta^{j-1} T_{i+1} - \Delta^{j-1} T_i}{V_{i+j}^T - V_i^T}$$

5.1 FORMULA FOR DIVIDE DIFFERENCE INTERPOLATION

By the definition of divide difference

$$f(V^T, V_0^T) = \frac{f(V^T) f(V_0^T)}{V^T - V_0^T} \tag{39}$$

Or $$f(V^T) = f(V_0^T) + (V^T - V_0^T) f(V^T, V_0^T)$$

Again by the definition of second divided difference

$$f(V^T, V_0^T, V_1^T) = \frac{f(V^T, V_0^T) - f(V_0^T, V_1^T)}{V^T - V_1^T}$$

Or $$f(V^T, V_0^T) = f(V_0^T, V_1^T) + (V^T - V_1^T) f(V^T, V_0^T, V_1^T) \quad (40)$$

Similarly $$f(V^T, V_0^T, V_1^T) = f(V_0^T, V_1^T, V_2^T) + (V^T - V_2^T) f(V^T, V_0^T, V_1^T, V_2^T) \quad (41)$$

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Proceeding in similar way, we got:

$$f(V^T, V_0^T, V_1^T, \ldots\ldots\ldots\ldots V_{n-1}^T) = f(V_0^T, V_1^T, V_2^T, \ldots\ldots\ldots\ldots V_n^T) + (V^T - V_n^T) f(V^T, V_0^T, V_n^T) \quad (42)$$

Multiplying equation (40) by $(V^T - V_0^T)$,

Multiplying equation (41) by $(V^T - V_0^T)\ (V^T - V_1^T)$,

Multiplying equation (42) by $(V^T - V_0^T)\ (V^T - V_1^T)$ ..... $(V^T - V_{n-1}^T)$

And adding to equation (39), we got:

$$f(V^T) = f(V_0^T) + (V^T - V_0^T) f(V_0^T, V_1^T) + (V^T - V_1^T)(V^T - V_2^T) f(V_0^T, V_1^T, V_2^T) + \ldots\ldots$$
$$\ldots\ldots + (V^T - V_0^T)(V^T - V_1^T)(V^T - V_2^T)\ldots\ldots\ldots(V^T - V_{n-1}^T) f(V_0^T, V_1^T, V_2^T \ldots\ldots\ldots V_n^T) + R_n$$

Where R_n is the reminder and is given by

$$R_n = (V^T - V_0^T)(V^T - V_1^T)(V^T - V_2^T)\ldots\ldots\ldots(V^T - V_n^T) f(V_0^T, V_1^T, V_2^T \ldots\ldots\ldots V_n^T)$$

If the function $f(V^T)$ is polynomial of degree n, then $f(V_0^T, V_1^T, V_2^T, \ldots\ldots\ldots\ldots V_n^T)$ vanishes so that

$$f(V^T) = f(V_0^T) + (V^T - V_0^T) f(V_0^T, V_1^T) + (V^T - V_1^T)(V^T - V_2^T) f(V_0^T, V_1^T, V_2^T) + \ldots\ldots$$
$$\ldots\ldots + (V^T - V_0^T)(V^T - V_1^T)(V^T - V_2^T)\ldots\ldots\ldots(V^T - V_{n-1}^T) f(V_0^T, V_1^T, V_2^T \ldots\ldots\ldots V_n^T)$$

5.1.1 ESTIMATION OF ERROR

Let $f(V^T)$ be a real-valued function define n interval and $(n+1)$ times differentiable on (a,b). If $P_n(V^T)$ is the polynomial. Which interpolates $f(V^T)$ at the $(n+1)$ distinct points $V_0^T, V_1^T \ldots\ldots V_n^T \in (a,b)$, then for all $\overline{V^T} \in [a,b]$,there exists $\xi = \xi\left(\overline{V^T}\right) \in (a,b)$

$$e_n\left(\overline{V^T}\right) = f\left(\overline{V^T}\right) - P_n\left(\overline{V^T}\right)$$

$$= \frac{f^{(n+1)}(\xi)}{(n+1)} \prod_{j=0}^{n} \left(\overline{V^T} - V_j^T\right)$$

This is mathematical expression for estimation of error, if intervals are not being equally spaced.

6 WHEN THE TABULATED VALUES OF $V^T = f(T)$ ARE NOT EQUIDISTANT

If $f(V_0^T), f(V_1^T), f(V_2^T)\ldots\ldots\ldots\ldots f(V_n^T)$ is to be vales of the inverse function corresponding to arguments $V_0^T, V_1^T, V_2^T \ldots\ldots V_n^T$ not necessarily equally spaced.

Let $f(V^T)$ be a polynomial of degree n in V^T and since $(n+1)$ values of $f(V^T)$ are given so $(n+1)^{th}$ difference are zero.

Consider,

$$\begin{aligned} f(V^T) &= A_0(V^T - V_1^T)(V^T - V_2^T)\ldots.(V^T - V_n^T) + A_1(V^T - V_0^T)(V^T - V_2^T)\ldots.(V^T - V_n^T) \\ &+ A_2(V^T - V_0^T)(V^T - V_1^T)\ldots\ldots\ldots(V^T - V_n^T) + \ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ &\ldots\ldots + A_n(V^T - V_0^T)(V^T - V_1^T)\ldots\ldots\ldots(V^T - V_{n-1}^T) \end{aligned} \quad (43)$$

Where $A_0, A_1, A_2 \ldots\ldots\ldots\ldots\ldots A_n$ all are constants[19].

Now put $V^T = V_0^T$ in equation (43), we got:

$$f(V_0^T) = A_0(V_0^T - V_1^T)(V_0^T - V_2^T)\ldots\ldots\ldots(V_0^T - V_n^T)$$

$$\therefore A_0 = \frac{f(V_0^T)}{(V_0^T - V_1^T)(V_0^T - V_2^T)\ldots\ldots\ldots(V_0^T - V_n^T)} \quad (44)$$

Again put $V^T = V_1^T$ in equation (43), we got:

$$f(V_1^T) = A_1(V_1^T - V_1^T)(V_1^T - V_2^T)\ldots\ldots\ldots(V_1^T - V_n^T)$$

$$\therefore A_1 = \frac{f(V_1^T)}{(V_1^T - V_1^T)(V_1^T - V_2^T)\ldots\ldots\ldots(V_1^T - V_n^T)} \quad (45)$$

Similarly $\therefore A_2 = \frac{f(V_2^T)}{(V_2^T - V_1^T)(V_2^T - V_2^T)\ldots\ldots\ldots(V_2^T - V_n^T)}$ (46)

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Proceeding in similar way, we got:

$$\therefore A_n = \frac{f(V_n^T)}{(V_n^T - V_1^T)(V_n^T - V_2^T)\ldots\ldots\ldots(V_n^T - V_n^T)} \quad (47)$$

Substituting the values of $A_0, A_1, A_2 \ldots\ldots\ldots\ldots A_n$ from equation (44), (45), (46), (47) in equation (43) we got:

$$f(V^T) = \frac{(V^T - V_1^T)(V^T - V_2^T)\ldots(V^T - V_n^T)}{(V_0^T - V_1^T)(V_0^T - V_2^T)\ldots(V_0^T - V_n^T)} f(V_0^T) + \frac{(V^T - V_0^T)(V^T - V_2^T)\ldots(V^T - V_n^T)}{(V_1^T - V_1^T)(V_1^T - V_2^T)\ldots(V_1^T - V_n^T)} f(V_1^T)$$
$$+ \frac{(V^T - V_0^T)(V^T - V_1^T)\ldots(V^T - V_n^T)}{(V_2^T - V_1^T)(V_2^T - V_2^T)\ldots(V_2^T - V_n^T)} f(V_2^T) + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$
$$\ldots\ldots + \frac{(V^T - V_0^T)(V^T - V_1^T)\ldots(V^T - V_{n-1}^T)}{(V_n^T - V_1^T)(V_n^T - V_2^T)\ldots(V_n^T - V_n^T)} f(V_n^T)$$

6.1 ESTIMATION OF ERROR

Since the approximating polynomial $f\left(V^T\right)$ given by Lagrangian formula has the same values $f\left(V_0^T\right) f\left(V_1^T\right) f\left(V_2^T\right) f\left(V_3^T\right) f\left(V_4^T\right) \ldots\ldots\ldots\ldots f\left(V_n^T\right)$ as does $T = f(V^T)$ for the arguments V_0^T, V_1^T, V_2^T, V_3^T, V_4^T ……., V_0^T the error term must have zeros at these $(n+1)$ points.

There for $(V^T - V_0^T)$ $(V^T - V_1^T)$ $(V^T - V_2^T)$ $(V^T - V_3^T)$ …… $(V^T - V_n^T)$ must be factors of the error and we can write:

$$F(V^T) = f(V^T) + \frac{(V^T - V_0^T)(V^T - V_1^T)(V^T - V_2^T)(V^T - V_3^T)\ldots\ldots\ldots(V^T - V_n^T)}{(n+1)!} K(V^T) \quad (48)$$

Let x to be fixed in value and consider the function

$$W(x) = F(x) - f(x)\frac{(x - V_0^T)(x - V_1^T)(x - V_2^T)(x - V_3^T)\ldots\ldots\ldots\ldots(x - V_n^T)}{(n+1)!} K(V^T) \quad (49)$$

Then $W(x)$ has zero $x = V_0^T, V_1^T, V_2^T, V_3^T \ldots\ldots\ldots V_n^T$ and V^T.

Since the $(n+1)^{th}$ derivative of the n^{th} degree polynomial $f(V^T)$ is zero.

$$W^{(n+1)}(x) = F^{(n+1)}(x) - K(V^T) \quad (50)$$

As a consequence of Rolle's Theorem [20] [21], the $(n+1)^{th}$ derivative of $W(x)$ has at least one real zero $x = \xi$ in the range $V_0^T < \xi < V_n^T$

Therefore substituting $x = \xi$ in equation (50)

$$W^{(n+1)}(\xi) = F^{(n+1)}(\xi) - K(V^T)$$

Or
$$K(V^T) = F^{(n+1)}(\xi) - W^{(n+1)}(\xi)$$
$$= F^{(n+1)}(\xi)$$

Using this expression for $K(V^T)$ and writing out $f(V^T)$

$$f(V^T) = \frac{(V^T - V_1^T)(V^T - V_2^T)...(V^T - V_n^T)}{(V_0^T - V_1^T)(V_0^T - V_2^T)...(V_0^T - V_n^T)} f(V_0^T) + \frac{(V^T - V_0^T)(V^T - V_2^T)...(V^T - V_n^T)}{(V_1^T - V_0^T)(V_1^T - V_2^T)...(V_1^T - V_n^T)} f(V_1^T) + ...$$

$$....+ \frac{(V^T - V_0^T)(V^T - V_1^T)...(V^T - V_{n-1}^T)}{(V_n^T - V_0^T)(V_n^T - V_1^T)...(V_n^T - V_{n-1}^T)} f(V_n^T) + \frac{(V^T - V_0^T)(V^T - V_1^T)...(V^T - V_n^T)}{(n+1)!} f^{(n+1)}(\xi)$$

Where $V_0^T < \xi < V_n^T$

This is mathematical expression for estimation of error, if the tabulated values of the function are not equidistant.

7 FORWARD DIFFERENCE FOR CONCENTRATION OF SUBSTRATE

If $(V_0^S, S_0), (V_1^S, S_1), (V_2^S, S_2).....(V_n^S, S_n)$ denoted the values of the inverse function then $S_1 - S_0$, $S_2 - S_1$, $S_3 - S_2$, $S_4 - S_3$,..... $S_n - S_{n-1}$, S are called the forward differences of S. These differences are denoted as ΔS_0, ΔS_1, ΔS_2, ΔS_3,..... ΔS_{n-1} therefore

$\Delta S_0 = S_1 - S_0$

$\Delta S_1 = S_2 - S_1$,

$\Delta S_2 = S_3 - S_2$,

$\Delta S_3 = S_4 - S_3$,

:

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:

$\Delta S_{n-1} = S_n - S_{n-1}$

Where Δ is called the forward difference operator, and ΔS_0, ΔS_1 ΔS_2 ΔS_3 ..... ΔS_{n-1} are called first order forward differences. The differences of the first order difference are called second order forward differences and are denoted as $\Delta^2 S_0$, $\Delta^2 S_1$, $\Delta^2 S_2$, $\Delta^2 S_3$,... etc.

$\Delta^2 S_0 = \Delta S_1 - \Delta S_0$

$\Delta^2 S_1 = \Delta S_2 - \Delta S_1$

$\Delta^2 S_2 = \Delta S_3 - \Delta S_2$

$\Delta^2 S_3 = \Delta S_4 - \Delta S_3$

In general, the first order forward difference at the i^{th} point is

$\Delta S_i = S_{i+1} - S_i$

And the order forward difference at the point is

$\Delta^j S_i = \Delta^{j-1} S_{i+1} - \Delta^{j-1} S_i$

7.1 FORMULA FOR FORWARD DIFFERENCE INTERPOLATION

If $f(b), f(b+h),\ldots\ldots\ldots, f(b+nh)$ are be values of inverse function then

$$V^S = b, b+h, \ldots\ldots, b+nh$$

Let $f(V^S)$ be a polynomial of degree n and let

$$\begin{aligned} f(V^S) &= B_0 + B_1(V^S - b) + B_2(V^S - b)(V^S - b - h) + \\ &\quad B_3(V^S - b)(V^S - b - h)(V^S - b - 2h) + \\ &\quad \ldots\ldots\ldots + B_n[(V^S - b)(V^S - b - h)\ldots\ldots\{V^S - b - (n-1)h\}] \end{aligned} \tag{51}$$

Where $B_0, B_1\ldots\ldots\ldots\ldots B_n$ all are constants [19].

Putting $V^S = a$ in equation (51), we got:

$$f(a) = B_0 \tag{52}$$

Again putting $V^S = a + h$ in equation (51), we got:

$$\begin{aligned} f(b+h) &= B_0 + B_1 h \\ A_1 h &= f(b+h) - B_0 \\ &= f(b+h) - f(b) \\ &= \Delta f(b) \end{aligned}$$

$$A_1 = \frac{\Delta f(b)}{h} \tag{53}$$

Again putting $V^S = b + 2h$ in equation (51), we got:

$$\begin{aligned} f(b+2h) &= B_0 + B_1(2h) + B_2(2h)(h) \\ &= B_0 + 2hB_1 + B_0 + 2h^2 B_2 \end{aligned}$$ [from equation (52) and (53)]

Or $$\begin{aligned} 2h^2 B_2 &= f(b+2h) - B_0 - 2hB_1 \\ &= f(b+2h) - f(b) - 2\Delta f(b) \\ &= f(b+2h) - f(b) - 2\{f(b+h) - f(b)\} \\ &= f(b+2h) - 2\{f(b+h) + f(b)\} \\ &= \Delta^2 f(b) \end{aligned}$$

$$\therefore B_2 = \frac{1}{2h^2}\Delta^2 f(b)$$

Or $$B_2 = \frac{1}{2!h^2}\Delta^2 f(b) \tag{54}$$

Similarly $B_3 = \frac{1}{3!h^3}\Delta^3 f(b)$ (55)

:

:

Proceeding in similar way, we got: $B_n = \frac{1}{n!h^n}\Delta^n f(b)$ (56)

substituting the values of $B_0, B_1, B_2, \ldots\ldots, B_n$ in equation (51), we got:

$$f(V^S) = f(b) + \frac{\Delta f(b)}{h}(V^S - b) + \frac{\Delta^2 f(b)}{2!h^2}(V^S - b)(V^S - b - h) + \ldots. + \frac{\Delta^n f(b)}{n!h^n}(V^S - b)(V^S - b - h)\ldots..\{V^S - b - (n-1)h\} \quad (57)$$

Now let $V^S = b + hu$

$\therefore V - b = hu$

$V^S - b - h = (u-1)h$

$V^S - b - 2h = (u-2)h$

:

:

:

:

$V^S - b - (n-1)h = \{u - (n-1)\}h$

Putting these values in equation (57), we got:

$$f(b+hu) = f(b) + \frac{\Delta f(b)}{h}(uh) + \frac{\Delta^2 f(b)}{2!h^2}(uh)(u-1)h + \ldots\ldots\ldots + \frac{\Delta^n f(b)}{n!h^n}(uh)(u-1)h\ldots..\{u-(n-1)h\}$$

Simplifying, we got:

$$f(b+hu) = f(b) + u\Delta f(b) + \frac{\Delta^2 f(b)}{2!}\{u(u-1)\} + \ldots. + \frac{\Delta^n f(b)}{n!}(u)(u-1)\ldots..\{u-(n-1)\} \quad (58)$$

Also we know that: $u^{(m)} = u(u-1)(u-2)\ldots\ldots\ldots\{u-(m-1)\}$ (59)

From equation (58) and (59), we have:

$$f(b+hu) = f(b) + \Delta f(b)\frac{u^{(1)}}{1!} + \Delta^2 f(b)\frac{u^{(2)}}{2!} + \Delta^3 f(b)\frac{u^{(3)}}{3!} + \ldots.. + \Delta^n f(b)\frac{u^{(n)}}{n!} \quad (60)$$

7.1.1 ESTIMATION OF ERROR

Let $V = f(T)$ be a function defined by $(n+1)$ points $(V_0^S, T_0), (V_1^S, T_1).....(V_n^S, T_n)$. When $V_0^S, V_1^S, V_2^S, V_3^S .....V_n^S$ are equally spaced with interval h and this function is continuous and differentiable $(n+1)$ times.

The function be approximated by a polynomial $P_n(V^S)$ of degree not exceeding a such that

$$P_n(V_i^S) = S_i \qquad [\text{Where } i = 0,1,2,3.....n] \tag{61}$$

Since the expression $f(V^S) - P_n(V^S)$ vanishes for $V^S = V_0^S, V_1^S, V_2^S, V_3^S .....V_n^S$,

We put $f(V^S) - P_n(V^S) = K\phi(V^S)$ (62)

Where $\phi(V^S) = (V^S - V_0^S)(V^S - V_1^S).....(V^S - V_n^S)$ (63)

And K is to be determined in such a way that equation (62) holds for any intermediate values of V^S, say $V^S - V'^S$ [where $V_0^S \le V'^S \le V_n^S$].

Therefore from equation (62),

$$K = \frac{f(V'^S) - P(V'^S)}{\varphi(V'^S)} \tag{64}$$

Now we construct a function $f(V^S)$ such that

$$f(V_0^S) = f(V_1^S) - P_n(V^S) - K\varphi(V^S)$$

Where K is given by equation (64).

It is clear that

$$f(V_0^S) = f(V_1^S) = f(V_2^S) = f(V_3^S) = ...f(V_n^S) = f(V'^S) = 0 \tag{65}$$

Let $f(V^S)$ vanishes (n+2) times in the interval $V_0^S \le V^S \le V_n^S$; consequently, by the repeated application of Rolle's Theorem [20] [21], $f'(V^S)$ must vanish $(n+1)$ times, $f''(V^S)$ must vanish n times etc in the interval $V_0^S \le V^S \le V_n^S$.

Particularly, $f^{(n+1)}(V^S)$ must vanish once in the interval $V_0^S \le V^S \le V_n^S$. Let this point be $V^S = W$, $V_0^S < W < V_n^S$.

Now differentiating equation (65) $(n+1)$ times with respect to V^S and putting $V^S = W$, we got:

$$f^{(n+1)}(W) - K(n+1)! = 0$$

Or $$K = \frac{f^{(n+1)}(W)}{(n+1)!} \tag{66}$$

Putting this value of K in equation (64), we got:

$$\frac{f^{(n+1)}(W)}{(n+1)!} = \frac{f(V'^S) - P_n(V'^S)}{\varphi(V'^S)}$$

Or $$f(V'^S) - P_n(V'^S) = \frac{f^{(n+1)}(W)}{(n+1)!}\varphi(V'^S) \quad , \qquad V_0^S < W < V_n^S$$

Since V'^S is arbitrary therefore on dropping the prime on V'^S we got:

$$f(V^S) - P_n(V^S) = \frac{f^{(n+1)}(W)}{(n+1)!}\varphi(V^S), \quad V_0^S < W < V_n^T \tag{67}$$

Now we use Taylor's theorem [22] [23]:

$$f(W+h) = f(W) + hf'(W) + \frac{h^2}{2!}f''(W) + \ldots + \frac{h^n}{n!}f^n(W) + \ldots \tag{68}$$

Neglecting the terms containing second and higher powers of h in equation (68), we got:

$$f(W+h) = f(W) + hf'(W)$$

Or $$f'(W) = \frac{f(W+h) - f(W)}{h} \tag{69}$$

Or $$f'(W) = \frac{1}{h}\Delta f(W) \qquad [\because \Delta f(V^S + h) f(V^S)]$$

$$Df(W) = \frac{1}{h}\Delta f(W) \qquad [\because D = \frac{d}{dW}]$$

$$D = \frac{1}{h}\Delta \qquad \text{[Because } f(W) \text{ is arbitrary]}$$

$$\therefore D^{n+1} = \frac{1}{h^{n+1}}\Delta^{n+1}$$

From equation (69), we got:

$$f^{(n+1)}(W) = \frac{1}{h^{(n+1)}}\Delta^{(n+1)}f(W)$$

Putting the values of $f^{(n+1)}(W)$ in equation (67), we got:

$$f(V^S) - P_n(V^S) = \left[\frac{\varphi(V^S)}{(n+1)!}\right]\left[\frac{1}{h^{(n+1)}}\Delta^{(n+1)}f(W)\right]$$

$$f(V^S) - P_n(V^S) = \left[\frac{(V^S - V_0^S)(V^S - V_1^S)(V^S - V_2^S)....(V^S - V_0^S)}{(n+1)!}\right]\left[\frac{1}{h^{(n+1)}}\Delta^{(n+1)}f(W)\right] \tag{70}$$

If $\frac{V^S - V_n^S}{h} = \beta$

Then:

$$V^S - V_0^S = h\beta$$

$$V^S - V_1^S = V^S - (V_0^S - h) = (V^S - V_0^S) - h = (h\beta - h) = h(\beta - 1)$$

Similarly $V^S - V_2^S = h(\beta - 2)$

:

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Similarly $V^S - V_n^S = h(\beta - n)$

Putting these values in equation (70), we got:

$$f(V^S) - P_n(V^S) = \left[\frac{(h\beta)\{h(\beta-1)\}\{h(\beta-2)\}\{h(\beta-3)\}.....\{(\beta-n)\}}{(n+1)!}\right]\left[\frac{1}{h^{(n+1)}}\Delta^{(n+1)} f(W)\right]$$

This is mathematical expression for estimation of error, if the point lies in the lower half.

8 BACKWARD DIFFERENCE OF SUBSTRATE CONCENTRATION

If $(V_0^S, S_0), (V_1^S, S_1), (V_2^S, S_2), \ldots\ldots\ldots (V_n^S, S_n)$ denoted the values of the inverse then $S_1 - S_0$ $S_2 - S_1$, $S_3 - S_2$, $S_4 - S_3$, ... $S_n - S_{n-1}$ are called the backward differences of S. These differences are denoted as $\nabla S_1, \nabla S_2, \nabla S_3, \ldots\ldots\ldots \nabla S_{n-1}$ therefore

$\Delta S_1 = S_1 - S_0$

$\Delta S_2 = S_2 - S_1$,

$\Delta S_3 = S_3 - S_2$,

$\Delta S_4 = S_4 - S_3$,

:

:

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:

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:

$\Delta S_n = S_n - S_{n-1}$

Where ∇ is called the backward difference operator, and ∇S_1 ∇S_2, ∇S_3, ..., ∇S_{n-1} are called first order backward differences. The differences of the first order difference are called second order backward differences and are denoted as, $\nabla^2 S_2, \nabla^2 S_3, \nabla^2 S_4, \nabla^2 S_5$ .....etc.

$\nabla^2 S_2 = \nabla S_2 - \nabla S_1$

$\nabla^2 S_3 = \nabla S_3 - \nabla S_2$

$\nabla^2 S_4 = \nabla S_4 - \nabla S_3$

$\nabla^2 S_5 = \nabla S_5 - \nabla S_4$

In general, the first order forward difference at the i^{th} point is

$\nabla S_i = S_i - S_{i-1}$

And the order forward difference at the point is

$\nabla^j S_i = \nabla^{j-1} S_i - \nabla^{j-1} S_{i-1}$

8.1 FORMULA FOR BACKWARD DIFFERENCE INTERPOLATION

If $f(b), f(b+h), \ldots\ldots\ldots, f(b+nh)$ are be values of inverse function then

$V^S = b, b+h, \ldots\ldots, b+nh$

Let $f(V^S)$ be a polynomial of degree n and let

$$\begin{aligned} f(V^S) &= B_0 + B_1(V^S - b - nh) + B_2(V^S - b - nh)\{V^S - b(n-1)h\} \\ &\quad + B_3(V^S - b - nh)\{V^S - b - (n-1)h\}\{V^S - b - (n-2)h\} + \ldots\ldots \\ &\quad \ldots\ldots + B_n[(V^S - b - nh)\{V^S - b - (n-1)h\}\ldots\ldots(V^S - b - h) \end{aligned} \quad (71)$$

Where $B_0, B_1, B_2, \ldots\ldots\ldots\ldots B_n$ all are constants [19].

Putting $V^S = b + nh$ in equation (71), we got: $f(b+nh) = B_0$ (72)

Again putting $V^S = b + (n-1)h$ in equation (71), we got:

$$f\{b+(n-1)h\} = B_0 + B_1 h$$

$$\begin{aligned} B_1 h &= B_0 - f\{b+(n-1)h\} \\ &= f(b+nh) - f\{b+(n-1)h\} \\ &= \Delta f(b+nh) \end{aligned}$$

$$B_1 = \frac{\Delta f(b+nh)}{h} \quad (73)$$

Again putting $V^S = b + (n-2)h$ in equation (71), we got:

$$f\{b+(n-2)h\} = B_0 + B_1(-2h) + B_2(-2h)(-h)$$

$$2h^2 B_2 = f\{b+(n-2)h\} - B_0 - 2hB_1$$

Or $2h^2 B_2 = f\{b+(n-2)h\} - f(a+nh) + 2\nabla f(a+nh)$ [from equation(72) and (73)]

$$\begin{aligned} &= f\{a+(n-2)h\} - f(a+nh) + 2[\{f(a+nh)\} - f\{a+(n-1)h\}] \\ &= f\{a+(n-2)h\} - f(a+nh) - 2f\{a+(n-1)h\} \\ &= f(a+nh) - 2[f\{a+(n-1)h\} + f(a)] \\ &= \Delta^2 f(a+nh) \end{aligned}$$

$$\therefore B_2 = \frac{1}{2h^2}\Delta^2 f(b)$$

Or $A_2 = \frac{1}{2!h^2}\Delta^2 f(a=nh)$ (74)

Similarly $A_3 = \frac{1}{3!h^3}\Delta^3 f(a+nh)$ (75)

$$\vdots$$
$$\vdots$$

Proceeding in similar way, we got: $A_n = \frac{1}{n!h^n}\Delta^n f(a+nh)$ (76)

substituting the values of $A_0, A_1, A_2, \ldots\ldots, A_n$ in equation (71), we got:

$$f(V^S) = f(a+nh) + \frac{\Delta f(a)}{h}(V^S - a - nh) + \frac{\Delta^2 f(a+nh)}{2!h^2}(V^S - a - nh)\{V^S - a - (n-1)h\} + \ldots\ldots\ldots\ldots\ldots\ldots + \frac{\Delta^n f(a+nh)}{n!h^n}(V^S - a - nh)\{V^S - a - (n-1)h\}\ldots\ldots(V^S - a - n) \quad (77)$$

Now let: $V^S = a + nh + hu$

$$\therefore V^S - a = nh + hu$$

$$V^S - a - (n-1)h = (u+1)h$$

$$V^S - a - (n-2)h = (u+2)h$$

$$\vdots$$

$$\vdots$$

$$\vdots$$

$$\vdots$$

$$V^S - a - h = \{u + (n-1)\}h$$

Putting these values in equation (77), we got:

$$f(a+nh+hu) = f(a+nh) + \frac{\Delta f(a+nh)}{h}(uh) + \frac{\Delta^2 f(a+nh)}{2!h^2}(uh)(u+1)h + \ldots\ldots\ldots + \frac{\Delta^n f(a+nh)}{n!h^n}(uh)(u+1)h\ldots\ldots\{u+(n-1)h\}$$

Simplifying, we got:

$$f(a+nh+hu) = f(a+nh) + u\Delta f(a+nh) + \frac{\Delta^2 f(a+nh)}{2!}\{u(u+1)\} + \ldots\ldots\ldots\ldots + \frac{\Delta^n f(a+nh)}{n!}(u)(u+1)\ldots\ldots\{u+(n-1)\} \quad (78)$$

8.1.1 ESTIMATION OF ERROR

Let $V = f(T)$ be a function defined by $(n+1)$ points $(V_0^S, E_0), (V_1^S, E_1)\ldots\ldots\ldots(V_n^S, E_n)$. When $V_0^S, V_1^S, V_2^S, V_3^S \ldots\ldots\ldots\ldots V_n^S$ are equally spaced with interval h and this function is continuous and differentiable $(n+1)$ times.

The function be approximated by a polynomial $P_n(V^S)$ of degree not exceeding a such that

$$P_n(V_i^S) = E_i \qquad [\text{Where } i = 1,2,3\ldots\ldots\ldots n] \quad (79)$$

Since the expression $f(V^S) - P_n(V^S)$ vanishes for $V^S = V_0^S, V_1^S, V_2^S, V_3^S \ldots\ldots\ldots\ldots V_n^S$,

We put $f(V^S) - P_n(V^S) = K\phi(V^S)$ (80)

Where $\phi_1(V^S) = (V^S - V_n^S)(V^S - V_{n-1}^S).....(V^S - V_0^S)$ (81)

And K is to be determined in such a way that equation (81) holds for any intermediate values of V^S, say $V^S - V'^S$ [where $V_0^S \le V'^S \le V_n^S$].

Therefore from equation (81),

$$K = \frac{f(V'^S) - P_n(V'^S)}{\varphi_1(V'^S)} \tag{82}$$

Now we construct a function $f(V^S)$ such that

$$f(V_0^S) = f(V_1^S) - P_n(V^S) - K\varphi_1(V^S)$$

Where K is given by equation (82).

It is clear that

$$f(V_0^S) = f(V_1^S) = f(V_2^S) = f(V_3^S) = ...f(V_n^S) = f(V'^S) = 0 \tag{83}$$

Let $f(V^S)$ vanishes (n+2) times in the interval $V_0^S \le V^S \le V_n^S$; consequently, by the repeated application of Rolle's Theorem [20] [21], $f'(V^S)$ must vanish $(n+1)$ times, $f''(V^S)$ must vanish n times etc in the interval $V_0^S \le V^S \le V_n^S$.

Particularly, $f^{(n+1)}(V^S)$ must vanish once in the interval $V_0^S \le V^S \le V_n^S$. Let this point be $V^S = W$, $V_0^S < W < V_n^S$.

Now differentiating equation (83) $(n+1)$ times with respect to V^S and putting $V^S = W$, we got:

$$f^{(n+1)}(W) - K(n+1)! = 0$$

Or
$$K = \frac{f^{(n+1)}(W)}{(n+1)!} \tag{84}$$

Putting this value of K in equation (82), we got:

$$\frac{f^{(n+1)}(W)}{(n+1)!} = \frac{f(V'^S) - P_n(V'^S)}{\varphi_1(V'^S)}$$

Or $$f(V'^S) - P_n(V'^S) = \frac{f^{(n+1)}(W)}{(n+1)!}\varphi_1(V'^S), \qquad V_0^S < W < V_n^S$$

Since V'^S is arbitrary therefore on dropping the prime on V'^S we got:

$$f(V^S) - P_n(V^S) = \frac{f^{(n+1)}(W)}{(n+1)!}\varphi_1(V^S), \quad V_0^S < W < V_n^S \tag{85}$$

Now we use Taylor's theorem [22] [23]:

$$f(W+h) = f(W) + hf'(W) + \frac{h^2}{2!}f''(W) + ... + \frac{h^n}{n!}f^n(W) + ... \tag{86}$$

Neglecting the terms containing second and higher powers of h in equation (86), we got:

$$f(W+h) = f(W) + hf'(W)$$

Or $$f'(W) = \frac{f(W+h) - f(W)}{h} \tag{87}$$

Or $$f'(W) = \frac{1}{h}\Delta f(W) \qquad [\because \Delta f(W) = f(W+h) - f(W)]$$

$$Df(W) = \frac{1}{h}\Delta f(W) \qquad [\because D = \frac{d}{dW}]$$

$$D = \frac{1}{h}\Delta \qquad \text{[Because } f(W) \text{ is arbitrary]}$$

$$\therefore D^{n+1} = \frac{1}{h^{n+1}}\Delta^{n+1}$$

From equation (87), we got:

$$f^{(n+1)}(W) = \frac{1}{h^{(n+1)}}\Delta^{(n+1)} f(W)$$

Putting the values of $f^{(n+1)}(Y)$ in equation (85), we got:

$$f(V^S) - P_n(V^S) = \left[\frac{\varphi_1(V^S)}{(n+1)!}\right]\left[\frac{1}{h^{(n+1)}}\Delta^{(n+1)} f(W)\right]$$

$$f(V^S) - P_n(V^S) = \left[\frac{(V^S - V_0^S)(V^S - V_1^S)(V^S - V_2^S).....(V^S - V_0^S)}{(n+1)!}\right]\left[\frac{1}{h^{(n+1)}}\Delta^{(n+1)} f(W)\right] \tag{88}$$

If $\frac{V^S - V_n^S}{h} = \beta$

Then

$$V^S - V_n^S = h\beta$$

$$V^S - V_{n-1}^S = V^S - (V_n^S - h) = (V^S - V_n^S) + h = (h\beta + h) = h(\beta + 1)$$

Similarly $V^S - V_{n-2}^S = h(\beta + 2)$

:

:

:

Similarly $V^S - V_0^S = h(\beta + n)$

Putting these values in equation (20), we got:

$$f(V^S) - P_n(V^S) = \left[\frac{(h\beta)\{h(\beta+1)\}\{h(\beta+2)\}\{h(\beta+3)\}.....\{(\beta+n)\}}{(n+1)!}\right]\left[\frac{1}{h^{(n+1)}}\Delta^{(n+1)} f(W)\right]$$

OR

$$f(V^S) - P_n(V^S) = \left[\frac{\beta(\beta+1)(\beta+2)(\beta+3).....(\beta+n)}{(n+1)!}\right]\left[\Delta^{(n+1)} f(W)\right]$$

This is mathematical expression for estimation of error, if the point lies in the lower half.

9 DIVIDE DIFFERENCE OF SUBSRATE CONCENTRATION

If $(V_1^S, S_1), (V_2^S, S_2).....(V_n^S, S_n)$ denoted the values of the inverse function then $\frac{S_2 - S_1}{V_2^S - V_1^S}$, $\frac{S_3 - S_2}{V_3^S - V_2^S}$, $\frac{S_4 - S_3}{V_4^S - V_3^S}$,..... $\frac{S_n - S_{n-1}}{V_n^S - V_{n-1}^S}$ are called the divide differences of S. These differences are denoted as $\Delta_d S_1$, $\Delta_d S_2$, $\Delta_d S_3$,..... $\Delta_d S_{n-1}$ therefore

$$\Delta_d S_1 = \frac{S_2 - S_1}{V_2^S - V_1^S},$$

$$\Delta_d S_2 = \frac{S_3 - S_2}{V_3^S - V_2^S},$$

$$\Delta_d S_3 = \frac{S_4 - S_3}{V_4^S - V_3^S},$$

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$$\Delta_d S_{n-1} = \frac{S_n - S_{n-1}}{V_n^S - V_{n-1}^S}$$

Where Δ_d is called the divide difference operator, and $\Delta_d S_1$ $\Delta_d S_2$ $\Delta_d S_3$ ..... $\Delta_d S_{n-1}$ are called first order divide differences. The differences of the first order difference are called second order divide differences and are denoted as $\Delta_d^2 S_1$, $\Delta_d^2 S_2$, $\Delta_d^2 S_3$,... .etc.

$$\Delta_d^2 S_1 = \frac{\Delta_d S_2 - \Delta_d S_1}{V_3^S - V_1^S}$$

$$\Delta_d^2 S_2 = \frac{\Delta_d S_3 - \Delta_d S_2}{V_4^S - V_2^S}$$

$$\Delta_d^2 S_3 = \frac{\Delta_d S_4 - \Delta_d S_3}{V_5^S - V_3^S}$$

In general, the first order divide difference at the i^{th} point is

$$\Delta_d S_i = \frac{S_{i+1} - S_i}{V_{i+1}^S - V_i^S}$$

And the order divide difference at the point is

$$\Delta^j S_i = \frac{\Delta^{j-1} S_{i+1} - \Delta^{j-1} S_i}{V_{i+j}^S - V_i^S}$$

9.1 FORMULA FOR DIVIDE DIFFERENCE INTERPOLATION

By the definition of divide difference

$$f(V^S, V_0^S) = \frac{f(V^S) f(V_0^S)}{V^S - V_0^S} \quad (89)$$

Or $f(V^S) = f(V_0^S) + (V^S - V_0^S) f(V^S, V_0^S)$

Again by the definition of second divided difference

$$f(V^S, V_0^S, V_1^S) = \frac{f(V^S, V_0^S) - f(V_0^S, V_1^S)}{V^S - V_1^S}$$

Or $f(V^S, V_0^S) = f(V_0^S, V_1^S) + (V^S - V_1^S) f(V^S, V_0^S, V_1^S)$ (90)

Similarly $f(V^S, V_0^S, V_1^S) = f(V_0^S, V_1^S, V_2^S) + (V^S - V_2^S) f(V^S, V_0^S, V_1^S, V_2^S)$ (91)

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Proceeding in similar way, we got:

$$f(V^S, V_0^S, V_1^S, \ldots\ldots\ldots\ldots V_{n-1}^S) = f(V_0^S, V_1^S, V_2^S, \ldots\ldots\ldots\ldots V_n^S) + (V^S - V_n^S) f(V^S, V_0^S, V_n^S) \quad (92)$$

Multiplying equation (90) by $(V^S - V_0^S)$,

Multiplying equation (91) by $(V^S - V_0^S)$ $(V^S - V_0^S)$,

Multiplying equation (92) by $(V^S - V_0^S)$ $(V^S - V_1^S)$ ..... $(V^S - V_{n-1}^S)$

And adding to equation (89), we got:

$$f(V^S) = f(V_0^S) + (V^S - V_0^S) f(V_0^S, V_1^S) + (V^S - V_1^S)(V^S - V_2^S) f(V_0^S, V_1^S, V_2^S) + \ldots\ldots$$
$$\ldots\ldots + (V^S - V_0^S)(V^S - V_1^S)(V^S - V_2^S) \ldots\ldots\ldots (V^S - V_{n-1}^S) f(V_0^S, V_1^S, V_2^S \ldots\ldots\ldots V_n^S) + R_n$$

Where R_n is the reminder and is given by

$$R_n = (V^S - V_0^S)(V^S - V_1^S)(V^S - V_2^S) \ldots\ldots\ldots (V^S - V_n^S) f(V_0^S, V_1^S, V_2^S \ldots\ldots\ldots V_n^S)$$

If the function $f(V^S)$ is polynomial of degree n, then $f(V_0^S, V_1^S, V_2^S, \ldots\ldots\ldots\ldots V_n^S)$ vanishes so that

$$f(V^S) = f(V_0^S) + (V^S - V_0^S) f(V_0^S, V_1^S) + (V^S - V_1^S)(V^S - V_2^S) f(V_0^S, V_1^S, V_2^S) + ...$$
$$.....+ (V^S - V_0^S)(V^S - V_1^S)(V^S - V_2^S).....(V^S - V_{n-1}^S) f(V_0^S, V_1^S, V_2^S .....V_n^S)$$

9.1.1 ESTIMATION OF ERROR

Let $f(V^S)$ be a real-valued function define n interval and $(n+1)$ times differentiable on (a,b). If $P_n(V^S)$ is the polynomial. Which interpolates $f(V^S)$ at the $(n+1)$ distinct points $V_0^S, V_1^S .....V_n^S \in (a,b)$, then for all $\overline{V^S} \in [a,b]$,there exists $\xi = \xi\left(\overline{V^S}\right) \in (a,b)$

$$e_n\left(\overline{V^S}\right) = f\left(\overline{V^S}\right) - P_n\left(\overline{V^S}\right)$$

$$= \frac{f^{(n+1)}(\xi)}{(n+1)} \prod_{j=0}^{n} \left(\overline{V^S} - V_j^S\right)$$

This is mathematical expression for estimation of error, if intervals are not be equally spaced.

10 WHEN THE TABULATED VALUES OF $V^S = f(S)$ ARE NOT EQUIDISTANT

If $f(V_0^S), f(V_1^S), f(V_2^S).....f(V_n^S)$ is to be vales of the inverse function corresponding to arguments $V_0^S, V_1^S, V_2^S .....V_n^S$ not necessarily equally spaced.

Let $f(V^S)$ be a polynomial of degree n in V^S and since $(n+1)$ values of $f(V^S)$ are given so $(n+1)^{th}$ difference are zero.

Consider:

$$f(V^T) = A_0(V^S - V_1^S)(V^S - V_2^S).....(V^S - V_n^S) + A_1(V^S - V_0^S)(V^S - V_2^S)....(V^S - V_n^S)$$
$$+ A_2(V^S - V_0^S)(V^S - V_1^S)....(V^S - V_n^S) + ...$$
$$.....+ A_n(V^S - V_0^S)(V^S - V_1^S).....(V^S - V_{n-1}^S) \quad (93)$$

Where $A_0, A_1, A_2 .... A_n$ all are constants.

Now put $V^S = V_0^S$ in equation (93), we got:

$$f(V_0^S) = A_0(V_0^S - V_1^S)(V_0^S - V_2^S).....(V_0^S - V_n^S)$$

$$\therefore A_0 = \frac{f(V_0^S)}{(V_0^S - V_1^S)(V_0^S - V_2^S).....(V_0^S - V_n^S)} \quad (94)$$

Again put $V^S = V_1^S$ in equation (93), we got:

$$f(V_1^S) = A_1(V_1^S - V_1^S)(V_1^S - V_2^S).....(V_1^S - V_n^S)$$

$$\therefore A_1 = \frac{f(V_1^S)}{(V_1^S - V_1^S)(V_1^S - V_2^S).....(V_1^S - V_n^S)} \quad (95)$$

Similarly $\therefore A_2 = \dfrac{f(V_2^S)}{(V_2^S - V_1^S)(V_2^S - V_2^S).....(V_2^S - V_n^S)}$ (96)

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Proceeding in similar way, we got:

$$\therefore A_n = \frac{f(V_n^S)}{(V_n^S - V_1^S)(V_n^S - V_2^S).....(V_n^S - V_n^S)} \quad (97)$$

Substituting the values of $A_0, A_1, A_2 \ldots\ldots\ldots\ldots A_n$ from equation (94),(95),(96),(97) in equation (93)we got:

$$f(V^S) = \frac{(V^S - V_1)(V^S - V_2^S).....(V^S - V_n^S)}{(V_0^S - V_1^S)(V_0^S - V_2^S).....(V_0^S - V_n^S)} f(V_0^S) + \frac{(V^S - V_0^S)(V^S - V_2^S).....(V^S - V_n^S)}{(V_1^S - V_1^S)(V_1^S - V_2^S).....(V_1^S - V_n^S)} f(V_1^S)$$
$$+ \frac{(VS - V_0^S)(V^S - V_1^S).....(V^S - V_n^S)}{(V_2^S - V_1^S)(V_2^S - V_2^S).....(V_2^S - V_n^S)} f(V_2^S) + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$
$$\ldots\ldots + \frac{(V^S - V_0^S)(V^S - V_1^S).....(V^S - V_{n-1}^S)}{(V_n^S - V_1^S)(V_n^S - V_2^S).....(V_n^S - V_n^S)} f(V_n^S)$$

10.1 ESTIMATION OF ERROR

Since the approximating polynomial $f(V^S)$ given by Lagrangian formula has the same values $f(V_0^S)\ f(V_1^S)\ f(V_2^S)\ f(V_3^S)\ f(V_4^S)\ldots\ldots\ldots\ldots f(V_n^S)$ as does $T = f(V^S)$ for the arguments $V_0^S,\ V_1^S,\ V_2^S,\ V_3^S,\ V_4^S$ ……,V_0^S the error term must have zeros at these $(n+1)$ points.

There for $(V^S - V_0^S)\ (V^S - V_1^S)\ (V^S - V_2^S)\ (V^S - V_3^S)$ …… $(V^S - V_n^S)$ must be factors of the error and we can write:

$$F(V^S) = f(V^S) + \frac{(V^S - V_0^S)(V^S - V_1^S)(V^S - V_2^S)(V^S - V_3^S).....(V^S - V_n^S)}{(n+1)!} K(V^S) \quad (98)$$

Let x to be fixed in value and consider the function

$$W(x) = F(x) - f(x)\frac{(x - V_0^S)(x - V_1^S)(x - V_2^S)(x - V_3^S).....(x - V_n^S)}{(n+1)!} K(V^S) \quad (99)$$

Then $W(x)$ has zero $x = V_0^S, V_1^S, V_2^S, V_3^S \ldots\ldots V_n^S$ and V^S.

Since the $(n+1)^{th}$ derivative of the n^{th} degree polynomial $f(V^S)$ is zero.

$$W^{(n+1)}(x) = F^{(n+1)}(x) - K(V^S) \quad (100)$$

As a consequence of Rolle's Theorem [15] [16], the $(n+1)^{th}$ derivative of $W(x)$ has at least one real zero $x = \xi$ in the range $V_0^S < \xi < V_n^S$

Therefore substituting $x = \xi$ in equation (100)

$$W^{(n+1)}(\xi) = F^{(n+1)}(\xi) - K(V^S)$$

Or
$$K(V^S) = F^{(n+1)}(\xi) - W^{(n+1)}(\xi)$$
$$= F^{(n+1)}(\xi)$$

Using this expression for $K(V^S)$ and writing out $f(V^S)$

$$f(V^S) = \frac{(V^S - V_1^S)(V^S - V_2^S)...(V^S - V_n^S)}{(V_0^S - V_1^S)(V_0^S - V_2^S)...(V_0^S - V_n^S)} f(V_0^S) + \frac{(V^S - V_0^S)(V^S - V_2^S).....(V^S - V_n^S)}{(V_1^S - V_0^S)(V_1^S - V_2^S)....(V_1^S - V_n^S)} f(V_1^S) + ...$$
$$.....+ \frac{(V^S - V_0^S)(V^S - V_1^S)....(V^S - V_{n-1}^S)}{(V_n^S - V_0^S)(V_n^S - V_1^S)....(V_n^S - V_{n-1}^S)} f(V_n^S) + \frac{(V^S - V_0^S)(V^S - V_1^S)....(V^S - V_n^S)}{(n+1)!} f^{(n+1)}(\xi)$$

Where $V_0^S < \xi < V_n^S$

This is mathematical expression for estimation of error, if the tabulated values of the function are not equidistant.

11 FORWARD DIFFERENCE OF ENZYME CONCENTRATION

If $(V_0^E, E_0), (V_1^E, E_1), (V_2^E, E_2).....(V_n^E, E_n)$ denoted the values of the inverse function then $E_1 - E_0$, $E_2 - E_1$, $E_3 - E_2, E_4 - E_3, ... E_n - E_{n-1}, E$ are called the forward differences of E. These differences are denoted as $\Delta E_0, \Delta E_1, \Delta E_2, \Delta E_3, ... \Delta E_{n-1}$ therefore

$\Delta E_0 = E_1 - E_0$

$\Delta E_1 = E_2 - E_1$,

$\Delta E_2 = E_3 - E_2$,

$\Delta E_3 = E_4 - E_3$,

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$\Delta E_{n-1} = E_n - E_{n-1}$

Where Δ is called the forward difference operator, and $\Delta E_0, \Delta E_1\ \Delta E_2\ \Delta E_3$ ..... ΔE_{n-1} are called first order forward differences. The differences of the first order difference are called second order forward differences and are denoted as $\Delta^2 E_0, \Delta^2 E_1, \Delta^2 E_2, \Delta^2 E_3$,... .etc.

$\Delta^2 E_0 = \Delta E_1 - \Delta E_0$

$\Delta^2 E_1 = \Delta E_2 - \Delta E_1$

$\Delta^2 E_2 = \Delta E_3 - \Delta E_2$

$\Delta^2 E_3 = \Delta E_4 - \Delta E_3$

In general, the first order forward difference at the i^{th} point is

$\Delta E_i = E_{i+1} - E_i$

And the order forward difference at the point is : $\Delta^j E_i = \Delta^{j-1} E_{i+1} - \Delta^{j-1} E_i$

11.1 FORMULA FOR FORWARD DIFFERENCE INTERPOLATION

If $f(g), f(g+h), \ldots\ldots\ldots, f(g+nh)$ are be values of inverse function then

$$V^E = g, g+h, \ldots\ldots, g+nh$$

Let $f(V^E)$ be a polynomial of degree n and let

$$\begin{aligned} f(V^E) &= G_0 + G_1(V^E - g) + G_2(V^E - g)(V^E - g - h) \\ &\quad + A_3(V^E - g)(V^E - g - h)(V^E - g - 2h) + \ldots\ldots\ldots \\ &\quad \ldots\ldots\ldots + G_n[(V^E - g)(V^E - g - h)\ldots\ldots\{V^E - g - (n-1)h\}] \end{aligned} \quad (101)$$

Where $G_0, G_1 \ldots\ldots\ldots\ldots\ldots G_n$ all are constants [19].

Putting $V^E = g$ in equation (101), we got:

$$f(g) = G_0 \quad (102)$$

Again putting $V^E = g + h$ in equation (101), we got:

$$\begin{aligned} f(g+h) &= G_0 + G_1 h \\ G_1 h &= f(g+h) - G_0 \\ &= f(g+h) - f(g) \\ &= \Delta f(g) \end{aligned}$$

$$G_1 = \frac{\Delta f(g)}{h} \quad (103)$$

Again putting $V^E = g + 2h$ in equation (101), we got:

$$\begin{aligned} f(g+2h) &= G_0 + G_1(2h) + G_2(2h)(h) \\ &= G_0 + 2hG_1 + G_0 + 2h^2 G_2 \end{aligned}$$ [from equation (102) and (103)]

Or $$\begin{aligned} 2h^2 G_2 &= f(g+2h) - G_0 - 2hG_1 \\ &= f(g+2h) - f(g) - 2\Delta f(g) \\ &= f(g+2h) - f(g) - 2\{f(g+h) - f(g)\} \\ &= f(g+2h) - 2\{f(g+h) + f(g)\} \\ &= \Delta^2 f(g) \end{aligned}$$

$$\therefore G_2 = \frac{1}{2h^2}\Delta^2 f(g)$$

Or $$G_2 = \frac{1}{2!h^2}\Delta^2 f(g) \quad (104)$$

Similarly $G_3 = \frac{1}{3!h^3}\Delta^3 f(g)$ (105)

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Proceeding in similar way, we got: $G_n = \frac{1}{n!h^n}\Delta^n f(g)$ (106)

substituting the values of $G_0, G_1, G_2, \ldots\ldots, G_n$ in equation (101), we got:

$$f(V^E) = f(g) + \frac{\Delta f(g)}{h}(V^E - g) + \frac{\Delta^2 f(g)}{2!h^2}(V^E - g)(V^E - g - h) + \ldots. + \frac{\Delta^n f(g)}{n!h^n}(V^E - g)(V^E - g - h)\ldots..\{V^E - g - (n-1)h\} \quad (107)$$

Now let $V^E = g + hu$

$\therefore V^E - a = hu$

$V^E - g - h = (u-1)h$

$V^E - g - 2h = (u-2)h$

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$V^E - g - (n-1)h = \{u - (n-1)\}h$

Putting these values in equation (107), we got:

$$f(g+hu) = f(g) + \frac{\Delta f(g)}{h}(uh) + \frac{\Delta^2 f(g)}{2!h^2}(uh)(u-1)h + \ldots\ldots\ldots + \frac{\Delta^n f(g)}{n!h^n}(uh)(u-1)h\ldots..\{u-(n-1)h\}$$

Simplifying, we got:

$$f(g+hu) = f(g) + u\Delta f(g) + \frac{\Delta^2 f(g)}{2!}\{u(u-1)\} + \ldots. + \frac{\Delta^n f(g)}{n!}(u)(u-1)\ldots\{u-(n-1)\} \quad (108)$$

Also we know that

$$u^{(m)} = u(u-1)(u-2)\ldots\ldots\ldots\{u-(m-1)\} \quad (109)$$

From equation (108) and (109), we have:

$$f(g+hu) = f(g) + \Delta f(g)\frac{u^{(1)}}{1!} + \Delta^2 f(g)\frac{u^{(2)}}{2!} + \Delta^3 f(g)\frac{u^{(3)}}{3!} + \ldots.. + \Delta^n f(g)\frac{u^{(n)}}{n!} \quad (110)$$

11.1.1 ESTIMATION OF ERROR

Let $V = f(T)$ be a function defined by $(n+1)$ points $(V_0^E, E_0), (V_1^E, E_1).....(V_n^E, E_n)$. When $V_0^E, V_1^E, V_2^E, V_3^E .....V_n^E$ are equally spaced with interval h and this function is continuous and differentiable $(n+1)$ times.

The function be approximated by a polynomial $P_n(V^E)$ of degree not exceeding a such that

$$P_n(V_i^E) = E_i \qquad [\text{Where } i = 0,1,2,3.....n] \tag{111}$$

Since the expression $f(V^E) - P_n(V^E)$ vanishes for $V^E = V_0^E, V_1^E, V_2^E, V_3^E .....V_n^E$,

We put $f(V^E) - P_n(V^E) = K\varphi(V^E)$ (112)

Where $\varphi(V^E) = (V^E - V_0^E)(V^E - V_1^E).....(V^E - V_n^E)$ (113)

And K is to be determined in such a way that equation (112) holds for any intermediate values of V^E, say $V^E - V'^E$ [where $V_0^E \le V'^E \le V_n^E$].

Therefore from equation (112),

$$K = \frac{f(V'^E) - P(V'^E)}{\varphi(V'^E)} \tag{114}$$

Now we construct a function $f(V^E)$ such that

$$f(V_0^E) = f(V_1^E) - P_n(V^E) - K\varphi(V^E)$$

Where K is given by equation (114).

It is clear that

$$f(V_0^E) = f(V_1^E) = f(V_2^E) = f(V_3^E) = ...f(V_n^E) = f(V'^E) = 0 \tag{115}$$

Let $f(V^E)$ vanishes (n+2) times in the interval $V_0^E \le V^E \le V_n^E$; consequently, by the repeated application of Rolle's Theorem [20] [21], $f'(V^E)$ must vanish $(n+1)$ times, $f''(V^E)$ must vanish n times etc in the interval $V_0^E \le V^E \le V_n^E$.

Particularly, $f^{(n+1)}(V^E)$ must vanish once in the interval $V_0^E \le V^E \le V_n^E$. Let this point be $V^E = W$, $V_0^E < W < V_n^E$.

Now differentiating equation (15) $(n+1)$ times with respect to V^E and putting $V^E = W$, we got:

$$f^{(n+1)}(W) - K(n+1)! = 0$$

Or
$$K = \frac{f^{(n+1)}(W)}{(n+1)!} \tag{116}$$

Putting this value of K in equation (114), we got:

$$\frac{f^{(n+1)}(W)}{(n+1)!} = \frac{f(V'^E) - P_n(V'^E)}{\varphi(V'^E)}$$

Or
$$f(V'^E) - P_n(V'^E) = \frac{f^{(n+1)}(W)}{(n+1)!}\varphi(V'^E), \qquad V_0^E < W < V_n^E$$

Since V'^E is arbitrary therefore on dropping the prime on V'^E we got:

$$f(V^E) - P_n(V^E) = \frac{f^{(n+1)}(W)}{(n+1)!}\varphi(V^E), \quad V_0^E < W < V_n^E \tag{117}$$

Now we use Taylor's theorem [22] [23]:

$$f(W+h) = f(W) + hf'(W) + \frac{h^2}{2!}f''(W) + \ldots\ldots\ldots + \frac{h^n}{n!}f^n(W) + \ldots\ldots \tag{118}$$

Neglecting the terms containing second and higher powers of h in equation (118), we got:

$$f(W+h) = f(W) + hf'(W)$$

Or
$$f'(W) = \frac{f(W+h) - f(W)}{h} \tag{119}$$

Or
$$f'(W) = \frac{1}{h}\Delta f(W) \qquad [\because \Delta f(V^E + h) f(V^E)]$$

$$Df(W) = \frac{1}{h}\Delta f(W) \qquad [\because D = \frac{d}{dW}]$$

$$D = \frac{1}{h}\Delta \qquad \text{[Because } f(W) \text{ is arbitrary]}$$

$$\therefore D^{n+1} = \frac{1}{h^{n+1}}\Delta^{n+1}$$

From equation (119), we got: $f^{(n+1)}(W) = \frac{1}{h^{(n+1)}}\Delta^{(n+1)} f(W)$

Putting the values of $f^{(n+1)}(W)$ in equation (117), we got:

$$f(V^E) - P_n(V^E) = \left[\frac{\varphi(V^E)}{(n+1)!}\right]\left[\frac{1}{h^{(n+1)}}\Delta^{(n+1)} f(W)\right]$$

$$f(V^E) - P_n(V^E) = \left[\frac{(V^E - V_0^E)(V^E - V_1^E)(V^E - V_2^E).....(V^E - V_0^E)}{(n+1)!}\right]\left[\frac{1}{h^{(n+1)}}\Delta^{(n+1)} f(W)\right] \tag{120}$$

If $\frac{V^E - V_n^E}{h} = \beta$ Then:

$$V^E - V_0^E = h\beta$$

$$V^E - V_1^E = V^E - (V_0^E - h) = (V^E - V_0^E) - h = (h\beta - h) = h(\beta - 1)$$

Similarly $V^E - V_2^E = h(\beta - 2)$

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Similarly $V^E - V_n^E = h(\beta - n)$

Putting these values in equation (20), we got:

$$f(V^E)-P_n(V^E)=\left[\frac{(h\beta)\{h(\beta-1)\}\{h(\beta-2)\}\{h(\beta-3)\}.....\{(\beta-n)\}}{(n+1)!}\right]\left[\frac{1}{h^{(n+1)}}\Delta^{(n+1)}f(W)\right]$$

This is mathematical expression for estimation of error, if the point lies in the lower half.

12 BACKWARD DIFFERENCE OF ENZYME CONCENTRATION

If $(V_0^E,E_0),(V_1^E,E_1),(V_2^E,E_2),.....(V_n^E,E_n)$ denoted the values of the inverse then E_2-E_1 , E_3-E_2, E_4-E_3,..... E_n-E_{n-1} are called the backward differences of E. These differences are denoted as $\nabla E_1,\nabla E_2,\nabla E_3,.....\nabla E_{n-1}$ therefore:

$\Delta E_1=E_1-E_0$

$\Delta E_2=E_2-E_1$,

$\Delta E_3=E_3-E_2$,

$\Delta E_4=E_4-E_3$,

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$\Delta E_n=E_n-E_{n-1}$

Where ∇ is called the backward difference operator, and $\nabla E_1\ \nabla E_2$, ∇E_3 ....., ∇E_{n-1} are called first order backward differences. The differences of the first order difference are called second order backward differences and are denoted as, $\nabla^2E_2,\nabla^2E_3,\nabla^2E_4,\nabla^2E_5$ .....etc.

$\nabla^2E_2=\nabla E_2-\nabla E_1$

$\nabla^2E_3=\nabla E_3-\nabla E_2$

$\nabla^2E_4=\nabla E_4-\nabla E_3$

$\nabla^2E_5=\nabla E_5-\nabla E_4$

In general, the first order forward difference at the i^{th} point is: $\nabla E_i=E_i-E_{i-1}$

And the order forward difference at the point is: $\nabla^j E_i=\nabla^{j-1}E_i-\nabla^{j-1}E_{i-1}$

12.1 FORMULA FOR BACKWARD DIFFERENCE INTERPOLATION

If $f(k),f(k+h),.....,f(k+nh)$ are be values of inverse function then: $V^E=k,k+h,.....,k+nh$

Let $f(V^E)$ be a polynomial of degree n and let

$$\begin{aligned}f(V^E)&=K_0+K_1(V^E-k-nh)+K_2(V^E-k-nh)\{V^E-K(n-1)h\}\\&\quad+K_3(V^E-k-nh)\{V^E-k-(n-1)h\}\\&\{V^E-k-(n-2)h\}+\quad.....+K_n[(V^E-k-nh)\{V^E-k-(n-1)h\}.....(V^E-k-h)\end{aligned}\qquad(121)$$

Where $K_0, K_1, K_2, \ldots\ldots\ldots K_n$ all are constants [19].

Putting $V^E = k + nh$ in equation (121), we got: $f(k+nh) = K_0$ (122)

Again putting $V = k + (n-1)h$ in equation (121), we got:

$$f\{k+(n-1)h\} = K_0 + K_1 h$$
$$K_1 h = K_0 - f\{k+(n-1)h\}$$
$$= f(k+nh) - f\{k+(n-1)h\}$$
$$= \Delta f(k+nh)$$

$$K_1 = \frac{\Delta f(k+nh)}{h} \quad (123)$$

Again putting $V^E = k + (n-2)h$ in equation (121), we got:

$$f\{k+(n-2)h\} = K_0 + K_1(-2h) + K_2(-2h)(-h)$$

$$2h^2 K_2 = f\{K+(n-2)h\} - K_0 - 2hK_1$$

Or $2h^2 K_2 = f\{k+(n-2)h\} - f(k+nh) + 2\nabla f(k+nh)$ [from equation(122) and (123)]

$$= f\{k+(n-2)h\} - f(k+nh) + 2[\{f(k+nh)\} - f\{k+(n-1)h\}]$$
$$= f\{k+(n-2)h\} - f(k+nh) - 2f\{k+(n-1)h\}$$
$$= f(k+nh) - 2[f\{k+(n-1)h\} + f(k)]$$
$$= \Delta^2 f(k+nh)$$

$$\therefore K_2 = \frac{1}{2h^2}\Delta^2 f(k)$$

Or $$K_2 = \frac{1}{2!h^2}\Delta^2 f(k=nh) \quad (124)$$

Similarly $K_3 = \frac{1}{3!h^3}\Delta^3 f(k+nh)$ (125)

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Proceeding in similar way, we got: $K_n = \frac{1}{n!h^n}\Delta^n f(k+nh)$ (126)

substituting the values of $K_0, K_1, K_2, \ldots\ldots\ldots, K_n$ in equation (121), we got:

$$f(V^E) = f(k+nh) + \frac{\Delta f(k)}{h}(V^E - k - nh)$$
$$+ \frac{\Delta^2 f(k+nh)}{2!h^2}(V^E - k - nh)\{V^E - k - (n-1)h\} + \ldots\ldots\ldots\ldots \quad (127)$$
$$+ \frac{\Delta^n f(k+nh)}{n!h^n}(V^E - k - nh)\{V^E - k - (n-1)h\}\ldots\ldots(V^E - k - n)$$

Now let: $V^E = k + nh + hu$

$$\therefore V^E - k = nh + hu$$

$$V^E - k - (n-1)h = (u+1)h$$

$$V^E - k - (n-2)h = (u+2)h$$

$$\vdots$$

$$\vdots$$

$$\vdots$$

$$\vdots$$

$$V^E - k - h = \{u + (n-1)\}h$$

Putting these values in equation (127), we got:

$$f(k+nh+hu) = f(k+nh) + \frac{\Delta f(k+nh)}{h}(uh) + \frac{\Delta^2 f(k+nh)}{2!h^2}(uh)(u+1)h + \ldots\ldots\ldots\ldots$$

$$+ \frac{\Delta^n f(k+nh)}{n!h^n}(uh)(u+1)h\ldots\ldots\{u+(n-1)h\}$$

Simplifying, we got:

$$f(k+nh+hu) = f(k+nh) + u\Delta f(k+nh) + \frac{\Delta^2 f(k+nh)}{2!}\{u(u+1)\} + \ldots\ldots$$

$$+ \frac{\Delta^n f(k+nh)}{n!}(u)(u+1)\ldots\ldots\{u+(n-1)\} \qquad (128)$$

12.1.1 ESTIMATION OF ERROR

Let $V = f(T)$ be a function defined by $(n+1)$ points $(V_0^E, E_0), (V_1^E, E_1)\ldots\ldots\ldots\ldots(V_n^E, E_n)$. When $V_0^E, V_1^E, V_2^E, V_3^E \ldots\ldots\ldots\ldots V_n^E$ are equally spaced with interval h and this function is continuous and differentiable $(n+1)$ times.

The function be approximated by a polynomial $P_n(V^E)$ of degree not exceeding a such that

$$P_n(V_i^E) = E_i \qquad [\text{Where } i = 1,2,3\ldots\ldots\ldots n] \qquad (129)$$

Since the expression $f(V^E) - P_n(V^E)$ vanishes for $V^E = V_0^E, V_1^E, V_2^E, V_3^E \ldots\ldots\ldots\ldots V_n^E$,

We put $$f(V^E) - P_n(V^E) = K\varphi(V^E) \qquad (130)$$

Where $$\phi_1(V^E) = (V^E - V_n^E)(V^E - V_{n-1}^E)\ldots\ldots\ldots\ldots(V^E - V_0^E) \qquad (131)$$

And K is to be determined in such a way that equation (12) holds for any intermediate values of V^E, say $V^E - V'^E$ [where $V_0^E \le V'^E \le V_n^E$].

Therefore from equation (130),

$$K = \frac{f(V'^E) - P_n(V'^E)}{\varphi_1(V'^E)} \qquad (132)$$

Now we construct a function $f(V^E)$ such that

$$f(V_0^E) = f(V_1^E) - P_n(V^E) - K\varphi_1(V^E)$$

Where K is given by equation (132).

It is clear that

$$f(V_0^E) = f(V_1^E) = f(V_2^E) = f(V_3^E) = \ldots\ldots\ldots\ldots f(V_n^E) = f(V'^E) = 0 \qquad (133)$$

Let $f(V^E)$ vanishes (n+2) times in the interval $V_0^E \le V^E \le V_n^E$; consequently, by the repeated application of Rolle's Theorem [20] [21], $f'(V^E)$ must vanish $(n+1)$ times, $f''(V^E)$ must vanish n times etc in the interval $V_0^E \le V^E \le V_n^E$.

Particularly, $f^{(n+1)}(V^E)$ must vanish once in the interval $V_0^E \le V^E \le V_n^E$. Let this point be $V^E = W$, $V_0^E < W < V_n^E$.

Now differentiating equation (133) $(n+1)$ times with respect to V^E and putting $V^E = W$, we got:

$$f^{(n+1)}(W) - K(n+1)! = 0$$

Or
$$K = \frac{f^{(n+1)}(W)}{(n+1)!} \qquad (134)$$

Putting this value of K in equation (132), we got:

$$\frac{f^{(n+1)}(W)}{(n+1)!} = \frac{f(V'^E) - P_n(V'^E)}{\varphi_1(V'^E)}$$

Or
$$f(V'^E) - P_n(V'^E) = \frac{f^{(n+1)}(W)}{(n+1)!}\varphi_1(V'^E), \qquad V_0^E < W < V_n^E$$

Since V'^E is arbitrary therefore on dropping the prime on V'^E we got:

$$f(V^E) - P_n(V^E) = \frac{f^{(n+1)}(W)}{(n+1)!}\varphi_1(V^E), \quad V_0^E < W < V_n^E \qquad (135)$$

Now we use Taylor's theorem [22] [23]:

$$f(W+h) = f(W) + hf'(W) + \frac{h^2}{2!}f''(W) + \ldots\ldots\ldots + \frac{h^n}{n!}f^n(W) + \ldots\ldots \qquad (136)$$

Neglecting the terms containing second and higher powers of h in equation (136), we got:

$$f(W+h) = f(W) + hf'(W)$$

Or
$$f'(W) = \frac{f(W+h) - f(W)}{h} \qquad (137)$$

Or
$$f'(W) = \frac{1}{h}\Delta f(W) \quad [\because \Delta f(W) = f(W+h) - f(W)]$$

$$Df(W) = \frac{1}{h}\Delta f(W) \qquad [\because D = \frac{d}{dW}]$$

$$D = \frac{1}{h}\Delta \qquad \text{[Because } f(W) \text{ is arbitrary]}$$

$$\therefore D^{n+1} = \frac{1}{h^{n+1}}\Delta^{n+1}$$

From equation (137), we got: $f^{(n+1)}(W) = \frac{1}{h^{(n+1)}}\Delta^{(n+1)} f(W)$

Putting the values of $f^{(n+1)}(Y)$ in equation (135), we got:

$$f(V^E) - P_n(V^E) = \left[\frac{\varphi_1(V^E)}{(n+1)!}\right]\left[\frac{1}{h^{(n+1)}}\Delta^{(n+1)} f(W)\right]$$

$$f(V^E) - P_n(V^E) = \left[\frac{(V^E - V_0^E)(V^E - V_1^E)(V^E - V_2^E)...(V^E - V_0^E)}{(n+1)!}\right]\left[\frac{1}{h^{(n+1)}}\Delta^{(n+1)} f(W)\right] \quad (138)$$

If $\frac{V^E - V_n^E}{h} = \beta$ Then:

$$V^E - V_n^E = h\beta$$

$$V^E - V_{n-1}^E = V^E - (V_n^E - h) = (V^E - V_n^E) + h = (h\beta + h) = h(\beta + 1)$$

Similarly $V^E - V_{n-2}^E = h(\beta + 2)$

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Similarly $V^E - V_0^E = h(\beta + n)$

Putting these values in equation (138), we got:

$$f(V^E) - P_n(V^E) = \left[\frac{(h\beta)\{h(\beta+1)\}\{h(\beta+2)\}\{h(\beta+3)\}.....\{(\beta+n)\}}{(n+1)!}\right]\left[\frac{1}{h^{(n+1)}}\Delta^{(n+1)} f(W)\right]$$

OR

$$f(V^E) - P_n(V^E) = \left[\frac{\beta(\beta+1)(\beta+2)(\beta+3).....(\beta+n)}{(n+1)!}\right]\left[\Delta^{(n+1)} f(W)\right]$$

This is mathematical expression for estimation of error, if the point lies in the lower half.

13 DIVIDE DIFFERENCE OF ENZYME CONCENTRATION

If $(V_1^E, E_1), (V_2^E, E_2).....(V_n^E, E_n)$ denoted the values of the inverse function then $\frac{E_2 - E_1}{V_2^E - V_1^E}$,

$\frac{E_3 - E_2}{V_3^E - V_2^E}$,

$\frac{E_4 - E_3}{V_4^E - V_3^E}$

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$\frac{E_n - E_{n-1}}{V_n^E - V_{n-1}^E}$, are called the divide differences of E. These differences are denoted as $\Delta_d E_1$, $\Delta_d E_2$, $\Delta_d E_3$,…… $\Delta_d E_{n-1}$ therefore

$$\Delta_d E_1 = \frac{E_2 - E_1}{V_2^E - V_1^E},$$

$$\Delta_d E_2 = \frac{E_3 - E_2}{V_3^E - V_2^E},$$

$$\Delta_d E_3 = \frac{E_4 - E_3}{V_4^E - V_3^E},$$

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$$\Delta_d E_{n-1} = \frac{E_n - E_{n-1}}{V_n^E - V_{n-1}^E}$$

Where Δ_d is called the divide difference operator, and $\Delta_d E_1$ $\Delta_d E_2$ $\Delta_d E_3$ …… $\Delta_d E_{n-1}$ are called first order divide differences. The differences of the first order difference are called second order divide differences and are denoted as $\Delta_d^2 E_1$, $\Delta_d^2 E_2$, $\Delta_d^2 E_3$,… .etc.

$$\Delta_d^2 E_1 = \frac{\Delta_d E_2 - \Delta_d E_1}{V_3^E - V_1^E}$$

$$\Delta_d^2 E_2 = \frac{\Delta_d E_3 - \Delta_d E_2}{V_4^E - V_2^E}$$

$$\Delta_d^2 E_3 = \frac{\Delta_d E_4 - \Delta_d E_3}{V_5^E - V_3^E}$$

In general, the first order divide difference at the i^{th} point is: $\Delta_d E_i = \frac{E_{i+1} - E_i}{V_{i+1}^E - V_i^E}$

And the order divide difference at the point is: $\Delta^j E_i = \frac{\Delta^{j-1} E_{i+1} - \Delta^{j-1} E_i}{V_{i+j}^E - V_i^E}$

13.1 FORMULA FOR DIVIDE DIFFERENCE

By the definition of divide difference: $f(V^E, V_0^E) = \frac{f(V^E) f(V_0^E)}{V^E - V_0^E}$ (139)

Or $f(V^E) = f(V_0^E) + (V^E - V_0^E) f(V^E, V_0^E)$

Again by the definition of second divided difference: $f(V^E, V_0^E, V_1^E) = \frac{f(V^E, V_0^E) - f(V_0^E, V_1^E)}{V^E - V_1^E}$

Or $f(V^E, V_0^E) = f(V_0^E, V_1^E) + (V^E - V_1^E) f(V^E, V_0^E, V_1^E)$ (140)

Similarly $f(V^E, V_0^E, V_1^E) = f(V_0^E, V_1^E, V_2^E) + (V^E - V_2^E) f(V^E, V_0^E, V_1^E, V_2^E)$ (141)

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Proceeding in similar way, we got:

$$f(V^E, V_0^E, V_1^E, ...V_{n-1}^E) = f(V_0^E, V_1^E, V_2^E, ...V_n^E) + (V^E - V_n^E) f(V^E, V_0^E, V_n^E) \quad (142)$$

Multiplying equation (140) by $(V^E - V_0^E)$,

Multiplying equation (141) by $(V^E - V_0^E)\ (V^E - V_1^E)$,

Multiplying equation (142) by $(V^E - V_0^E)\ (V^E - V_1^E)$ ..... $(V^E - V_{n-1}^E)$

And adding to equation (139), we got:

$$f(V^E) = f(V_0^E) + (V^E - V_0^E) f(V_0^E, V_1^E) + (V^E - V_1^E)(V^E - V_2^E) f(V_0^E, V_1^E, V_2^E) + ...$$
$$.....+ (V^E - V_0^E)(V^E - V_1^E)(V^E - V_2^E)...(V^E - V_{n-1}^E) f(V_0^E, V_1^E, V_2^E ....V_n^E) + R_n$$

Where R_n is the reminder and is given by

$$R_n = (V^E - V_0^E)(V^E - V_1^E)(V^E - V_2^E)...(V^E - V_n^E) f(V_0^E, V_1^E, V_2^E ...V_n^E)$$

If the function $f(V^E)$ is polynomial of degree n, then $f(V_0^E, V_1^E, V_2^E, ...V_n^E)$ vanishes so that:

$$f(V^E) = f(V_0^E) + (V^E - V_0^E) f(V_0^E, V_1^E) + (V^E - V_1^E)(V^E - V_2^E) f(V_0^E, V_1^E, V_2^E) + ...$$
$$.....+ (V^E - V_0^E)(V^E - V_1^E)(V^E - V_2^E).....(V^E - V_{n-1}^E) f(V_0^E, V_1^E, V_2^E .....V_n^E)$$

13.1.1 ESTIMATION OF ERROR

Let $f(V^E)$ be a real-valued function define n interval and $(n+1)$ times differentiable on (a,b). If $P_n(V^E)$ is the polynomial. Which interpolates $f(V^E)$ at the $(n+1)$ distinct points $V_0^E, V_1^E .....V_n^E \in (a,b)$, then for all $\overline{V^E} \in [a,b]$,there exists $\xi = \xi(\overline{V^E}) \in (a,b)$

$$e_n\left(\overline{V^E}\right) = f\left(\overline{V^E}\right) - P_n\left(\overline{V^E}\right)$$

$$= \frac{f^{(n+1)}(\xi)}{(n+1)} \prod_{j=0}^{n} \left(\overline{V^E} - V_j^E\right) \quad (143)$$

This is mathematical expression for estimation of error, if intervals are not be equally spaced.

14 WHEN THE TABULATED VALUES OF $V^E = f(E)$ ARE NOT EQUIDISTANT

If $f(V_0^E), f(V_1^E), f(V_2^E)\ldots\ldots\ldots\ldots f(V_n^E)$ is to be vales of the inverse function corresponding to arguments $V_0^E, V_1^E, V_2^E \ldots\ldots V_n^E$ not necessarily equally spaced.

Let $f(V^T)$ be a polynomial of degree n in V^E and since $(n+1)$ values of $f(V^E)$ are given so $(n+1)^{th}$ difference are zero.

Consider,

$$\begin{aligned} f(V^E) &= A_0(V^E - V_1^E)(V^E - V_2^E)\ldots\ldots\ldots(V^E - V_n^E) \\ &+ A_1(V^E - V_0^E)(V^E - V_2^E)\ldots\ldots\ldots(V^E - V_n^E) \\ &+ A_2(V^E - V_0^E)(V^E - V_1^E)\ldots\ldots\ldots(V^E - V_n^E) + \ldots\ldots\ldots\ldots\ldots \\ &\ldots\ldots + A_n(V^E - V_0^E)(V^E - V_1^E)\ldots\ldots\ldots(V^E - V_{n-1}^E) \end{aligned} \quad (144)$$

Where $A_0, A_1, A_2 \ldots\ldots\ldots\ldots\ldots A_n$ all are constants.

Now put $V^E = V_0^E$ in equation (144), we got:

$$f(V_0^E) = A_0(V_0^E - V_1^E)(V_0^E - V_2^E)\ldots\ldots\ldots(V_0^E - V_n^E)$$

$$\therefore A_0 = \frac{f(V_0^E)}{(V_0^E - V_1^E)(V_0^E - V_2^E)\ldots\ldots\ldots(V_0^E - V_n^E)} \quad (145)$$

Again put $V^E = V_1^E$ in equation (144), we got:

$$f(V_1^E) = A_1(V_1^E - V_1^E)(V_1^E - V_2^E)\ldots\ldots\ldots(V_1^E - V_n^E)$$

$$\therefore A_1 = \frac{f(V_1^E)}{(V_1^E - V_1^E)(V_1^E - V_2^E)\ldots\ldots\ldots(V_1^E - V_n^E)} \quad (146)$$

Similarly $\therefore A_2 = \frac{f(V_2^E)}{(V_2^E - V_1^E)(V_2^E - V_2^E)\ldots\ldots\ldots(V_2^E - V_n^E)}$ (147)

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Proceeding in similar way, we got:

$$\therefore A_n = \frac{f(V_n^E)}{(V_n^E - V_1^E)(V_n^E - V_2^E)\ldots\ldots\ldots(V_n^E - V_n^E)} \quad (148)$$

Substituting the values of $A_0, A_1, A_2 \ldots\ldots\ldots\ldots A_n$ from equation (145), (146), (147), (148) in equation (144) we got:

$$f(V^E) = \frac{(V^E - V_1^E)(V^E - V_2^E)\ldots\ldots\ldots(V^E - V_n^E)}{(V_0^E - V_1^E)(V_0^E - V_2^E)\ldots\ldots\ldots(V_0^E - V_n^E)} f(V_0^E) + \frac{(V^E - V_0^E)(V^E - V_2^E)\ldots\ldots\ldots(V^E - V_n^E)}{(V_1^E - V_1^E)(V_1^E - V_2^E)\ldots\ldots\ldots(V_1^E - V_n^E)} f(V_1^E)$$
$$+ \frac{(V^E - V_0^E)(V^E - V_1^E)\ldots\ldots\ldots(V^E - V_n^E)}{(V_2^E - V_1^E)(V_2^E - V_2^E)\ldots\ldots\ldots(V_2^E - V_n^E)} f(V_2^E) + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$
$$\ldots\ldots + \frac{(V^E - V_0^E)(V^E - V_1^E)\ldots\ldots\ldots(V^E - V_{n-1}^E)}{(V_n^E - V_1^E)(V_n^E - V_2^E)\ldots\ldots\ldots(V_n^E - V_n^E)} f(V_n^E)$$

14.1 ESTIMATION OF ERROR

Since the approximating polynomial $f\left(V^E\right)$ given by Lagrangian formula has the same values $f\left(V_0^E\right) f\left(V_1^E\right) f\left(V_2^E\right) f\left(V_3^E\right) f\left(V_4^E\right)\ldots\ldots\ldots\ldots f\left(V_n^E\right)$ as does $T = f(V^E)$ for the arguments $V_0^E, V_1^E, V_2^E \ldots\ldots V_n^E$ the error term must have zeros at these $(n+1)$ points.

There for $(V^E - V_0^E)\ (V^E - V_1^E)\ (V^E - V_2^E)\ (V^E - V_3^E)\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (V^E - V_n^E)$ must be factors of the error and we can write:

$$F(V^E) = f(V^E) + \frac{(V^E - V_0^E)(V^E - V_1^E)(V^E - V_2^E)(V^E - V_3^E)\ldots\ldots(V^E - V_n^E)}{(n+1)!} K(V^E) \qquad (149)$$

Let x to be fixed in value and consider the function

$$W(x) = F(x) - f(x)\frac{(x - V_0^E)(x - V_1^E)(x - V_2^E)(x - V_3^E)\ldots\ldots(x - V_n^E)}{(n+1)!} K(V^E) \qquad (150)$$

Then $W(x)$ has zero $x = V_0^E, V_1^E, V_2^E, V_3^E \ldots\ldots\ldots\ldots V_n^E$ and V^E.

Since the $(n+1)^{th}$ derivative of the n^{th} degree polynomial $f(V^E)$ is zero.

$$W^{(n+1)}(x) = F^{(n+1)}(x) - K(V^E) \qquad (151)$$

As a consequence of Rolle's Theorem [15] [16], the $(n+1)^{th}$ derivative of $W(x)$ has at least one real zero $x = \xi$ in the range $V_0^T < \xi < V_n^E$

Therefore substituting $x = \xi$ in equation (151)

$$W^{(n+1)}(\xi) = F^{(n+1)}(\xi) - K(V^E)$$

Or

$$K(V^E) = F^{(n+1)}(\xi) - W^{(n+1)}(\xi)$$
$$= F^{(n+1)}(\xi)$$

Using this expression for $K(V^E)$ and writing out $f(V^E)$

$$f(V^E) = \frac{(V^E - V_1^E)(V^E - V_2^E)\ldots\ldots(V^E - V_n^E)}{(V_0^E - V_1^E)(V_0^E - V_2^E)\ldots(V_0^E - V_n^E)} f(V_0^E) + \frac{(V^E - V_0^E)(V^E - V_2^E)\ldots(V^E - V_n^E)}{(V_1^E - V_0^E)(V_1^E - V_2^E)\ldots\ldots(V_1^E - V_n^E)} f(V_1^E) + \ldots\ldots$$
$$\ldots\ldots + \frac{(V^E - V_0^E)(V^E - V_1^E)\ldots(V^E - V_{n-1}^E)}{(V_n^E - V_0^E)(V_n^E - V_1^E)\ldots\ldots(V_n^E - V_{n-1}^E)} f(V_n^E) + \frac{(V^E - V_0^E)(V^E - V_1^E)\ldots\ldots(V^E - V_n^E)}{(n+1)!} f^{(n+1)}(\xi)$$

Where $V_0^E < \xi < V_n^E$

This is mathematical expression for estimation of error, if the tabulated values of the function are not equidistant.

15 CONCLUSION

The higher order differences become smaller in size. Further, in the forward and backward interpolation, the n^{th} order difference is divided by $n!$, thereby further reducing its contribution to the value of the interpolation function. If the function happens to be a polynomial of degree n, then the n^{th} order difference would be constant and the $(n+1)$ and higher differences would be zero. Derived formulas are useful to obtaining intermediate values of the Temperature, substrate concentration and enzyme concentration. Mathematical expressions are useful to estimation of the errors in the formulas for obtaining intermediate values of the Temperature, substrate concentration and enzyme concentration. All formulas and expressions are worked in n limit which is the optimum limit.

REFERENCES

[1] Nizam Uddin, Enzyme Concentration, Substrate Concentration and Temperature based Formulas for obtaining intermediate values of the rate of enzymatic reaction using Lagrangian polynomial. International Journal of Basic and Applied Sciences, 1(3), 299-302, 2012.

[2] Nizam Uddin, "Estimation of Errors: Mathematical Expressions of Temperature, Substrate Concentration and Enzyme Concentration based Formulas for obtaining intermediate values of the Rate of Enzymatic Reaction," International Journal of Innovation and Applied Studies, vol. 2, no. 2, pp. 153–172, Feb. 2013.

[3] Nizam Uddin, "Interpolate the Rate of Enzymatic Reaction: Temperature, Substrate Concentration and Enzyme Concentration based Formulas using Newton's Method", International Journal of Research in Biochemistry and Biophysics, 2(2), 5-9, 2012.

[4] Abramowitz, M. and Stegun, I. A. (Eds.). "Differences." §25.1 in Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables, 9th printing. New York: Dover, pp. 877-878, 1972.

[5] Beyer, W. H. CRC Standard Mathematical Tables, 28th ed. Boca Raton, FL: CRC Press, pp. 429-515, 1987.

[6] Boole, G. and Moulton, J. F. A Treatise on the Calculus of Finite Differences, 2nd rev. ed. New York: Dover, 1960.

[7] Iyanaga, S. and Kawada, Y. (Eds.). "Interpolation." Appendix A, Table 21 in Encyclopedic Dictionary of Mathematics. Cambridge, MA: MIT Press, pp. 1482-1483, 1980.

[8] Stirling, J. Methodus differentialis, sive tractatus de summation et interpolation serierum infinitarium. London, 1730. English translation by Holliday, J. The Differential Method: A Treatise of the Summation and Interpolation of Infinite Series. 1749.

[9] Tweddle, C. James Stirling: A Sketch of His Life and Works Along with his Scientific Correspondence. Oxford, England: Oxford University Press, pp. 30-45, 1922.

[10] Beyer, W. H. CRC Standard Mathematical Tables, 28th ed. Boca Raton, FL: CRC Press, pp. 429 and 433, 1987.

[11] Sloane, N. J. A. and Plouffe, S. The Encyclopedia of Integer Sequences. San Diego, CA: Academic Press, p. 10, 1995.

[12] Andersen, K. M. "A Characterization of Polynomials." Math. Mag. 69, 137-142, 1996.

[13] Schwaiger, J. "On a Characterization of Polynomials by Divided Differences." Aequationes Math. 48, 317-323, 1994.

[14] Whittaker, E. T. and Robinson, G. "Divided Differences" and "Theorems on Divided Differences." §11-12 in The Calculus of Observations: A Treatise on Numerical Mathematics, 4th ed. New York: Dover, pp. 20-24, 1967.

[15] Bailey, D. F. "A Mean-Value Property of Cubic Polynomials--Without Mean Values." Math. Mag. 65, 123-124, 1992.

[16] Bailey, D. F. "A Mean-Value Property of Cubic Polynomials--Without Mean Values." Math. Mag. 65, 123-124, 1992.

[17] Sauer, T. and Xu, Y. "On Multivariate Lagrange Interpolation." Math. Comput. 64, 1147-1170, 1995.

[18] Nizam Uddin, "Formulas for Obtaining Intermediate Values of Biological Activity in QSAR using Lagrangian polynomial and Newton's method", Science Insights: An International Journal, 2(4), 21-23, 2012.

[19] Nizam Uddin, "Mathematical Expressions for Estimation of Errors in the Formulas which are used to obtaining intermediate values of Biological Activity in QSAR," International Journal of Innovation and Applied Studies, vol. 2, no. 3, pp. 272–279, March 2013.

[20] Anton, H. "Rolle's Theorem; Mean Value Theorem." 4.9 in Calculus: A New Horizon, 6th ed. New York: Wiley, pp. 260-266, 1999.

[21] Apostol, T. M. Calculus, 2nd ed., Vol. 1: One-Variable Calculus, with an Introduction to Linear Algebra. Waltham, MA: Blaisdell, p. 184, 1967.

[22] Dehn, M. and Hellinger, D. "Certain Mathematical Achievements of James Gregory." Amer. Math. Monthly 50, 149-163, 1943.

[23] Jeffreys, H. and Jeffreys, B. S. "Taylor's Theorem." §1.133 in Methods of Mathematical Physics, 3rd ed. Cambridge, England: Cambridge University Press, pp. 50-51, 1988.

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Potentiel allélopathique du figuier de barbarie « *Opuntia ficus-indica (L.) Mill* » sur la germination et la croissance du jujubier « *Ziziphus lotus (L.) Desf.* »

[Allelopathic potential of Barbary fig « *Opuntia ficus-indica (L.) Mill* » on the germination and growth of wild jujube « *Ziziphus lotus (L.) Desf.* »]

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ABSTRACT: Phytoecological observations made in agro-ecosystems in the Chaouia region revealed that the tufts of wild jujube "*Ziziphus lotus (L.) Desf.* " enclaved in the hedges of Barbary fig "*Opuntia ficus-indica (L.) Mill*." slow their biological activity and their growth and ends by being eliminated completely. The hypothesis that put into play the phenomenon of allelopathy as a mechanism of interference between the two species has been verified in this study. Thus, bioassays were conducted in vitro in the laboratory in order to test the effects of aqueous and hydro-ethanolic extracts of aerial and belowground parts of Barbary fig on seed germination and seedling growth of wild jujube. A dosage of total phenols by Folin-Ciocalteu reagent and a subsequent identification of these phenols compounds have been made. The results showed that these phenols are present in both stems and roots of Barbary fig, with varying concentrations (6.91 to 42.75 mg EAG/g of dry weight) according organ of the plant and the solvent used in the extraction. Very significant inhibitory effects up to 100% were observed on the kinetics and the final rate of jujube seed germination as well as its growth. These results allowed us to infer the existence of a strong correlation between allelopathic effects of Barbary fig on jujube and the concentration of total phenols content in different parts of this species of cactus.

KEYWORDS: *Opuntia ficus-indica (L.) Mill*, allelopathy, *Ziziphus lotus (L.) Desf*, phenols, germination, growth.

RESUME: Les observations phytoécologiques effectuées dans les agro-écosystèmes de la région de la Chaouia ont permis de constater que les touffes du jujubier « *Ziziphus lotus (L.) Desf*. » enclavées dans les haies au figuier de barbarie « *Opuntia ficus-indica (L.) Mill*. » ralentissent leur activité biologique et leur croissance et finissent par être éliminées définitivement. L'hypothèse de mise en jeu du phénomène d'allélopathie comme mécanisme d'interférence entre les deux espèces a été vérifié dans cette étude. Ainsi, des essais biologiques ont été conduits in vitro au laboratoire dans le but de tester les effets des extraits aqueux et hydro-éthanoliques des parties aérienne et souterraine du figuier de barbarie sur la germination des graines et la croissance des plantules du jujubier. Un dosage des phénols totaux par la méthode de Folin-Ciocalteu et l'identification de ces composés phénoliques ont été effectués. Les résultats obtenus ont montré que ces phénols sont présents dans les raquettes et les racines du figuier de barbarie, avec des concentrations variantes (6,91 à 42,75 mg EAG/g matière sèche) selon l'organe de cette plante et le solvant utilisé dans l'extraction. Des effets inhibiteurs très significatifs allant jusqu'à 100% ont été observés sur la cinétique et le taux de germination des grains du jujubier ainsi que sur sa croissance. Ces résultats nous a permis de déduire l'existence d'une forte corrélation entre les différents effets allélopathiques du figuier de barbarie observés sur le jujubier et la concentration en phénols totaux contenus dans les différentes parties de cette espèce de cactus.

MOTS-CLEFS: O*puntia ficus- indica (L.) Mill, allélopathie, Ziziphus lotus (L.) Desf,* phénols, germination, croissance.

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1 INTRODUCTION

Au Maroc, le jujubier (*Ziziphus lotus (L.) Desf*.) appelé communément sedra est une espèce présente dans plusieurs biotopes des régions aride et semi-aride. Sa répartition géographique dans la région de Chaouia a montré que cet arbuste est présent dans 48 % des communes et s'étale sur une superficie totale de 113 434 ha, soit 11 % de la superficie totale de la Chaouia. Il se comporte comme adventice dans plusieurs cultures, notamment les céréales d'hiver et de printemps, les légumineuses alimentaires et les cultures maraîchères et envahie les terrains de parcours [1]. Plusieurs opérations d'éradication chimique, à base des herbicides contenant le glyphosate, de cette espèce ont été lancées par la Direction Provinciale d'Agriculture dans les zones touchées de la Chaouia. Cependant, le contrôle chimique total de cet arbuste était une tache très difficile avec ces produits. Ainsi, il est impératif d'améliorer et/ou maîtriser les conditions d'application de ce genre d'herbicides ou de chercher d'autres méthodes alternatives pour contrôler efficacement cet arbuste adventice.

Les touffes du jujubier, enclavées dans les haies au figuier de barbarie (*Opuntia ficus- indica (L.) Mill*.), ralentissent leur activité biologique et croissance et pourraient avec le temps être éliminées définitivement par étouffement. Ce phénomène suppose une implication des composés allélochimiques libérés par ce figuier dans son entourage. L'allélopathie est définie comme l'ensemble des phénomènes qui sont dus à l'émission ou à la libération de substances organiques par divers organes végétaux, vivants ou morts et qui s'expriment par l'inhibition de la croissance des plantes se développant au voisinage de ces espèces ou leur succédant sur le même terrain [2]. Les substances allélopathiques peuvent être émises par volatilisation [3], notamment pour les plantes des régions arides; par lessivage des parties aériennes, par décomposition des résidus et par exsudats racinaires [4]-[5]. Beaucoup de travaux de recherche récents, munis dans plusieurs pays du monde, ont identifié un certain nombre d'espèces qui ont des effets allelopathiques contre d'autres plantes à savoir: Salvia syriaca et Cardia draba[6], Dodonaea viscosa [7], Lactuca sativa [8], Azaddirachta indica [9], Cassia angustifolia [10] et Helanthus annuus [11]. Quant au Maroc, les espèces suivantes ont des effets allélopathiques sur d'autres plantes: Medicago sativa [12]-[13], Oxalis pes-caprea [14], et Verbesina encelioïdes [15].

Le but de cette étude est de vérifier l'hypothèse des phénomènes allélopathiques chez le figuier de barbarie sur le jujubier et d'analyser et identifier les composés chimiques mis en jeux.

2 MATERIEL ET METHODES

2.1 PRÉPARATION DES ÉCHANTILLONS

- Echantillons du figuier de barbarie (*Opuntia ficus- indica (L.) Mill*.):

Les raquettes et les racines du figuier de barbarie variété Aissa inerme ont été prélevées à partir d'un champ situé à Ouled Ghaname, commune rurale de Mzamza Gharbia, province de Settat (Maroc). Ces échantillons ont été mis dans des sachets en plastique et placés immédiatement dans une glacière. Ramenés au laboratoire, ces échantillons ont été ensuite rincés et séchés avec du papier buvard et mis dans un réfrigérateur jusqu'à leur utilisation.

- Echantillons de grains du jujubier (*Ziziphus lotus (L.) Desf*.):

Les échantillons de grains ont été extraits des fruits récoltés des arbustes du jujubier en plein production dans la zone d'El Brouj, province de Settat. Ces grains ont été conservés dans des tubes bien fermés avec des couvercles absorbant de l'humidité.

2.2 PRÉPARATION DES EXTRAITS

Une quantité de 200 g de chaque partie fraîche des échantillons de racines et raquettes du figuier de barbarie a été lavé avec de l'eau potable, puis avec une solution de l'hypochlorite de sodium à 10% et nettoyée avec de l'eau distillée. Chaque échantillon a été découpé en petits morceaux et partagé en deux lots. Le premier lot a été utilisé directement à l'état frais. Les morceaux du second lot ont été coupés en tranches fines et séchés dans une étuve à une température de 50°C pendant 72 heures, puis broyés à l'aide d'un broyeur (type Gulatti MFC) qui tourne à vitesse de 1000 tr/min et équipé d'un tamis de maille de 0,85 mm (80 mesh).

Les différents échantillons ont été macérés séparément sous agitation dans l'eau distillée ou dans une solution hydro-éthanolique (éthanol-eau; v/v) à raison de 50 g/200 ml pour les échantillons de la matière fraîche et 5 g/200 ml pour les échantillons de la matière sèche. Après 48 heures, les macérâts ont été filtrés au moyen d'un tamis de 0,75 mm. Les homogénats obtenus ont été ensuite centrifugés à 12000 g pendant 20 min à une température de 4°C. Les surnageants des

extraits hydro-éthanoliques ainsi récupérés ont été évaporés à une température de 40°C à l'aide d'un évaporateur rotatif pour éliminer l'éthanol. Les extraits ainsi obtenus ont été conservés à -4°C jusqu'à leur utilisation.

2.3 MISE EN GERMINATION DES GRAINS DU JUJUBIER

Les grains du jujubier ont été désinfectés par trempage pendant 2 min dans une solution d'un fongicide à base de difénoconazole (3mg/10 ml). Après désinfection, ces grains ont été placés dans des tubes à essais (2 grains/tube) contenant un milieu gélosé préparé avec les différents extraits du figuier de barbarie à raison de 12 g d'agar/l d'extrait et stérilisés à 120°c /20 min. Le témoin a été préparé avec l'eau distillée. Trois répétitions ont été utilisées à raison de 5 tubes/répétition. Les tubes à essais ont été ensuite incubés pendant 22 jours à une température de 30°C.

2.4 OBSERVATIONS ET MESURES

Les observations et mesures ont été portées sur la cinétique et le taux de germination des grains et la croissance des plantules (hauteur des tiges, longueur des racines et le poids des matières fraîche et sèche) du jujubier. Les résultats sont exprimés en pourcentage d'inhibition selon les formules suivantes:

% d'inhibition de la germination= ((G-g)/G) X 100

avec G: germination dans le témoin (eau distillée); g: germination dans les différents extraits

% d'inhibition de la croissance = ((H-h)/H) X 100

avec H: hauteur des tiges ou longueur des racines dans le témoin (eau distillée); h: hauteur des tiges ou longueur des racines dans les différents extraits

% réduction de la matière fraiche ou sèche = ((M-m)/M) X 100

avec M: poids de la matière (fraiche ou sèche) dans le témoin (eau distillée); m: poids de la matière (fraiche ou sèche) dans les différents extraits.

L'évaluation de l'effet allélopathique de différents traitements (extraits du figuier de barbarie) sur le jujubier est jugée selon l'échelle de la commission des Essais Biologiques de la Société Française de Phytiatrie et de Phytopharmacie:

95 à 100% = très bonne effet

80 à 95% = bonne effet

60 à 80% = effet moyen

40 à 60% = effet faible

< à 40%= effet sans intérêt pratique.

2.5 ANALYSES STATISTIQUES

Les résultats obtenus ont été soumis à l'analyse de la variance. Les pourcentages ont été transformés en Arcsin de la racine carré avant analyse. La comparaison des moyennes a été faite avec le test de Tukey (HSD) à la probabilité de 5%. Le logiciel statistique utilisé est le STATISTIX. Version 9.0

2.6 ANALYSE DES SUBSTANCES ALLÉLOPATHIQUES

2.6.1 DOSAGE DES PHÉNOLS TOTAUX

La quantification des composés phénoliques totaux a été faite avec la méthode Folin-Ciocalteau [16]-[17], [18]. Pour doser les acides phénoliques, 1 ml du réactif Folin-Ciocalteau dilué 10 fois dans l'eau distillée a été ajouté à 1ml de chaque extrait. Après 4 min, 8 ml d'une solution de carbonate du sodium (75g/l) sont ajoutés. Après agitation et 2h d'incubation à l'abri de la lumière, l'absorbance a été mesurée avec un spectrophotomètre UV à la longueur de 765 nm. Les teneurs en phénols totaux sont calculées à partir de l'équation de régression linéaire (y=0.003X+0.08 avec r2=0.998) établie avec des gammes d'étalonnage d'acide gallique (0-200 mg/l) et sont exprimées en microgramme d'équivalent d'acide gallique par milligramme d'extrait (mg EAG/g).

2.6.2 IDENTIFICATION DES COMPOSÉS PHÉNOLIQUES PAR CCM

Les extraits hydro-éthanoliques des racines et raquettes sèches contenant les concentrations les plus élevées des acides phénoliques ont été sujets à l'analyse qualitatif par Chromatographie sur couche mince (CCM) sur plaques recouvertes avec un gel de silice 60 (G60, 250 µm). Des échantillons de 2 µl de chaque extrait ont été injectés à 2,5 cm de la base de la plaque. La plaque a été développée dans une cuve en verre avec un solvant constitué de chloroform-methanol-eau (20-5-0,5). Le temps de migration était environ 1h 15 min. Après séparation, la plaque a été desséchée sous la haute à l'aide d'un séchoir. Les chromatogrammes ont été visualisés dans une chambre noire sous la lumière ultra-violée de 254 et 365 nm [19].

3 RESULTATS ET DISCUSSION

3.1 EFFETS DES EXTRAITS DU FIGUIER DE BARBARIE SUR LA GERMINATION DU JUJUBIER

Les différents extraits d'*Opuntia ficus-indica (L.) Mill*., quelque soit leur partie d'origine et leur état (frais ou sec), ralentissent la cinétique de germination des grains du Ziziphus lotus (L.) Desf (Fig. 1 et 2) et diminuent significativement le taux de germination final (Tableau 1).

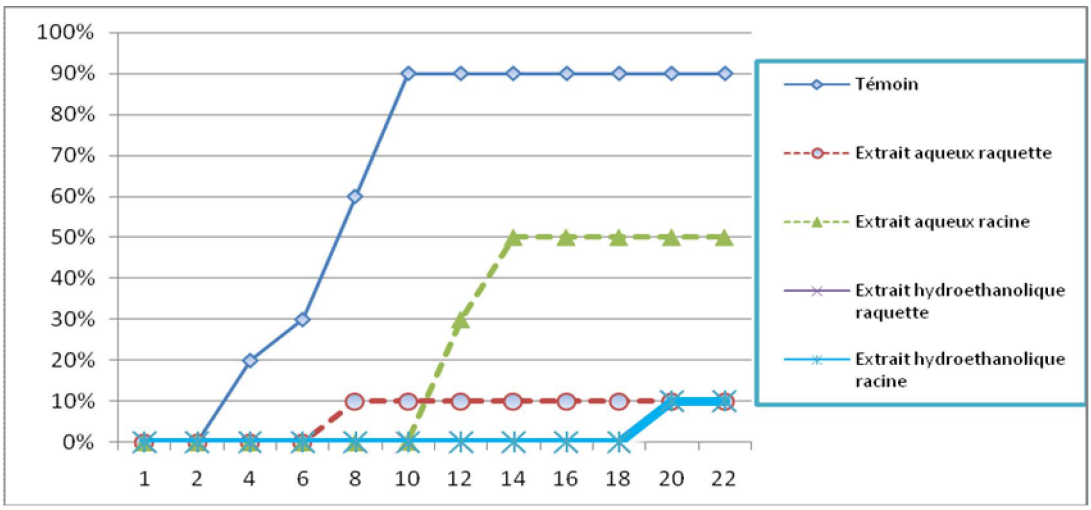

Fig. 1. Effet des extraits d'Opuntia ficus- indica (L.) Mill frais sur la cinétique de germination du Ziziphus lotus (L.) Desf

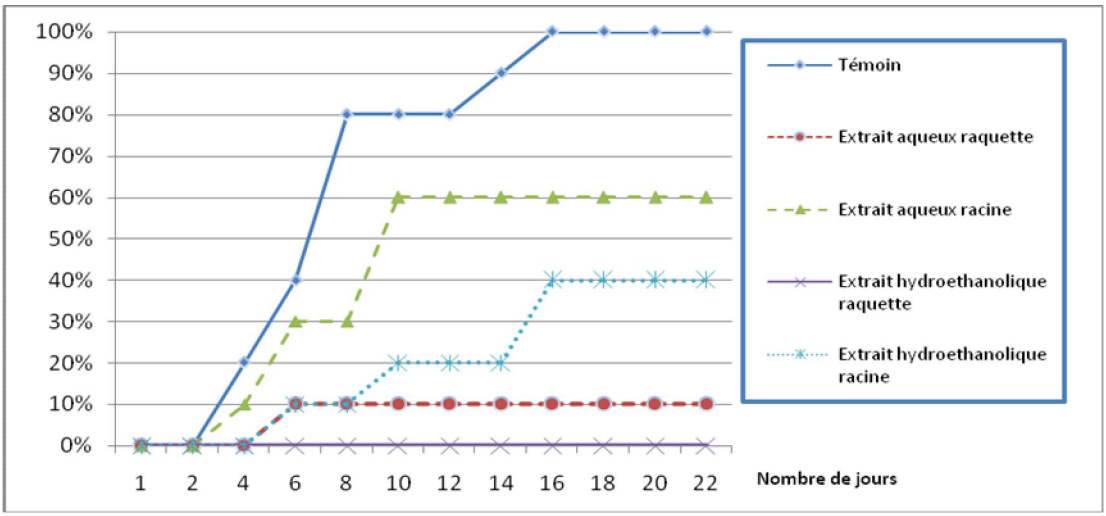

Fig. 2. Effet des extraits d'Opuntia ficus- indica (L.) Mill sèche sur la cinétique de germination du Ziziphus lotus (L.) Desf

Tableau 1. Effet des extraits d'Opuntia ficus- indica (L.) Mill sur le taux de germination du Ziziphus lotus (L.) Desf

Traitement	Effet des extraits du figuier de barbarie fraiche		Effet des extraits du figuier de barbarie sèche	
	Taux de germination	% d'inhibition	Taux de germination	% d'inhibition
Témoin (Eau distillée)	90% a	-	100% a	-
Extrait aqueux racine	50% b	44%	60% b	40%
Extrait aqueux raquette	10% c	89%	20% d	80%
Extrait hydro-ethanolique racine	10% c	89%	40% c	60%
Extrait hydro-ethanolique raquette	10% c	89%	0% e	100%

Dans une même colonne les chiffres suivies de la même lettre ne différent pas significativement selon le test de Tukey HSD (P≤5%).

Ce sont les extraits de la raquette qui induisent les effets inhibiteurs les plus élevés, avec des taux d'inhibition de 80% à 100%. A l'exception de l'extrait hydro-ethanolique de la racine fraiche qui a montré un bon effet (89%), les effets inhibiteurs de la germination des grains du jujubier des autres extraits de cette partie du figuier de barbarie, quelque soit son état, étaient moyens (40 à 60%).

Des effets inhibiteurs des extraits d'*Acacia melanoxylon* [20], de *Rottboellia cochinchinensis* [21], de *Cassia angustifolia* [10] et de *Ginkgo biloba* [22] de la germination d'autres espèces végétales similaires ont été rapportés par plusieurs chercheurs. Aussi, la culture de la luzerne aurait la capacité naturelle d'inhiber la germination de certaines adventices [23].

3.2 EFFETS DES EXTRAITS DU FIGUIER DE BARBARIE SUR LA CROISSANCE DES PLANTULES DU JUJUBIER

Après 22 jours d'incubation, l'effet inhibiteur de tous les extraits du figuier de barbarie sur la longueur des racines des plantules du jujubier est très significatif (Tableau 2 et 3). Sur la longueur des racines, à l'exception de l'extrait aqueux des racines séchées qui a montré un effet bon (89%), tous les autres extraits des deux parties utilisées fraiches ou sèches ont montré un très bon effet (supérieur 96%). Sur la hauteur des tiges, cette inhibition était bonne (93%) à très bonne (supérieure à 98%) respectivement pour l'extrait aqueux de la racine fraiche et les autres extraits des deux parties fraiches. Alors, que les extraits du figuier de barbarie séché, les effets inhibiteurs étaient moyens (74 à 80%) pour les extraits de la racine et bonne (94%) à très bonne (100%) respectivement pour les extraits aqueux et hydro-méthanolique de la raquette.

Tableau 2. Effet des extraits d'Opuntia ficus- indica (L.) Mill. frais sur la croissance des plantules du Ziziphus lotus (L.) Desf

Traitement	Effet sur Longueur des racines		Effet sur Hauteur des tiges		Effet sur la matière fraiche		Effet sur la matière sèche	
	cm	% d'inhibition	cm	% d'inhibition	Poids (mg)	% réduction	Poids (mg)	% réduction
Témoin (eau distillée)	7,04 a	-	3,38 a	-	153,33 a	-	15,20 a	-
Extrait aqueux raquette	0,06 b	99%	0,06 b	98%	2,06 d	99%	1,29 c	94%
Extrait aqueux racine	0,15 b	98%	0,24 b	93%	28,00 b	82%	6,76 b	55%
Extrait hydroethanolique raquette	0,00 b	100%	0,00 b	100%	0,00 e	100%	0,00 d	100%
Extrait hydroethanolique racine	0,06 b	99%	0,07 b	98%	16,00 c	90%	1,83 c	88%

Dans une même colonne les chiffres suivies de la même lettre ne différent pas significativement selon le test de Tukey HSD (P≤5%).

Tableau 3. Effet des extraits d'Opuntia ficus indica (L.) Mill séchée sur la croissance des plantules du Ziziphus lotus (L.) Desf.

Traitement	Effet sur Longueur des racines		Effet sur Hauteur des tiges		Effet sur la matière fraiche		Effet sur la matière sèche	
	cm	% d'inhibition	cm	% d'inhibition	Poids (mg)	% réduction	Poids (mg)	% réduction
Témoin (eau distillée)	12,14 a		3,40 a		152,00 a		18,00 a	
Extrait aqueux raquette	0,33 c	97%	0,23 d	94%	8,70 d	94%	1,70 d	91%
Extrait aqueux racine	1,38 b	89%	0,93 b	74%	75,33 b	50%	12,33 b	30%
Extrait hydroethanolique raquette	0,00 c	100%	0,00 e	100%	0,00 e	100%	0,00 e	100%
Extrait hydroethanolique racine	0,43 c	96%	0,72 c	80%	24,00 c	84%	6,40 c	64%

Dans une même colonne les chiffres suivies de la même lettre ne différent pas significativement selon le test de Tukey HSD (P≤5%).

De même, l'effet inhibiteur de différents extraits du figuier de barbarie sur la croissance du jujubier était très significatif en termes de la matière fraiche et sèche.

Pour les extraits des parties fraiches: la réduction en matière fraiche était bonne (82 à 90%) pour l'extrait de la racine et très bonne (99 à 100%) pour les extraits de la raquette, alors que cette réduction en matière sèche était faible (55%) à bonne (88%), respectivement, pour l'extrait aqueux et l'extrait hydroethanolique de la racine et bonne (94%) à très bonne (100%) pour les extraits de la raquette.

Pour les extraits des parties séchés: la réduction en matière fraiche était faible (50%) et bonne (84%), respectivement, pour l'extrait aqueux et hydroethanolique de la racine; alors que cette réduction était très bonne (94 à 100%) pour les extraits de racine. Selon l'échelle de la CEB, la réduction en matière sèche était sans intérêt pratique (30%) pour l'extrait aqueux de la racine, moyenne (64%) pour l'extrait hydroethanolique de la même partie, bonne (91%) pour l'extrait aqueux de la raquette et très bonne (100%) pour hydroethanolique de cette partie du figuier de barbarie.

En effet, ces propriétés allélopathiques de certaines plantes sur la croissance d'autres ont été mises en évidence pour plus de 90 espèces de mauvaises herbes [24].

3.3 ANALYSE DES SUBSTANCES ALLÉLOPATHIQUES

3.3.1 DOSAGE DES PHÉNOLS TOTAUX

La méthode de Folin-Ciocalteau est utilisée pour le dosage des composés phénoliques totaux. Ces composés sont oxydés par le réactif de Folin Ciocalteau. Ce dernier, de couleur orange, est constitué par un mélange d'acide phosphotungstique et d'acide phosphomolybdique qui sont réduits lors de l'oxydation des phénols en mélange d'oxydes bleus de tungstène et de molybdène. La coloration bleue produite est proportionnelle à la concentration des composés phénoliques et possède une absorption maximale à 765nm [18].

Les résultats présentés dans le tableau 4 montrent bien que ces composés phénoliques sont présents dans les différentes parties du figuier de barbarie avec des concentrations variantes (6,91 à 42,75 mg Equivalent d'Acide Gallique par gramme de matière sèche) selon l'organe de cette plante et le solvant utilisé dans la macération. En effet, les raquettes en contiennent environ trois fois plus que les racines. Alors que, les extraits hydroethnoliques en contient presque deux fois plus que les extraits aqueux. La présence de ces acides en quantité importante dans les raquettes du figuier de barbarie a été rapportée par plusieurs chercheurs. Ainsi, Teresta et al [25] ont obtenu pour des extraits éthanoliques des raquettes des variétés Mexicaines des concentrations allant jusqu' à 19,9mg EAG/g. Alors que Jeong et al. [26] ont trouvé des concentrations plus élevées de l'ordre de 180,3 m EAG /g pour la variété Coréenne « Saboten ». En effet, la variation de la concentration des acides phénoliques totaux pour la même plante dépend en grande partie du solvant utilisé dans l'extraction, ainsi, Clémentine et al. [27] ont démontré dans leurs travaux de recherche que l'éthanol est le meilleur solvant que l'eau. Il solubilise correctement les composés phénoliques moyennement polaires et peut entrainer aussi des substances lipophiles résiduelles. L'addition de l'eau au système d'extraction fait améliorer le rendement en composés phénoliques glycosylés et des phénols avec un degré de polymérisation plus élevé. Ce qui explique en partie et confirme les résultats que nous avons obtenus dans notre présent études.

Tableau 4. Concentration des phénols totaux contenus dans les extraits de différentes parties séchées du figuier de barbarie

Extraits	[phénols] en mg EAG*/g de M.S
Racine (aqueux)	6,91
Racine (eau-ethanol)	11,65
Raquette (aqueux)	19,03
Raquette (eau-ethanol)	42,75

(*): EAG= Equivalent acide gallique

Rice [28] et Putnam [29] ont rapporté que les substances allélopathiques sont présentes dans pratiquement tous les tissus de la plante, les feuilles, les fruits, les tiges et les racines. Elles sont libérées par des processus tels que la volatilisation, l'exsudation racinaire, la lixiviation et la décomposition des résidus végétaux. Les feuilles peuvent être la source la plus importante de ces composés, tandis que les racines sont considérées comme contenant des toxines de moins en moins puissantes. Ce qui corrobore avec nos résultats. Selon Aldrich [30], ces substances sont concentrées dans les feuilles, les tiges ou les racines plutôt que dans les fruits ou les fleurs. Si elle est concentrée dans ces organes, il est peu probable qu'elle puisse être disponible à temps pour interférer avec les plantes voisines.

L'étude de la corrélation entre les effets allélopathiques observés chez le figuier de barbarie et la concentration en phénols dans les différentes parties de cette espèce, nous a permis de déduire l'existence d'une corrélation linéaire négative significative entre les différents effets allélopathiques du figuier de barbarie observés sur le jujubier et la concentration en phénols totaux contenus dans les différentes parties de cette plante (figures 3, 4 et 5).

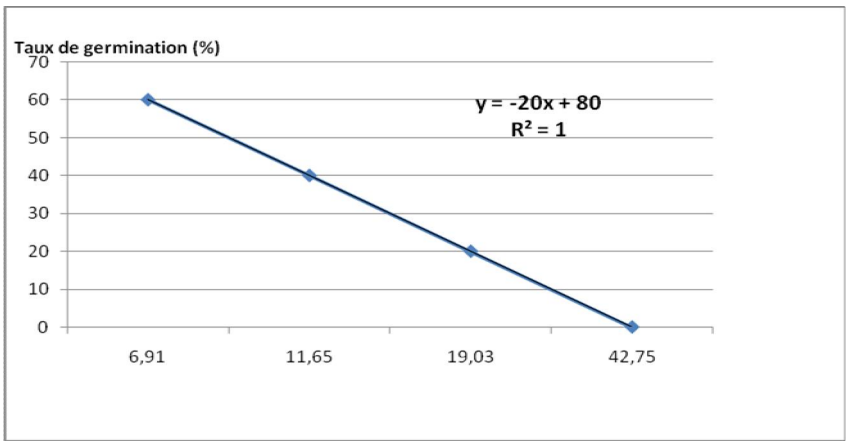

Fig. 3. Corrélation linéaire entre le pourcentage de germination de Z. lotus et la concentration en phénols contenus dans les différentes parties du figuier de barbarie

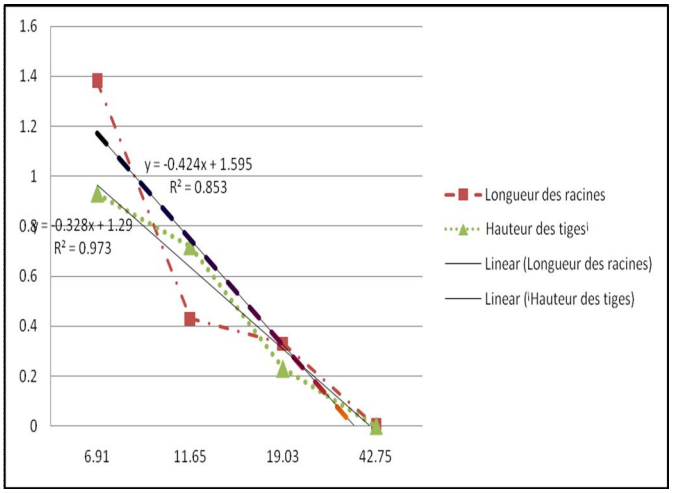

Fig 4: Corrélation linéaire entre la longueur des racines et, la hauteur des tiges des plantules de Z. lotus et la concentration en phénols contenus dans les différentes parties du figuier de barbarie

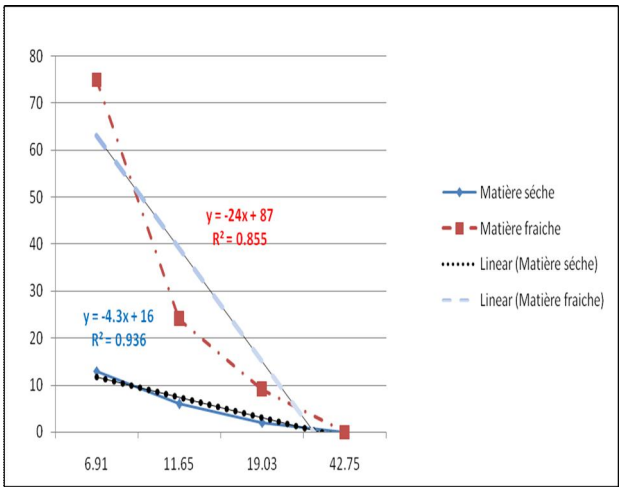

Fig 5: Corrélation linéaire entre les poids des matières fraiche et sèche de Z. lotus et la concentration en phénols contenus dans les différentes parties du figuier de barbarie

3.3.2 IDENTIFICATION DES COMPOSES PHENOLIQUES PAR CCM

Les extraits hydroéthanoliques des racines et raquettes sèches du figuier de barbarie contenant les concentrations des phénols les plus élevées et qui ont montré un effet inhibiteur le plus marqué sur la germination et la croissance du jujubier ont fait l'objet d'analyse par chromatographie sur couche Mince en utilisant 14 standards d'acides phénoliques (Tableau 5).

Tableau 5. Chromatographie des acides phénoliques par CCM (Solvant: Chloroform:Methanol:Eau « 20 : 5 : 0,5 v:v:v »)

Acides phénoliques	Raquette	Racine	Rf
AC trans-cinamique	P	P	0,93
AC Syringique	P	ND	0,89
AC Salicylique	P	ND	0,88
AC 4,hydroxy-3M.cinamique	ND	P	0,87
AC vanillique	P	ND	0,85
AC p. comarique	P	P	0,78
AC 4-Hydrobenzoique	P	ND	0,74
AC. Cafeique	P	ND	0,61
AC. 2-4 dihydroxybenzoique	P	ND	0,52
AC 2-5 dihydroxybenzoique	P	ND	0,38
AC fumarique	ND	ND	0,38
AC gallique	P	P	0,27
AC succinique	NV	NV	0
AC malique	NV	NV	0

ND: non détecté; P: présent; NV: Non visible;
Rf= distance parcourue par l'extrait/ distance parcourue par l'éluant.

Les observations et les mesures portées sur la chromatographie ont montré la présence de 10 acides phénoliques chez les raquettes et 4 chez les racines du figuier de barbarie. La couleur de ces acides observés à des longueurs d'onde de 254 et 365 nm varie du bleu foncé à bleu ciel. L'acide salicylique a une couleur violette.

Ces résultats montrent bien que ces molécules parmi d'autres sont responsables des inhibitions observées sur la germination et la croissance du jujubier. Blum [31] a rapporté que les composés allélopathiques sont le plus souvent des composés phénoliques et qu'ils ont un effet inhibiteur sur la germination des graines et sur la croissance des germes; leurs

effets peuvent être synergiques ou additifs. Ces substances affectent les mécanismes fondamentaux des plantes cibles comme la photosynthèse [32]- [33], la synthèse des protéines [34], la perméabilité membranaire [35], la respiration [34], la division cellulaire et la germination [5]. Pour être considérés comme composés allélopathiques, les acides phénoliques doivent notamment être sous forme active (libre et protonée) et interfèrent sur les processus physiologiques, biochimiques et moléculaires des plantes cibles [28]. En effet, leurs effets sur la germination ou sur la croissance des plantes-cibles ne sont que les signes secondaires de modifications primaires. Alors que leurs cibles principales, non exclusives l'une et l'autre sont: les hormones (auxine, gibbérellines, acide abscissique) qui contrôlent les grandes étapes du cycle vital de la plante (germination, croissance, floraison) et les membranes (perturbation de leur perméabilité) [36]. Ainsi, les substances allélopathiques peuvent être exploitées pour la lutte contre les mauvaises herbes et servir à l'élaboration d'herbicides [37].

4 CONCLUSION ET RECOMMENDATIONS

D'après les résultats de cette étude on peut conclure, donc, que l'hypothèse de mise en jeu du phénomène d'allélopathie comme mécanisme d'interférence entre le figuier de barbarie (*Opuntia ficus-indica (L.) Mill*) et le jujubier (*Ziziphus lotus (L.) Desf.*) est vérifiée. Les composés allélopathiques détectés dans les deux parties aérienne et racinaire du figuier de barbarie sont des composés phénoliques qui ont un effet inhibiteur sur la germination et la croissance de la plante cible. A cet effet, une forte corrélation linéaire négative entre ces différents effets allélopathiques du figuier de barbarie sur le jujubier et la concentration en phénols totaux contenus dans les différentes parties de cette plante a été notée.

Ces résultats peuvent être exploités dans une stratégie de lutte biologique contre le jujubier dans les terrains de parcours infestés par cet arbuste en utilisant le figuier de barbarie comme culture fourragère alternative vu son intérêt et son importance aussi bien en alimentation humaine qu'animal et en matière de transformation agro-industrielle à travers les techniques de valorisation, d'extraction et d'utilisation des produits à base de cette espèce dans les domaines nutritionnel, médicinal et cosmétique.

REFERENCES

[1] N. RSAISSI, M.BOUHACHE et B.BENCHARKI, "Importance et Impact agro-économique du jujubier (Ziziphus lotus) dans la Chaouia", Revue Marocaine de Protection des Plantes. 3, pp. 13-27, 2012.

[2] J.P.CAUSSANEL, "Phénomène de concurrence par l'allélopathie entre adventices et plantes cultivées. COLUMA-EWRC. Cycle international de perfectionnement en malherbologie, 7 p, 1975.

[3] C.H.MULLER, W.H. MULLER and B.L.HAINES, "Volatile growth inhibitors produced by shrubs. Science, pp. 143, 471, 1964

[4] M.HOROWITZ and J.FRIEDMAN, "Biological activity of subterranean residues of Cynodon dactylon L., Sorghum halapense L. and Cyperus rotundus L", Weed Research, 11, pp. 88-93, 1971.

[5] S.FERGUSON, H.P.BAIS, R.VEPACHEDU, S.GILROY and J.M.VIVANCO, "Allelopathy and exotic plant invasion from molecules and genes to species interactions", Science.301, pp. 1277-1380, 2003.

[6] J.R.QASEM, "Allelopathic potential of white top and syrian sage on vegetable crops",Agr.Jour., 93 : 97-71, 2001.

[7] BARATULLAH, F.HUSSAIN and M.IBRAR, "Allelopathic potential of Dodonaea viscosa (L.) JACQ", Pak. J. Bot., 42 (4), pp.2383-2390, 2010.

[8] S.U.CHON, H.G.JANG, D.K.KIM, H.O.BOO and Y.J.KIM, "Allellopathic potential in lettuc (Lectuca sativa l.) plant", Scientia Horticultura, 206 (3), pp. 309-317, 2005.

[9] T.D.XUN, E.T.TSUZUKI, T.HIRUKI, M.MITSUHIRO, T.D.KHANH and I.M.CHUNG, "Evaluation of phytotoxicity of neen (Azadirachta indica A.Juss) to crops weeds", Crop Protection, 23 (4), pp. 335-345, 2004.

[10] F.HUSSAIN, S.U.NSIDDIQUI, S.KHALID, A.JAMAL, A.QAYYUM and Z.AHMAD, "Allelopathic potential of Senna (Cassia angustifolia Vahl.) on germination and seedling characters of some major cereal crops and their associated grassy weeds. Pak.J.Bot., 39 (4), pp. 1145-1153, 2007.

[11] J.Kamal and A. Bano, "Potential allelopathic effects of sunflower (Helianthus annuus L.) on microorganisms", Afr. Jour. Biotech., 7(22), pp. 4208-4211, 2008.

[12] E.BENSELLAM H. And M. BOUHACHE, "Effet allelopathique de la luzerne sur le cyperus (Cyperus rotundus L.) : isolement et identification des substances allelopathiques", Proc. Xème Congrès Société Espagnole de Malherbologie, pp. 25-30, 2005.

[13] M.BOUHACHE And F.ASSALI, " Effet allélopathique de la luzerne (Medicago sativa L.) sur la germination des graines de la morelle jaune (Solanum elaeagnifolium Cav.) ", Proceeding du 2 ème congrès de l'AMPP, Rabat, pp. 171-178, 1995.

[14] M.BOUHACHE, A.TALEB And GHARMMATE A, "allelopathic effects of Oxalis pes-caprea L. on winter cereal crops", Proc. 2nd International Workshop on invasive plants in Mediterranean type Regions of the World, Trabzon (Turkey), EPPO, pp. 339-347, 2010.

[15] S.BEN-GHABRIT, "Les effets allèlopathiques de Verbesina encelioïdes sur la germination et la croissance du blé dur", Mémoire du projet de fin d'études, Faculté des Sciences, Université Mohamed V Agdal, Rabat, 33p, 2010.
[16] S.SEGADE, L.ROLLE, V.GERBI, I.ORRIOLS, "Phenolic ripeness assessment of grape skin by texture analysis", Journal of Food Composition and Analysis, 21, pp. 599-607, 2008.
[17] V.L.SINGLETON, R.ORTHOFER And R.M.LAMMUELA-RAVENTOS, "Analysis of total phenols and other oxidant substrates and antioxidants by means of Folin-Ciocalteu reagent", Methods Enzymol., 299, pp. 152-178, 1999.
[18] A.L.WATERHOUSE, "Determination of total phenolics", Current Protocols in Food Analytical Chemistry, , pp. 111-118, 2001.
[19] W. M. ELLNAIN and G.ZGORKA, "High-performance liquid chromatography and thin-layer chromatography of phenolic acids from Ginkgo biloba L. Leaves collected withing vegetative period", Technnol, 22 (10), pp. 1457-1471; 1999.
[20] I.H.MUHAMMAD, G.LUIS and J. R. MANUEL, "Allelopathic potential of Acacia melanoxylon on the germination and root growth of native species", Weed Biology and Management 11, pp. 18-28, 2011.
[21] M.SUNYATA and P.TOSAPON, "Allelopathic effet of Itchgrass (Rottboellia cochinchinensis) on seed germination and plant growth", Weed Biology and Management 10, pp. 16-24, 2010.
[22] S.LIN, Y.ZHENG, G.D.CAO, and A.WANG, "Effets of extrats from Ginkgo biloba leaves by superficiel fluid extraction on seed germination of Chinese fir. Jour", Plant Resources and Environnement, 12(3) , pp. 20-24, 2003.
[23] C.WALIGORA, "Rotation. Valoriser le non-labour avec les protéagineux", Rev.Techniques culturales simplifiées. N°30. nov/déc 2004, 223p, 2004.
[24] N.DELABAYS, "L'allélopathie et son utilisation en agriculture biologique", Journées techniques fruits et légumes et viticulture biologique. Beaune, les 6 et 7 décembre 2005, pp. 25-33, 2005.
[25] G-F.TERESITA, J-I.HUGO, L.R-E.MARIA, G.M.ANNE, B.L.BEBTE, L.LI-WEI, D.L-R.ANTONIO, S.F.INGE and P.B.ANA, "Proxime composition, phenolic acids, and flavonoids characterization of commercial and Wild nopal (Opuntia spp)", Journal of food composition and Analysis, pp. 525-532, 2010.
[26] C.JEONG, K.HAK-RYUL, J.KIM AND S.Y.JANG, "Antioxidant property of an ethanol extract of the Stem of Opuntia ficus-indica var. Saboten", J. Agric. Food Chem., 50, pp. 6490-6496, 2002.
[27] B.CLEMENTINE, S.MATHIEU, V.ELENA and S.ILONKA, "Etude de l'extraction de composés phénoliques à partir de pellicules d'arachid (Arachis hypogaea L.) ", Revue de génie industriel 7, pp. 35-45, 2012.
[28] RICE, E.L., 1984. "Allelopathy. 2nd edition", Academic Press.
[29] A.R.PUTNAM, "Weed allelopathy", In: S.O. Duke (Ed.). Weed physiology volume 1: Reproduction and Ecophysiology. CRC Press, pp. 131-155, 1985
[30] J.D.ALDRICH, "Weed-crop ecology: Principles and practices", Breton Publishers, pp. 215-241, 1984.
[31] B, J.BLUM, "Perspectives pratiques du contrôle biologique des adventices", AFPP-dix neuvième conférence du Columa. Journées internationales sur la lutte contre les mauvaises herbes. Dijon 8-9 et 10 dec 2004, 8p, 2004.
[32] F.A. EINHELLIG & , J.A.RASMUSSEN, "Effects of three phenolic acids on chlorophyll content and growth of soybean and grain sorghum seedlings", Journal of Chemical Ecology 5, pp. 815, 1979.
[33] D.T.PATTERSON, "Effects of allelochemicals on growth and physiological responses of soybeans (Glycine max)", Weed Science 29, pp. 53, 1981.
[34] E.L.RICE, "Allelopathy", Academic Press, 1974.
[35] J.P. Harper, and N.E. Balke, "Characterization of the inhibition of K+ absorption in oat roots by salicylic acid", Plant Physiol., 68, pp. 1349–53, 1981.
[36] J.F.DOBREMEZ, C.GALLET and F.PELLISSIER, "Guerre chimique chez les végétaux", La Recherche 279 (26), pp. 912-916, 1995.
[37] T.D. XUN, T. SHINKICHI, T.D. KHANH, and I.M.CHUNG, "Biological control of weeds and plant pathogens in paddy rice by exploiting plant allelopathy : An overvieew", Crop Protection, 24 (3), pp.197-206, 2005.

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Burn Depth Prediction Using Analytical and Numerical Solution of Penne's Bioheat Equation

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ABSTRACT: The correct evaluation of skin burn depth in order to make the appropriate choice of treatment is a serious concern in clinical practice. There is no difficulty in classifying first and third degree burns correctly. However, differentiation between the IIa (superficial dermal) and IIb (deep dermal) of second degree burn wounds is problematic even for experienced practitioners. An analytical solution of the three-dimensional Penne's steady-state equation has been obtained assuming a small burn-depth-to-extension ratio. The inverse problem has been posed in a search space consisting of geometrical parameters associated with the burned region. This space has been searched to minimize the error between the analytical and experimental skin surface temperatures. The technique has been greatly improved by using local one-dimensionality to provide the shape of the burned region. Heat transfer in the skin tissue was assumed to be transient and one-dimensional. Thermo physical parameters of successive skin layers are different, at the same time in sub domains of dermis and subcutaneous region the internal heating resulting from blood perfusion and metabolism is taken into account. The feasibility of using this technique and thermographs to determine skin burn depth has been analyzed. In this work the use of surface skin temperature for the determination of the depth of second-degree burns has been explored. Depth of the burn has been optimised numerically for different burning conditions.

KEYWORDS: Thermographs, Penne's equation, Burns, skin, Numerical estimation, Matlab.

1 INTRODUCTION

Bio-heat transfer is an important and vibrant field. Figures 1 and 3 show the first and 3rd degree burn respectively and Figure 2 shows different layer of skin. Because of the complexity of the phenomena numerical techniques have become an important method for analyzing bio-heat transfer problems [1]. This work has two main sections which deal with two of the most important and unique aspects of bio-heat transfer: a) heat transfer with blood flow and metabolism in living tissue and b) heat transfer with phase transformation (freezing) in living tissue. Thermo physical parameters of the skin vary widely from person to person; the analysis of the sensitivity of temperature field and burn predictions to these variations has been also carried out.

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Fig. 1. 3rd degree burn

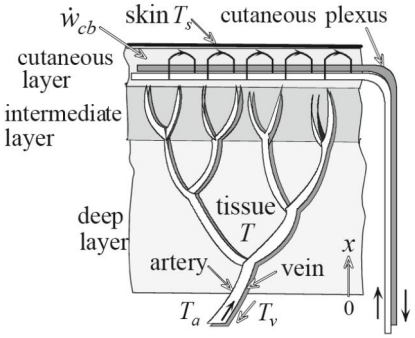

Fig. 2. Different layer of skin

Fig. 3. 1st degree burn

A. Shitzer et al [1] developed a finite difference scheme to solve the Penne's bio heat equation. H.Lee et al [2] gave the solution of application part of A.Shitzer. D.A.Kopriva et al [3] described Compact finite difference methods feature high-order accuracy with smaller stencils and easier application of boundary conditions. H. Barcroft, et al [4] used the Penne's equation to analyze digital cooling in 1958 and developed a whole body human thermal model in 1961. C.A. Brebbia et al [5] developed the numerical analysis of thermal process proceeding in the skin tissue due to external heat flux is presented. A. Holmes and M. Valvano et al [6] estimation of heat transfer coefficient from basic heat transfer analysis. W.P.Bechnke et al [7] developed a fourth-order compact finite-difference scheme for solving the 1-D Penne's bio heat transfer equation in a triple-layered skin structure. P.Moroz et al [8] The Penne's bio heat transfer well-known heat conduction equation has been used for mathematical representation of the temperature distribution in the tissue. K. Touloukian et al [9] established a Mathematical Modelling of Vessels-Tissue Heat Transfer. D. Anthony et al [10] the thermal therapies are based on the heat transfer in biological tissues.

Penne's [9] bio heat equation in 3D form is reduced to 1D form with suitable assumptions. Both analytical and numerical solutions using MATLAB has been found out. Temperature distribution in the burn depth zone has been plotted to quantify and analyse the intensity of burn depth in different burn conditions with discussion on the results. Figure [4] shows that the geometry of burned tissue in 2D and figure [5] shows that the degree of burn tissue in 3D.

2 MATHEMATICAL MODEL

The earlier models of heat transfer through regions in which temperature gradients exist are based on a liner superposition of two conductances: one based on tissue blood flow and the second based on the inherent thermal conductivity of tissue without blood flow. The heat flux (q''), within 2 centimetre of skin surface, is then given by:

$$q'' = \omega\rho_b C_b \delta(T_c - T_s) + \frac{k_t}{\delta}(T_c - T_s)$$

The steady-state Penne's equation for healthy tissue is

$$k\left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2}\right) + W_b C_b (T_a - T) + Q_m = 0 \quad (1)$$

The governing equations for each region can be written as

$$\frac{\partial^2 T_1}{\partial x^2} + \frac{\partial^2 T_1}{\partial y^2} + \frac{\partial^2 T_1}{\partial z^2} = 0 \; for \; 0 \le z < H(x,y) \quad (2)$$

$$k_2\left(\frac{\partial^2 T_2}{\partial x^2} + \frac{\partial^2 T_2}{\partial y^2} + \frac{\partial^2 T_2}{\partial z^2}\right) + W_b C_b (T_a - T_2) + Q_m = 0 \; for \; H(x,y) \le z < \infty \quad (3)$$

Where subscripts 1 and 2 are used for the respective regions.

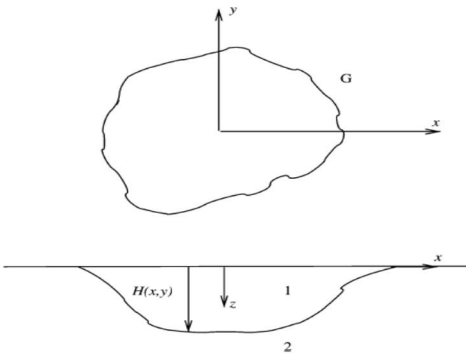

Fig. 4. Geometry of burned tissue

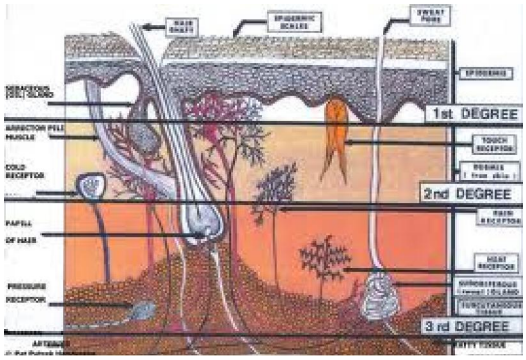

Fig. 5. Schematic of degree of burn tissue

3 ANALYTICAL SOLUTION

The boundary conditions are

$$k_1 \frac{\partial T_1}{\partial z} \mathrm{h}(\mathrm{T}_1 - \mathrm{T}_\infty) \mathrm{at\ z} = 0, \tag{4}$$

$$k_1 \frac{\partial T_1}{\partial z} = k_2 \frac{\partial T_2}{\partial z},\ at\ z = H(x,y), \tag{5}$$

$$T_1 = T_2\ at\ z = H(x,y), \tag{6}$$

$$T_2 = finite, as\ z \to \infty \tag{7}$$

And, zero heat fluxes at all other boundaries. It is assumed that there is no thermal resistance between the two layers. Here T_∞ is the ambient temperature and h, is the convective heat transfer coefficient between the surface of the skin and the surrounding air.

$$\xi = \frac{x}{R_c}$$

$$\eta = \frac{y}{R_c}$$

$$\zeta = \frac{z}{H_c}$$

$$\theta_{1,2} = \frac{T_{1,2} - T_a}{T_\infty - T_a}$$

$$\emptyset(\xi,\eta) = \frac{H}{H_c} \tag{8}$$

The governing equations and boundary conditions are:

$$\epsilon \frac{\partial^2 \theta_1}{\partial \xi^2} + \epsilon \frac{\partial^2 \theta_1}{\partial \eta^2} + \frac{\partial^2 \theta_1}{\partial \zeta^2} = 0, \text{ for } 0 \leq \zeta < \emptyset \tag{9}$$

$$\epsilon \frac{\partial^2 \theta_2}{\partial \xi^2} + \epsilon \frac{\partial^2 \theta_2}{\partial \eta^2} + \frac{\partial^2 \theta_2}{\partial \zeta^2} - m^2 \theta_2 + Q = 0, \text{ for } \emptyset \leq \zeta < \infty \tag{10}$$

$$\frac{\partial \theta_1}{\partial \zeta} = Bi(\theta_1 - 1)\ at\ \zeta = 0 \tag{11}$$

$$\frac{\partial \theta_1}{\partial \zeta} = k \frac{\partial \theta_2}{\partial \zeta},\ at\ \zeta = \emptyset \tag{12}$$

$$\theta_1 = \theta_2 \ , \quad at \ \zeta = \emptyset \tag{13}$$

$$\theta_2 = finite, as \ \zeta \to \infty \tag{14}$$

With zero normal temperature derivatives at all other boundaries. Here, $\emptyset(\xi,\eta)$, defines the non dimensional shape of the burned region, and the non-dimensional parameters are:

$$m^2 = \frac{W_b C_b H_c^2}{k_2}$$

$$Q = -\frac{Q_m H_c^2}{k_2(\mathrm{T}_\infty - \mathrm{T_a})}$$

$$\in = \frac{H_c^2}{R_c^2}$$

$$k = \frac{k_2}{k_1}$$

$$Bi = \frac{hH_c}{k_1} \tag{15}$$

Table 1. Properties

PROPERTY	C_b	k	W_b	Q_m	h	T_a	T_∞	H
MAGNITUDE	$4200(\frac{J}{kg℃})$	$0.2(\frac{W}{m℃})$	$0.5(\frac{kg}{m^3 S})$	$200(\frac{W}{m^3})$	$10(\frac{W}{m^2℃})$	36.5(℃)	22.5(℃)	0.0025(m)

Taking H_c =2.5mm and R_c=25mm, being typical value of second degree burns.

4 ONE DIMENSIONAL APPROXIMATION

The temperature field using a 1D approximation has been determined for use later. Such approximations are commonly made for the Penne's equation but rarely fully justified. In equations (9) and (10), the terms have different orders of magnitude: there are terms of order 1, m^2 and$\in$. If $\in \ll 1$, the derivatives with respect to ξ and η can be eliminated from equations (9) and (10), and the set of equations become 1D.

Under this approximation, equations (9) and (10) can be written as

$$\frac{d^2\theta_1}{d\zeta^2} = 0, \text{ for } 0 \le \zeta < \emptyset \tag{16}$$

$$\frac{d^2\theta_2}{d\zeta^2} - m^2\theta_2 + Q = 0 \text{ , for } \emptyset \le \zeta < \infty \tag{17}$$

The boundary conditions are:

$$\frac{d\theta_1}{d\zeta} = Bi(\theta_1 - 1), \text{ at } \zeta = 0 \tag{18}$$

$$\frac{d\theta_1}{d\zeta} = k\frac{d\theta_2}{d\zeta}, \text{ at } \zeta = \emptyset \tag{19}$$

$$\theta_1 = \theta_2 \text{ , at } \zeta = \emptyset \tag{20}$$

The solution to these equations is:

$$\theta_1 = \frac{mk(1-Qm^{-2})}{1+m\emptyset k+mkBi^{-1}}[-\zeta - \frac{1}{Bi}]+1 \tag{21}$$

$$\theta_2 = \frac{(1-Qm^{-2})}{1+m\emptyset k+mkBi^{-1}} \frac{\exp(-m\zeta)}{\exp(-m\emptyset)} \frac{Q}{m^2} \quad (22)$$

It is possible to evaluate the temperature at the surface at ζ = 0 of a layer of thickness $H = H_c$ for which ϕ = 1 everywhere, to get

$$\theta_s = 1 - \frac{mk(1-Qm^{-2})}{Bi+mkBi+mk} \quad (23)$$

Using for the parameters given in equation (15), substituting into equation (23) and solving for H_c, we get

$$H_c = \frac{k_1}{h} \left\{\frac{1-\bar{Q}}{1-Q_s} - 1 - \frac{h}{(k_2 W_b C_b)^{1/2}}\right\} \quad (24)$$

5 RESULTS AND DISCUSSION

It can be observed from fig.6 that the surface temperature is the smallest at $x = y = 0$, where the burn is thickest, and the maximum surface temperature is obtained for large values of x and y, where the thickness of the burn is negligible. In fig.7 the axes are the x and z coordinates and the contours are isotherms. The deeper tissue for large values of z exponentially approaches the body temperature $T_a - \frac{(T_\infty - T_a)Q}{m^2} = 36.59$℃, while the healthy skin closer to the burned tissue is colder. The temperature at $z - H = 0$ represents the temperature at the interface between healthy and burned tissue. Fig.8 shows the temperature inside a tissue composed of a burned layer and a healthy tissue substrate. The characteristic burn size is R_c = 0.025 m. Three different burn thicknesses, 0.00125, 0.0025 and 0.005 m, are plotted. For each, the burn temperature is linear and the healthy tissue temperature exponentially approaches the core tissue temperature of $T_a - \frac{(T_\infty - T_a)Q}{m^2} = 36.59$℃, for large values of z. Fig.9 shows the variation of the burned surface temperature as a function of the burn thickness. For the tissue properties, ambient temperature and convective heat transfer coefficient detailed in Table 1, the surface temperature approaches a value of 31.97◦C as the thickness approaches 0 value; as the burn thickness is increased the surface temperature decreases.

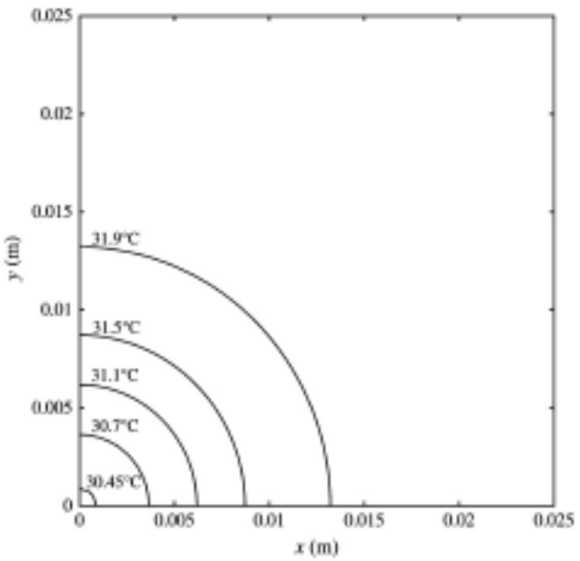

Fig. 6. Temperature contours at surface of skin T(x,y,0)

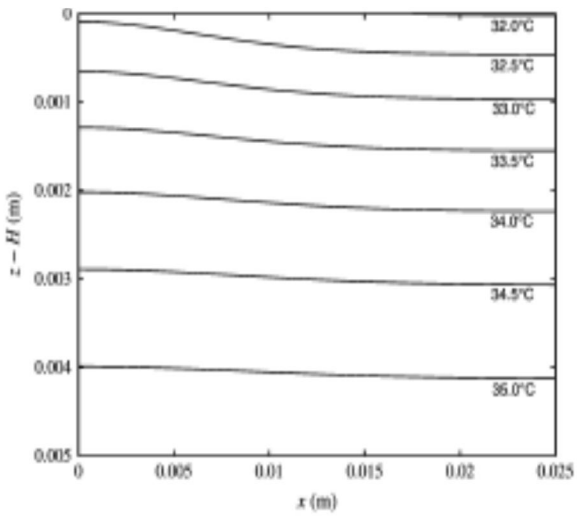

Fig. 7. shows the temperature contours in plane normal to skin, $T_2(x, 0, z - H)$

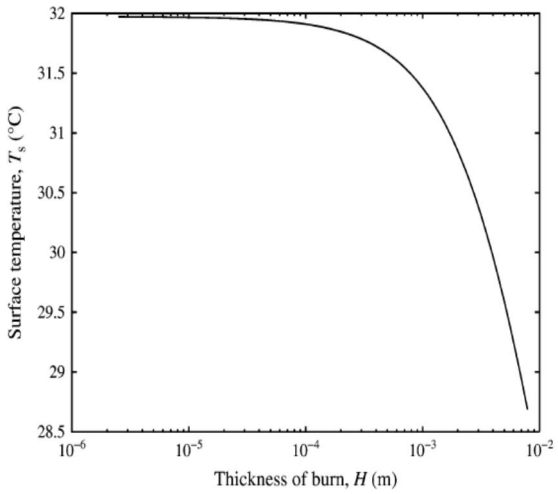

Fig. 8. Temperature profile inside a uniform Burn, T (Z), H=1.25mm, H=2.5mm, H=5mm

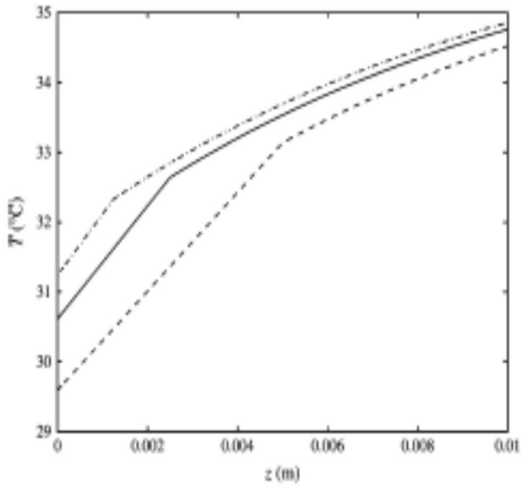

Fig. 9. Variation of the burned surface temperature as the function of burn thickness

6 CONCLUSION

It is most important to realize that when dealing with living tissue, any numerical model could provide only an approximation to conditions in actual life. However, the work as expounded here it can be helpful in both emergency medicines as well to plastic surgeons in deciding upon a course of action for the treatment of different burn injuries. We avoid developing a full 3D model of the burn for tissue damage analysis since it would not be of much extra meaning. Most real skin burns approximate to 1D heat transfer because the exposed surface is very large compared to the depth of burn. The advantage of analytical versus numerical solutions lies in the speed with which the results can be obtained. The present work assumes known properties of both burned and healthy tissues: the thermal conductivity is assumed known for both, and the arterial temperature and metabolic heat rate for the latter. In this work burn depth of a tissue or on any human being is simulated for different condition of burning which helps Doctors for medicines in types of burns.

REFERENCE

[1] A. Shitzer, and R.C. Eberhart, "Heat transfer in medicine and biology", Analysis and application, Vol. 1, pp. 256-270, 1985.

[2] H. Lee, and D.T.Backet, "Biological Thermodynamics", solution and application, Vol. 3, pp. 23-35, 2001.

[3] D. A. Kopriva, And K.C.Molen, "Compact finite difference methods feature high-order accuracy with smaller stencils", eddy simulation of turbulence, Vol. 9, pp. 187-200, 1986.

[4] H. Barcroft, and O. G. Edholm., **"**The effect of temperature on blood flow and deep temperature in the human forearm", human thermal model, Vol. 5, pp. 56-68, 1961.

[5] C. A. Brebbia, and J. Dominguez, "Boundary elements, an introductory course", computational mechanics publications, Vol.5, pp.94-108, 2003.

[6] A. Holmes and M. Valvano., "heat transfer coefficient from basic heat transfer analysis", the topologies of the inner surfaces of the heart, Vol. 6, pp. 26-52, 1998.

[7] W. P. Bechnke, "Predicting Flash Fire Protection of Clothing from Laboratory", tests using second-degree burn to rate performance, vol. 8, pp. 57–63, 1984.

[8] P. Moroz, S. K. Jones and B. N. Gray, "Magnetically mediated hyperthermia", current status and future directions, Vol. 3, pp. 267-284, 2002.

[9] K. Touloukian, and D. L.Magnina, "Mathematical Modelling of Vessels-Tissue Heat Transfer", the complex nature of heat transfer in living tissue, Vol. 7, pp. 53-65, 1984.

[10] D. Anthony, M.Metcalfe, and W.J. Ferguson, "Bioengineering skin using mechanisms of regeneration and repair", heat transfer in skin tissue using the clinical data, Vol. 8, pp. 185-210, 2007.

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New slotting technique of making compact octagonal patch for four band applications

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ABSTRACT: An improved but simple four band octagonal patch with new slotting technique of making a compact patch antenna is presented, which is suitable for C-band, X-band, Ku-band and K-band applications. This compact microstrip antenna realized by changing the geometric shape, obtained by inserting small circular slots in a new way. The simulation has been performed by simulation software GEMS version 7.71.01 and using Taconic TLY-5 dielectric substrate with relative permittivity 2.2 and height 1.588mm. The simulated return losses are obtained -16.50dB, -17.25dB, -39.22dB and -30.75dB at 7.49GHz, 10.89GHz, 15.70GHz and 20.10GHz respectively. Therefore, this antenna can be applicable for C-band, X-band, Ku-band and K-band applications respectively.

KEYWORDS: Octagonal patch, Four band patch antenna, Novel patch, Circular slots, Compact patch, Multi-band patch.

1 INTRODUCTION

Microstrip antennas are also referred to as patch antennas. The radiating elements and the feed lines are usually photo etched on the dielectric substrate. The radiating patch may be square, rectangular, thin strip, circular, elliptical, triangular etc. [1]. Here a new octagonal patch antenna is presented which operate in multi-band applications.

A microstrip antenna could be made compact through a number of methods. Some of the methods involve the use of a shorting pin, while others involve geometrical modification [2]. Here the compact patch is achieved by involving geometric modification.

With the rapid growth of the wireless communication system the future technologies need a very small and multiband antenna. Nowadays, people demand multiband wireless phone supporting more than one network, having different frequencies and simultaneous transmission of audio, video and data. These services are possible with the help of microstrip patch antenna having multiband characteristics. Modern wireless communication system also requires low profile, light weight, high gain, ease of installation, high efficiency, simple in structure to assure reliability and mobility characteristics. Microstrip antennas satisfy such requirements. The key features of a microstrip antenna are low profile, relative ease of construction, low weight, comfortable to planar and non-planar surfaces, low cost, simple and inexpensive to manufacture by using printed circuit board. These advantages of microstrip antennas make them popular in many wireless communication applications such as satellite communication, radar, medical applications, aircraft, spacecraft, and missile applications [3, 4, 5, 6, 7]. Many researchers have designed a single element patch in different way to gate multiband application such as double PIFA [8], U-slot [9], double U slot, E slot, H slot and other structures.

We know that C-band, X-band, Ku-band and K-band are worked at 4-8GHz, 8-12GHz, 12-18GHz and 18-27GHz respectively [10].

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In this paper the antenna is designed to support 7.49GHz, 10.89GHz, 15.70GHz, and 20.10GHz frequencies. So, this antenna is able to meet the demand of C-band, X-band, Ku-band and K-band applications. This frequency can be changed by varying the antenna size and geometrical modification. Here the simulation has been done by simulation software GEMS simulator version 7.71.01 with substrate height 1.588mm, Taconic TLY-5 dielectric substrate with permittivity 2.2 is used.

2 DESIGN OF PROPOSED ANTENNA

Microstrip antenna consists of a thin film. This strip of thin film placed on ground plane where the thickness of the metallic strip is restricted by $t<<\lambda_0$ and height is restricted by $0.000\lambda_0 \leq h \leq \lambda_0$ [1, 11, 12, 13]. The strip and ground plane are separated by a dielectric sheet referred to as the substrate. There are numerous substrates that can be used for the design of microstrip antennas and their dielectric constants are usually in the range of $2.2 \leq \varepsilon_r \leq 12$ [1, 11, 12, 13]. The performance of the microstrip antenna depends on its dimension. Depending on the dimension the operating frequency, radiation efficiency, directivity, return loss and other related parameter are also influenced [14, 15].

The proposed antenna consists of ground plane, dielectric substrate, and metallic octagonal patch. The patch has a simple octagonal structure fed by 50Ω microstrip line. The dielectric material selected for the design is Taconic TLY-5 which has dielectric constant of 2.2 and height of the substrate is 1.588mm. The length of the microstrip transmission line is 7.2mm and width is 1mm. The octagonal patch shown in Fig.1 has two types of arm one type has 6.4mm length and other type has 6.34mm length.

Fig. 1 shows the proposed compact microstrip patch antenna. Here the proposed antenna is obtained by inserting circular slots, like as the slots are created a circular ring into the octagonal patch. Each slot has 0.5mm radius and distance between the centre point of the patch and centre point of the slot is 5mm. After inserting slots into the patch its shape is changed and acts as a compact patch.

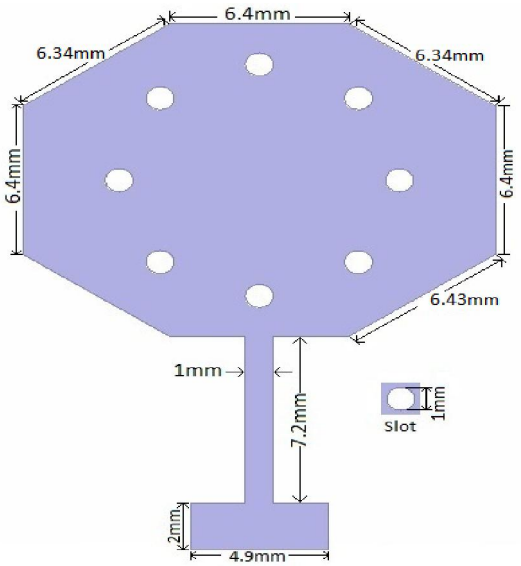

Fig. 1. Proposed compact microstrip patch antenna

3 SIMULATION RESULT AND DISCUSSION

The simulation results of return loss, directivity and radiation pattern for compact patch antenna are shown below.

The simulated compact patch antenna is operating at 7.49GHz, 10.89GHz, 15.70GHz and 20.10GHz. The corresponding return loss are -16.50dB, -17.25dB, -39.22dB and -30.75dB respectively and are shown in Fig.2. The gain at 7.49GHz, 10.89GHz, 15.70GHz and 20.10GHz are 5.654dBi, 5.0dBi, 5.35dBi and 3.47dBi respectively. Also the -10dB bandwidth is obtained 0.303GHz, 0.652GHz, 0.801GHz and 1.92GHz respectively. The directivity at 7.49GHz, 10.89GHz, 15.89GHz and 20.10GHz are 6.344dB, 5.82dB, 6.311dB and 6.46dB respectively and are shown in Fig.3. The 2D radiation pattern at 7.49GHz, 10.89GHz, 15.70GHz and 20.10GHz are shown in Fig. 4(a) and 4(b).

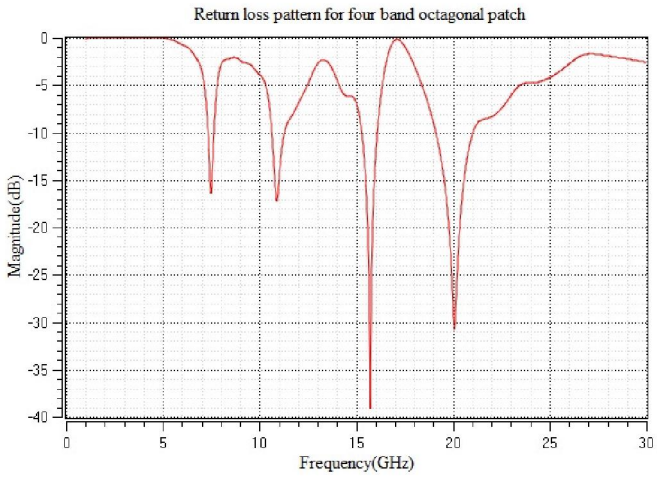

Fig. 2. Return loss pattern for octagonal compact patch.

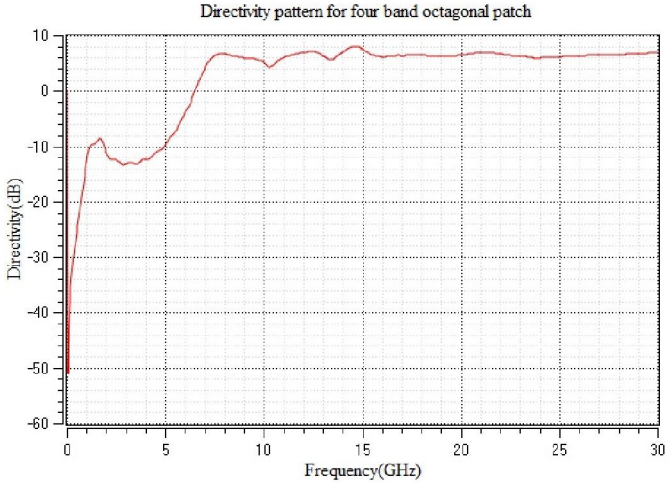

Fig. 3. Directivity pattern for octagonal compact patch.

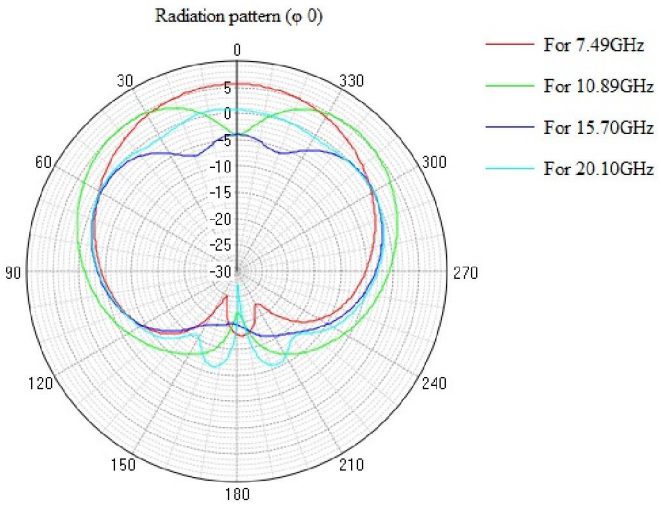

Fig. 4(a). Radiation Pattern (2D polar phi0^0) at 6.7GHz, 10.85GHz, 14.15GHz and 19.50GHz.

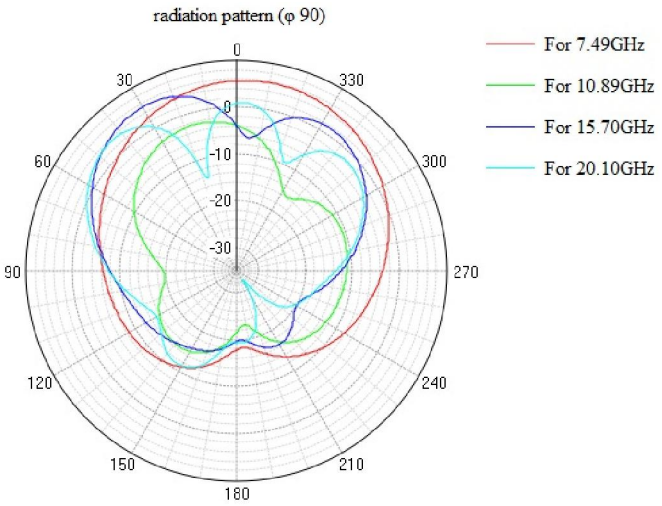

Fig. 4(b). Radiation Pattern (2D polar phi90^0) at 6.7GHz, 10.85GHz, 14.15GHz and 19.50GHz.

The far field pattern is shown in Fig.5, Fig.6, Fig.7 and Fig.8 for 7.49GHz, 10.89GHz, 15.89GHz and 20.10GHz. Here the far field is the value generated by 1V voltage at the 1 meter away from the antenna.

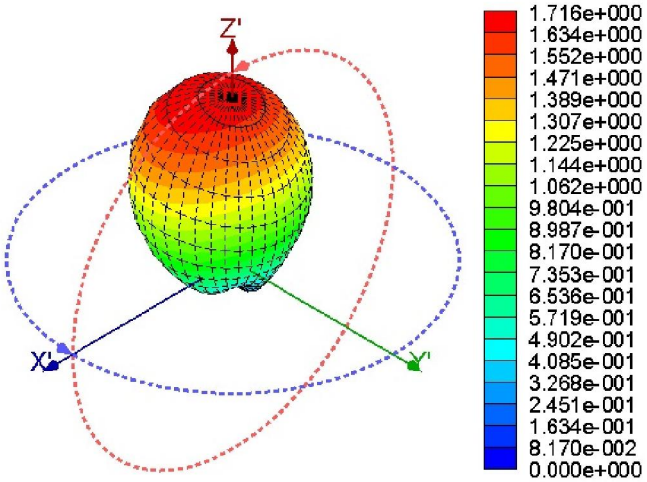

Fig. 5. Far field pattern for 7.49GHz (C-band).

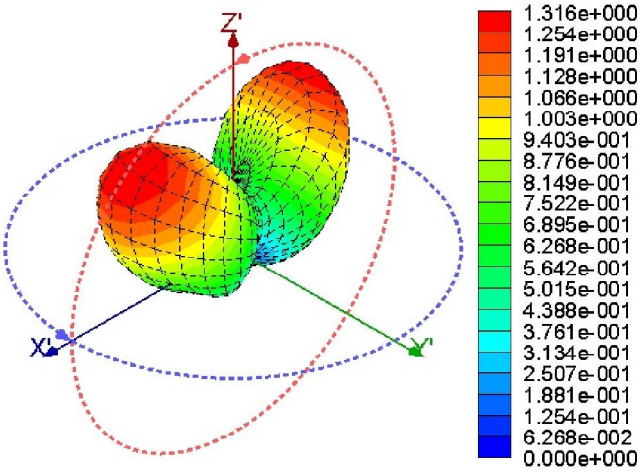

Fig. 6. Far field pattern for 10.89GHz (X-band).

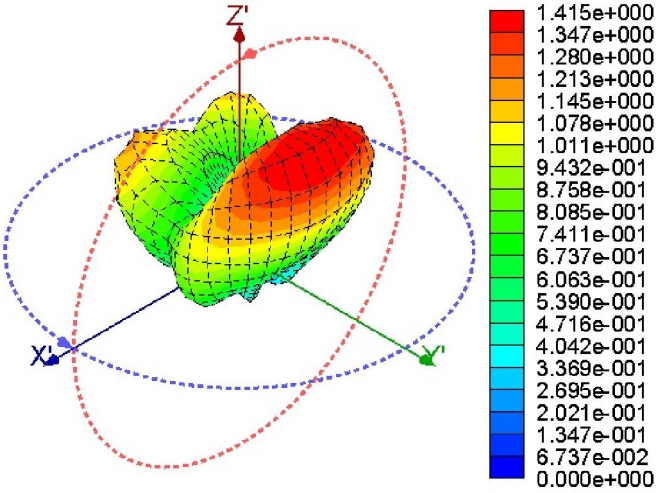

Fig. 7. Far field pattern for 15.70GHz (Ku-band).

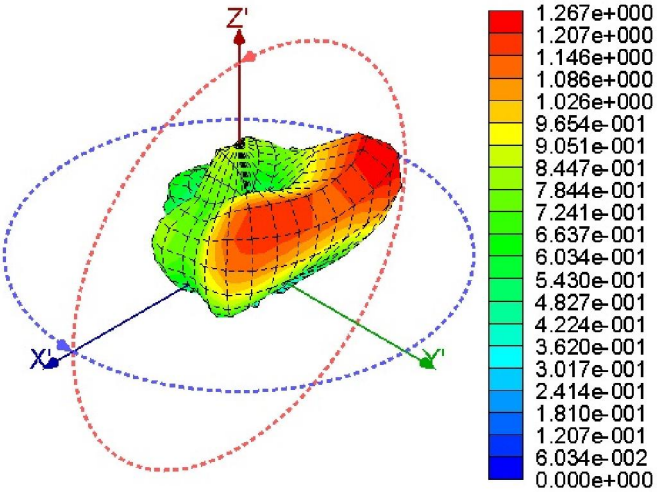

Fig. 8. Far field pattern for 20.10GHz (K-band).

After observing the performance analysis graph and pattern of octagonal compact patch antenna the obtained results are tabulated below for better analysis.

Table 1. Simulation results for compact patch at 7.49 GHz, 10.89 GHz, 15.70 GHz and 20.10 GHz.

Performance Parameter	Unit	Compact patch antenna			
		For 7.49GHz (C-band)	For 10.89GHz (X-band)	For 15.70GHz (Ku-band)	For 20.10GHz (K-band)
Simulated return loss	dB	-16.50	-17.25	-39.22	-30.75
Directivity	dB	6.344	5.82	6.311	6.46
-3dB bandwidth	GHz	1.039	3.312	2.828	7.867
-10dB bandwidth	GHz	0.303	0.652	0.801	1.92
Gain	dBi	5.654	5.00	5.35	3.47
Radiated power	mW	73.21	128.94	189.66	172.15

The corresponding graph of tabulated result is shown in figure 9. Here the x axis, y axis and z axis represent operating frequency, return loss and simulated gain respectively.

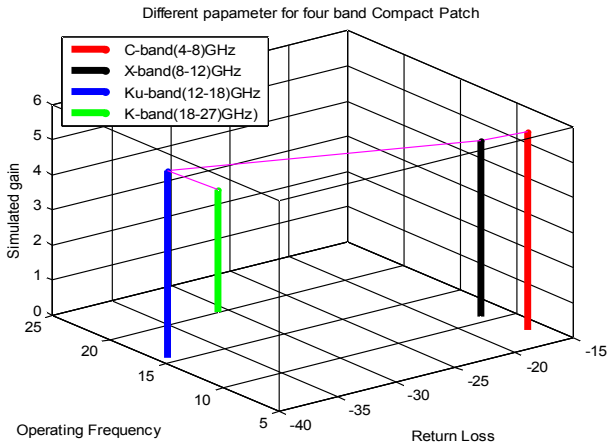

Fig. 9. Different parameter value of compact patch antenna.

After investigation of the above graphs and tabulated results we have reached the following decision-

- ✓ Here we get maximum return losses -16.50dB, -17.25dB, -39.22dB and -30.75dB at 7.49GHz, 10.89GHz, 15.70GHz and 20.10GHz respectively. We know the range for C-band is 4-8GHz; X-band is 8-12GHz, Ku-band is 12-18GHz and K-band is 18-27GHz. So, the antenna proposed in this paper can operated in C-band, X-band, Ku-band and K-band.

- ✓ -10dB bandwidth at C-band, X-band, Ku-band and K-band are 0.303GHz, 0.652GHz, 0.801GHz and 1.92GHz respectively. Here the bandwidth is not narrower for each case. The main disadvantage of any patch antenna is narrow bandwidth; this is not happening for this proposed antenna.

4 CONCLUSION

A new four band compact patch antenna with wideband is presented. This paper demonstrates a compact patch that is operated in C-band, X-band, Ku-band and K-band with corresponding return losses are -16.50dB, -17.25dB, -39.22dB and -30.75dB respectively. Using GEMS solver version 7.71.01 and Taconic TLY-5 dielectric substrate with relative permittivity 2.2 and height 1.588mm has been achieved in simulation.

This new configuration finds applications in various fields. Here the C-band is mainly used in satellite TV channel, satellite navigation etc. The X-band is primary used for medical accelerators, radar and satellite applications etc. The Ku-band is primary used for editing and broadcasting of satellite television, satellite Internet etc. The K-band is used primarily for radar, satellite communications, astronomical observations etc.

In future we will try to improve the return loss and bandwidth. Using this simple octagonal compact patch we will design different types of array such as series feed array, corporate feed array or corporate-series feed array to get higher directivity and higher gain.

Here designed antenna is covered C-band, X-band, Ku-band and K-band operating frequency, but it is possible to design for other specific system such as WLAN, WiMAX etc. applications by changing the antenna size and other parameters.

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We would like to express our gratitude to all those who gave us the possibility to complete this paper. We are deeply indebted to our teacher Md. Tanvir Ishtaique-ul Huque, providing simulation software, stimulating suggestions, knowledge, experience and encouragement helped us in all the times of study and analysis.

REFERENCES

[1] C. A. Balanis, *Antenna Theory: Analysis and Design, 2nd Edition*, Willey, pp. 722-783, 1997.

[2] J. George, K. Vasudeban, P. Mohanan and K.G. Nair, "Dual frequency miniature antenna," *IEE Electronics Letters*, Vol.34, No.12 , pp. 1168-1170, 11th June 1998.

[3] Gi-cho Kang, Hak-young Lee, Jong-kyu Kim, Myun-joo Park,"Ku-band High Efficiency Antenna with Corporate-Series-Fed Microstrip Array," *IEEE Antennas and Propagation Society International Symposium*, 2003.

[4] T. F. Lai, Wan Nor Liza Mahadi, Norhayatision, "Circular Patch Microstrip Array Antenna for KU-band," *World Academy of Science, Engineering and Technology*, vol. 48, pp. 298-302, 2008.

[5] K. Shambavi, C. Z. Alex, T. N. P. Krishna, "Design and Analysis of High Gain Milimeter Wave Microstrip Antenna Array for Analysis of High Gain Millimeter Wave Microstrip Antenna Array for Wireless Application," *Journal of Applied Theoretical and Information Technology (JATIT)*, 2009.

[6] Asghar Keshtkar, Ahmed Keshtkar and A. R. Dastkhosh, "Circular Microstrip Patch Array Antenna for C-Band Altimeter System," *International Journal of Antenna and Propagation*, article ID 389418, doi:10.1155/2008/389418, November, 2007.

[7] M. F. Islam, M. A. Mohd. Ali, B. Y. Majlis and N. Misran, "Dual Band Microstrip Patch Antenna for Sar Applications," *Australian Journal of Basic and Applied Sciences*, 4(10): 4585- 4591, 2010.

[8] Rod waterhouse, planar Inverted-F antenna, chapter 7, *Printed Antenna for wireless Communications*, John Wiley & Sons, Ltd, 2007, ISBN: 978-0-470-51069-8.

[9] H.F. Abu Tarbous, R.Nalavalan, H. S. Al-Raweshidy and D. Budimir "Design of Planar Inverted-F Antennas (PIFA) for Multiband Wireless Applications," *International Conference in Electromagnetic in Advanced Application*, pp. 78 – 81, Turin, Italy, September 2009.

[10] http://www.telecomabc.com/m/microwave-band.html

[11] Cheng-Chi Hu, Christina F. Jou, Cheng-Chi Hu, "An aperture-coupled linear microstrip leaky-wave antenna array with two-dimensional dual-beam scanning capability," *IEEE Transactions on Antennas and Propagation*, Vol.48 , Issue.6, pp. 909 – 913, Jun 2000.

[12] R. Garg, P. Bhartia, I. Bahl, A. Ittipiboon, "*Microstrip Antenna Design Handbook,*" Artech House inc.,2001.

[13] Md. Tanvir Ishtaique-ul Huque, Md. Kamal Hosain, Md. Shihabul Islam, Md. Al-Amin Chowdhury, "Design and Performance Analysis of Microstrip Array Antennas with Optimum Parameters for X-band Applications," *International Journal of Advanced Computer Science and Applications(IJACSA)*, Vol. 2, No. 4, Page no. 81-87, 2011, NY, USA.

[14] Thomas A. Milligan, *Modern Antenna Design, 2nd edition*, IEEE Press, Jhon Wiley & Sons inc., 2005, ISBN: 978-0471457763.

[15] M. I. Skolnik, *Introduction to RADAR System*, *3rd edition*, McGraw Hill Higher Education, 2000.

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Retention supports and geochemical interactions of Trace Elements in two soils irrigated by sewage (Meknes, Morocco)

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ABSTRACT: The Ourzirha area located in the north-western of the Meknes City is an important agricultural region. This region is one of the principal suppliers of agricultural products to the Meknes citizens. However, the cultivated areas in the Ourzirha region are irrigated by a raw wastewater in major part. To explain and to predict the principal supports of the Trace Elements retention in these soils, two profiles subject to a sewage spreading are taken, a calcareous soil and a vertisol.
Based on the vertical evolution of different studied parameters and the selective affinities of Trace Elements to the active soil fractions present in our profiles, we are tried to determine the various interactions between the considered Trace Elements and the clay, calcite and organic matter contents in studied profiles. The results of this study showed the importance of clay and organic matter as a dominant supports of these pollutants, especially in surface soil. In the calcareous soil, the calcite content influences strongly the distribution of Trace Elements along this profile.
The mechanisms of the Trace Elements retention on studied profiles are considered as a selective adsorption on organic matter, clay and on calcite essentially. In fact, the possibility of a weak co-precipitation with calcite and organic matter in the calcareous soil isn't excluding. Also, in the vertisol probably, the Trace Elements contents are strongly influenced by the particular entering, favoured by a macro-porosity of this profile.

KEYWORDS: Sewage, Trace Elements, soil, phase retention, Morocco.

1 INTRODUCTION

The agricultural activity is a principal sector of moroccan economic by their important contribution in Gross National Product (15 to 20%) and as a premiere employer sector (>35% of employment). This activity based on the fertile soils and a favourite climate of country [1]. However, these important resources are subject to different anthropic pressures. In general, the different degradation forms of soil quality are a result of excessive use of fertilizers and an overexploitation, especially in urban agriculture [2]. The protection and a best management of these resources is a principal objective of the actors in agricultural domain.

In this study, we try to do an identification of various site of Trace Elements retention in two studied profiles. These different geochemical interactions of the Trace Elements with various soil fractions are very important to identified different behaviours and bioavailability of these pollutants in the soils. This knowledge is very significant for the management of the quality and the setting of the culture of the soils, and also to be able to determine and set the standards on the limit of the contents of these pollutants. These Trace Elements in the soils have a different origins, geogenic origins (Parental material), or an exogenic origins due to the anthropic effects [3] , [4] , [5] et [6].

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In the past, the effect of the local remobilization [6] by the changes of physicochemical conditions in the soil mass [3] , [4] et [5]. In the soil, the exogenous Trace Elements are gown to be associated to the different soil components with various paths. These various associations are based on the affinities of these pollutants to the presence of active soil fractions. In general, these different information is an important factor to the determination of the mobility and biodisponibility of pollutant in soil [7] , [8] et [6].

Our study is carried out on two soils developed on rocks rich naturally in Trace Elements (Table 5), and which is subjected to a spreading by sewage. To study and evaluate the variation of the geochemical interactions with the principal components of the soil implied in their retentions, a profound interpretation of vertical variation of various studied parameters and correlations matrix for an explication of retention and fixed mechanism of these pollutants on two studied profiles [9].

2 MATERIALS AND METHODS

2.1 SITE DESCRIPTION

The Ourzirha area is closed to Meknes City (Fig.1). It is known by its agricultural activity. Indeed, cultivated are subjected to spreading by raw wastewater. Two profiles of soils were taken, a vertisol and a calcareous soil “French Classification of soil: CPCS, 1967” [10].

The calcareous soil is developed on quaternary limestone. It presents on the surface an Ap horizon, thick of 25cm, black colour and a Silty-sand texture, overcoming a structural horizon (B), thick of 45cm, and in bottom a Bca horizon, thick of 50cm, rich in Fe-Al oxyhydroxydes and limestone concretions (Table 1).

The vertisol developed on Miocene marl is characterized by a profile made up of a cultivated horizon Ap, thick of 15 cm, of brown colour and a Silty-clay-sandy texture, overcoming an A1 horizon, thick of 15cm, which differs from the Ap horizon by its clearer colour. The whole of the profile is dominated in its bottom by a (B)ca horizon, thick of 70cm very rich in clays (25%), (Table 2).

2.2 SAMPLING & ANALYSES

The samples are taken in pits of 1.2 m and 1 m depths for the calcareous soil and the vertisol respectively. 17 samples are taken on two profiles of soils irrigated by a raw wastewater. The samples after air drying and crushing were subjected to an analysis by ICP-AES for the determination of TEs (As, Cd, Cr, Cu, Ni, Pb and Zn).

The clay fraction is calculated after drying with the drying oven at 105°C and weighed solid load contained in the sample with the pipette of Robinson [11]. The organic matter was determined by the loss on the ignition [12], [6]. The percentage of calcite was determined by the calcimetry, using a Bernard calcimeter [13]. The rock-mothers show important contents of Trace Elements (Table 5).

3 RESULTS & DISCUSSIONS

Based in the vertical evolutions of Trace Elements contents on the studied profiles, and their different affinities to the various soil fractions, we can explain the principal geochemical interactions between the considered Trace Elements and clay, calcite and organic matter, as principal components of soils implied in their retentions [3] , [8] , [4] , [14] et [5]. However, the correlation matrixes are considered to explain a similarity of Trace Elements comportments along the studied profiles by the analysis of their significant correlations.

The retention mechanism type with active soil fractions is predict by the distribution of different studied parameters along studied profiles based on the literature data. These correlations can provide significant information on the sources and become Trace Elements in soils [9]. On the other hand, the different correlation between the considered Trace Elements and clay, calcite and organic matter are insignificant due to no linear relation between these parameters most likely.

3.1 ON CALCAREOUS SOIL PROFILE

The As and Cu are strongly correlated positively between them (Table 3) and this is an index of the same mechanism which controls their behaviours in the profile [12] et [5]. Figure 2, illustrate the vertical evolutions of different parameters along the calcareous profile. In this figure, the contents of the two Trace Elements follow the evolution of organic matter and clay, particularly in surface respectively. This comportment can be interpreted by the retention of these pollutants on the

profile by these soil fractions. The affinity of these pollutants with respect to these two active components of soil is very known [3], [8], [4] et [5]. The mechanism which controls the retention of these two Trace Elements on this profile is probably selective adsorption on the organic matter and clay in surface and on the calcite in the rest of profile.

Ni and Cd are slightly correlated, but its have a similar comportment in this profile, especially in the (B) horizon (Fig.2). Based in the vertical evolutions of the contents of the Ni and Cd in this profile, we can explain that these Trace Elements are retained with slightly contents on organic matter and clay, in surface, and principally on calcite along the profile. These Trace Elements are strongly fixed in the (B) and Bca horizons by the calcite probably.

The Cu, Pb, and Zn show a similar comportment along this profile. These Trace Elements are strongly correlated between them (Table 3). The vertical evolution of their contents in profile enables to say that the mechanism which controls the distribution of these Trace Elements in the profile is probably primarily adsorption on clay and organic matter in surface horizon and the calcite along the profile.

On this profile, the importance of calcite as support dominating in the retention of the Trace Elements in this calcareous soil is well marked [3] et [5]. But the retention of Trace Elements in surface horizon by the clay and organic matter constituents are dominated [8].

3.2 ON VERTISOL PROFILE

The Cd, Cu, Pb, and Zn are strongly correlated (Table 4) as an indication of this similar comportment along this profile. The vertical evolution of these Trace Elements on profile (Fig. 3), well show their important accumulations in surface, influenced by the organic matter and clay contents probably. In fact, these affinities are much known in soil surfaces [3], [8], [4], [14] et [5]. The mechanism of this retention in the profile can be interpreted as an adsorption organic matter and clay in surface and secondary on calcite in down layers [8], [14] et [15].

The As, Ni, and Cr show a good correlations between them (Table 4). Their contents are low along the profile with a small accumulation in surface (Table 3). Thus, the contents of the three Trace Elements in surface profile are influenced by the sewage application in soil [16]. The vertical evolutions of these Trace Elements in profile (Fig. 3) show a small variation, with weak accumulations in up soil. These accumulations are influencing essentially by organic matter and clay contents. And on the remainder of profiles the principal support is a calcite and clay fraction.

The two Trace Elements, Cr and Ni are small correlated on the profile (Table 3) indicate the difference of their principal retention mechanism along profile. The Ni is fixed essentially by the calcite in A1 and (B)ca horizons. On the other hand, the Cr is fixed by the organic matter in surface and the clay in the (B)ca horizons (Fig. 3).

4 TABLES AND FIGURES

4.1 TABLES

Table 1. Contents of various studied parameters on the calcareous soil

Depth (m)	Samples	OM %	Clays %	CaCO3 %	As (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Pb (mg/kg)	Zn (mg/kg)	Ni (mg/kg)
0	Cp2-8	17,34	14	13,9	5,1087	0,2425	26,1329	10,2174	19,6488	57,7675	18,4699
-0,25	Cp2-7	16,95	7	15,51	10,5565	0,1478	56,4541	9,868	11,0154	48,6515	29,145
-0,4	Cp2-6	11,44	9	18,72	6,5729	0,1846	24,4989	6,7721	6,3737	31,6693	17,1293
-0,55	Cp2-5	12,53	6	21,92	6,6082	0,3622	24,7808	6,6082	8,4668	30,15	17,1401
-0,7	Cp2-4	11,84	8	6,06	7,491	0,3754	33,8167	8,1331	11,1295	37,0271	51,153
-0,85	Cp2-3	11,91	4	13,19	9,5862	0,3821	45,3165	10,2398	11,547	46,1353	28,7586
-1,1	Cp2-2	11,62	4	8,56	13,6614	0,3928	47,703	10,526	11,6558	46,1353	29,7864
-1,2	Cp2-1	11,43	2	2,35	17,6948	0,1986	47,4638	16,8612	20,4011	54,3335	33,7243

OM : organic matter

Table 2. Contents of various studied parameters on the vertisol

Depth (m)	Samples	OM %	Clays %	CaCO3 %	As (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Zn (mg/kg)
0	Vp2-9	26.63	19	40,64	3,4049	0,3513	29,4421	10,4149	24,8355	12,4178	41,4534
-0.05	Vp2-8	26,13	20	40,64	2,2945	0,3659	33,5827	7,7178	16,687	7,092	44,0121
-0.1	Vp2-7	25.72	19	40,64	2,1219	0,3722	27,7974	7,0024	14,4292	7,8512	36,9217
-0.15	Vp2-6	25.43	18	40,64	1,0251	1,1835	28,8649	12,3707	16,4942	24,7414	294,8345
-0.2	Vp2-5	26,10	18	40,64	1,5965	0,35	27,5402	7,5835	17,3623	8,1822	38,1172
-0.25	Vp2-4	28,77	19	51,87	1,7187	0,3768	22,5583	7,3046	27,7145	6,4452	35,8784
-0.5	Vp2-3	29,23	18	59,89	5,41	0,163	27,8564	4,9221	24,3982	4,4978	30,2113
-0.7	Vp2-2	23,96	48	48,13	4,8714	0,2783	33,5449	7,4613	27,4608	7,2352	47,9331
-1	Vp2-1	22,79	19	41,71	5,8485	0,2222	34,4884	7,5144	21,2495	8,8436	41,4534

OM : organic matter

Table 3. Correlations Matrix of the Trace Elements on calcareous soil profile

	As	Cd	Cr	Cu	Pb	Zn	Ni
As	1	-0,11	0,74	0,84	0,41	0,43	0,34
Cd		1	-0,13	-0,26	-0,22	-0,29	0,29
Cr			1	0,58	0,20	0,49	0,41
Cu				1	0,81	0,76	0,26
Pb					1	0,88	0,13
Zn						1	0,08
Ni							1

The values in fat are significant

Table 4. Correlation Matrix of the Trace Elements on vertisol profile

	As	Cd	Cr	Cu	Ni	Pb	Zn
As	1	-0,63	0,53	-0,48	0,50	-0,44	-0,43
Cd		1	-0,14	0,83	-0,41	0,94	0,96
Cr			1	0,06	-0,14	0,01	-0,02
Cu				1	-0,23	0,93	0,72
Ni					1	-0,34	-0,36
Pb						1	0,91
Zn							1

The values in fat are significant

Table 5. Contents of Trace Elements (litho-geochemical Funds) of the rock-mothers of studied soils (Saïs Basin)

	As (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Zn (mg/kg)
Quaternary Calcareous	41.283	4.836	0.345	7.255	10.191	18.828	7.600
Miocene Marls	68.572	4.6145	50.7995	17.707	23.0265	78.6255	53.3745

4.2 FIGURES

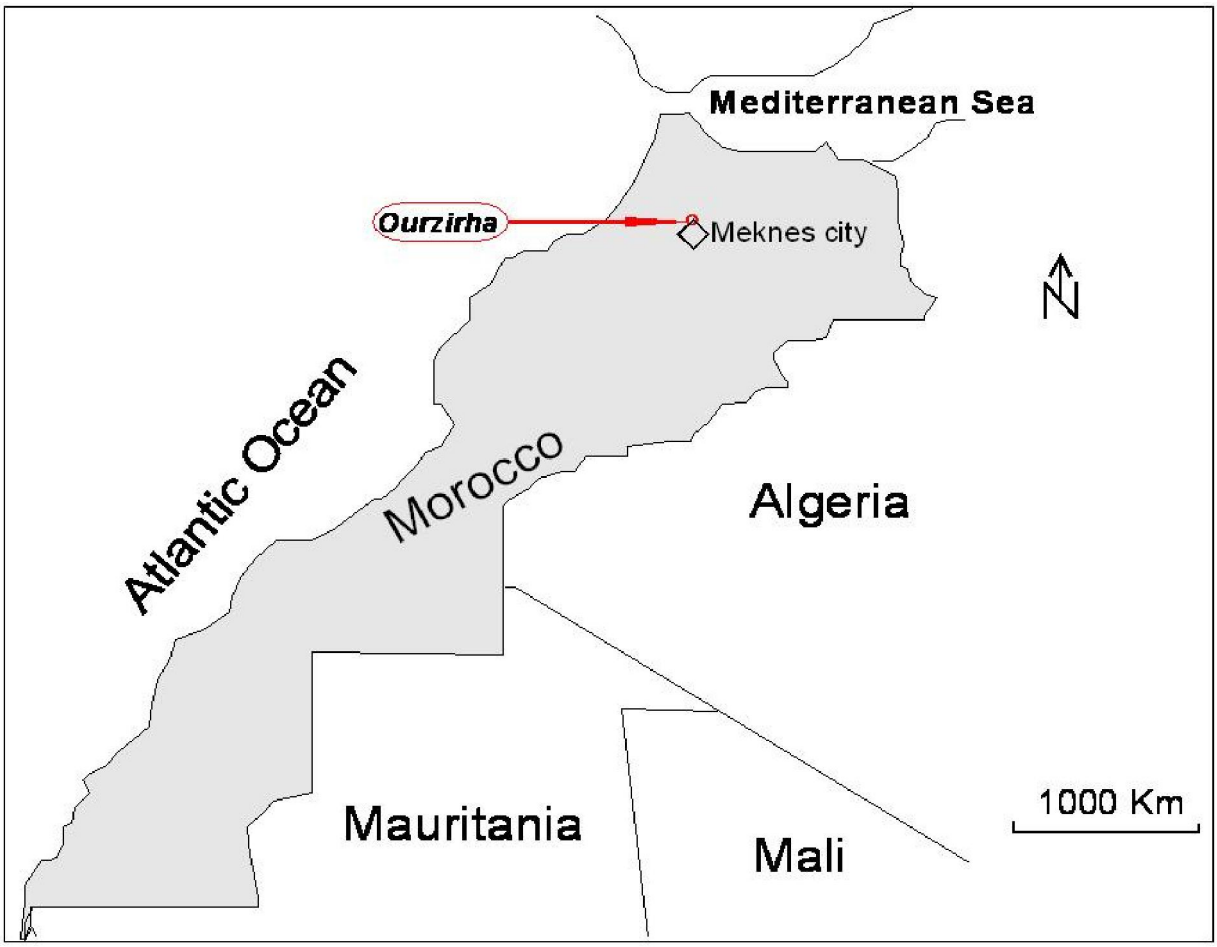

Fig. 1. Localization of the site of study

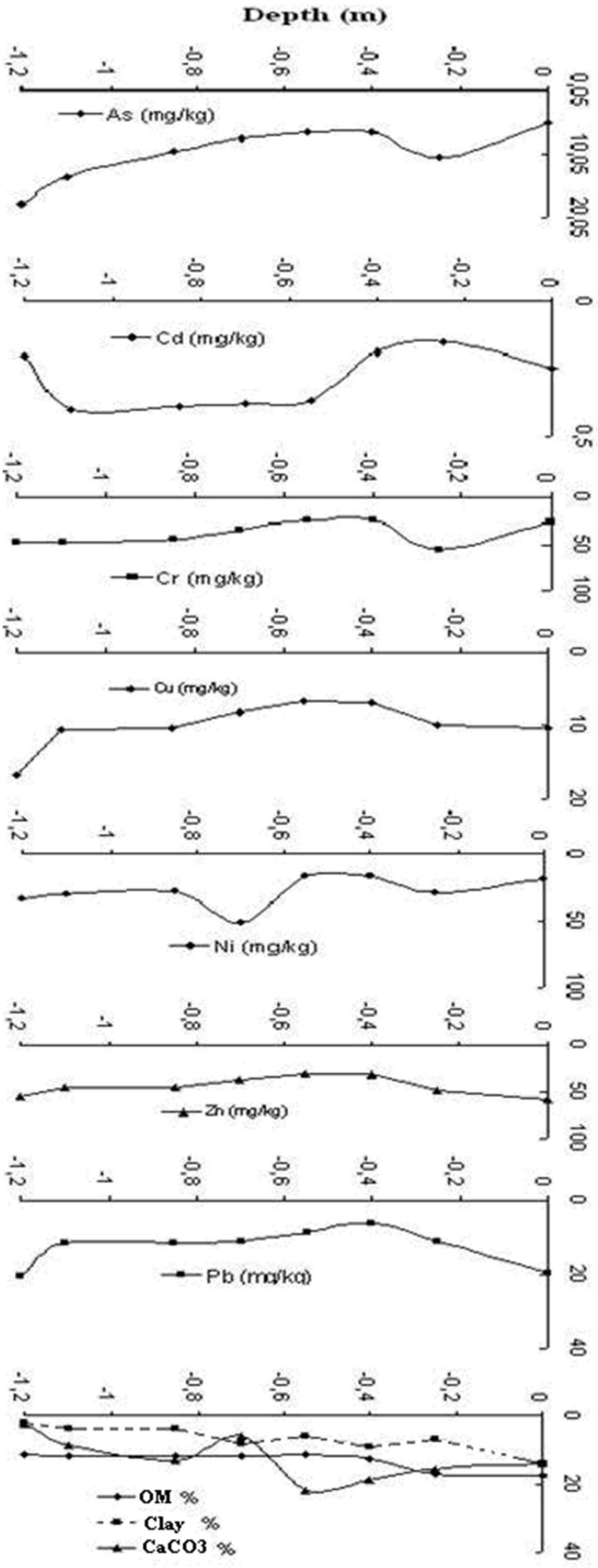

Fig. 2. Vertical variations of different parameters on calcareous soil profile; OM : organic matter.

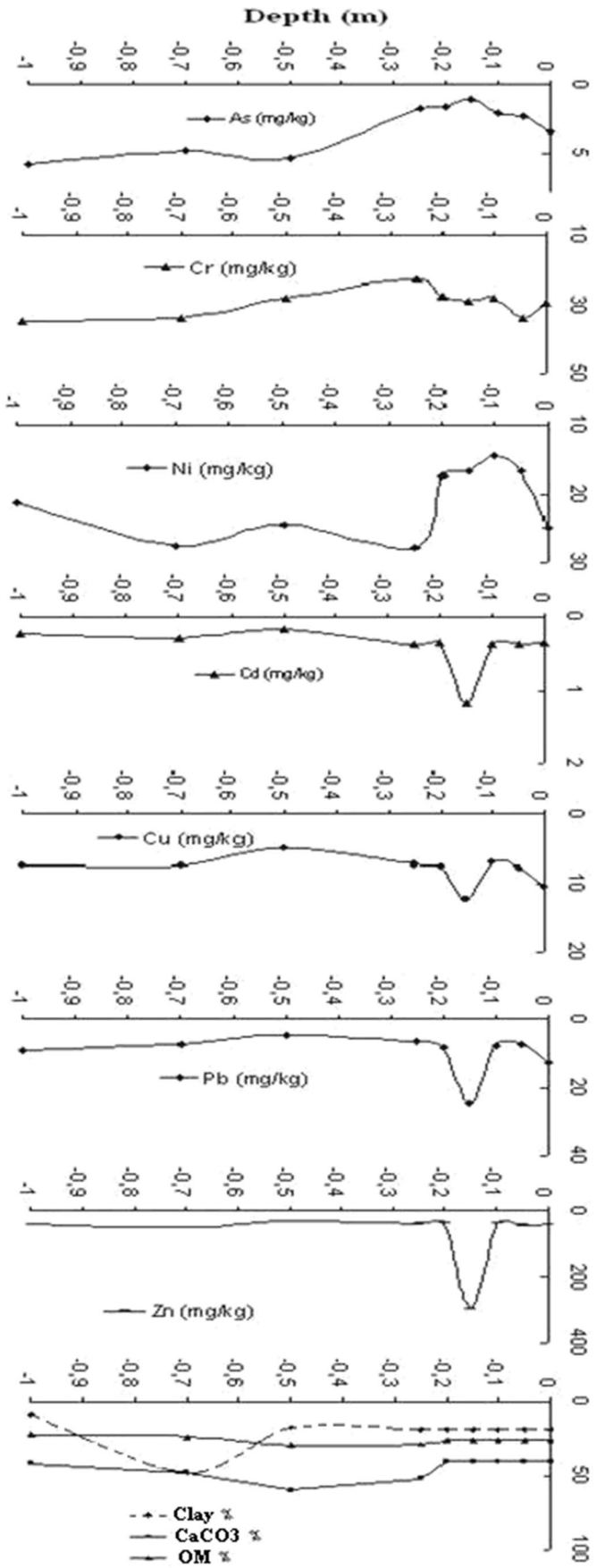

Fig. 3. Vertical variations of different parameters on vertisol profile; OM : organic matter

5 CONCLUSION

In this study the preliminary results show the major importance of active soil fraction, i.e., clay, organic matter and calcite in the Trace Elements retention in the two studied profiles. The contents of Trace Elements are fixed in majority in surface and in based profiles. After our analysis and different interpretations the more contents of organic matter in up-soil is a principal cause of this retention of trace elements in these layers on two profiles. The contents in bottom horizons are related to parental materials.

The dilution effect of calcite, - e.g., by a co-precipitation -, on pollutant contents is a major factor of the absence of positive anomalies in the calcareous profile. But, the importance Trace Elements contents in this profile, their different horizons haven't an abnormal accumulation. On the other hand, the vertisol profile showed an importance accumulation in surface soil, especially for Zn, Pb, Cd and Cu influenced by the exogenic contributions. And an important lixiviation on this profile through the macroporosity by particular transport with clay and organic matter essentially.

Finally, in the two profiles, the major role of calcite in the retention of the Trace Elements is quite illustrated, in particular on the calcareous soil, and also, the dominant importance of adsorption on the organic matter and clay in the upsoil.

These different results can be verified by the sequential extractions and/or a numerical models used for geochemical simulations with a specific software.

REFERENCES

[1] MADRPM (Ministère de l'Agriculture, du Développement Rural et des Pêches Maritimes), L'agriculture marocaine en chiffres. Brochure faite dans le cadre du Plan Maroc Vert, distribué dans la 5ème version du *SIAM*, du 28 Avril au 2 Mai 2009 à Meknès, 31p, 2009.

[2] Z. Ould Arby, A. Dekayir, and M. El Maataoui, ''Vertical Dynamics of the Trace Elements (TE) in Cultivated Soils Subject to an Application by the Sewage (Ourzirha, Meknes-Morocco),'' *European Journal of Scientific Research*, Vol. 43, n° 2, pp. 221-229, 2010.

[3] P.H Bourrelier, and J. Berthelin, Contamination des sols par les éléments en traces: les risques et leur gestion : Rapport n°42, Académie des Sciences, *Lavoisier*, 440p, 1998.

[4] G. Colinet, Eléments traces métalliques dans les sols : contribution à la connaissance des déterminants de leur distribution spatiale en région limoneuse Belge. Thèse de doctorat, *FUSA Gx*, 442p, 2003.

[5] C. Dère, Mobilité et redistribution à long terme des éléments traces métalliques exogènes dans les sols : Application à des Luvisols pollués par 100 ans d'épandage d'eaux usées brutes dans la plaine de Pierrelaye. Thèse de doctorat, *ENGREF*, 124p, 2006.

[6] D.G. Zaharescu, P.S. Hooda, A.P. Soler, J. Fernandez, and C.I. Burghelea, ''Trace metals and their source in the catchment of the high altitude Lake Respomuso, Central Pyrenees,'' *Science of the Total Environment*, n°. 407, pp. 3546–3553, 2009.

[7] C. Kabala, and B.R. Singh, ''Fractionation and Mobility of Copper, Lead, and Zinc in Soil Profiles in the Vicinity of a Copper Smelter,'' *J. Environ. Qual.*, n°. 30, pp. 485–492, 2001.

[8] A. Dube, R. Zbytniewski, T. Kowalkowski, E. Curowska, and B. Buszewski, ''Adsorption and Migration of Heavy Metals in Soil,'' *Polish Journal of Environmental Studies*, Vol. 10, n°. 1, pp. 1-10, 2001.

[9] X.Y. Zhang, F.F. Lin, M.T.F. Wong, XL Feng, and K. Wang, ''Identification of soil heavy metal sources from anthropogenic activities and pollution assessment of Fuyang County, China,'' *Environmental Monitoring and Assessment*, Vol. 154, n°. 1-4, pp. 439-449, 2009.

[10] M. El Idrissi, and L. Alla, Projet Intégré de Développement Agricole de Meknès, projet Meknès II, Carte pédologique de Meknès (deux feuilles). *Institut National de la Recherche Agronomique (INRA)*, Laboratoire Régional de Pédologie-Meknès (Maroc), Marché n°21/88, DPA-22, échelle 1 :50,000, 1988.

[11] M. Bonneau, and B. Souchier, Pédologie II: Constituants et propriétés du sol, *Masson*, pp. 619-654, 1994.

[12] M. Tahri, F. Benyaich, M. Bounakhla, E. Bilal, J.J. Gruffat, J. Moutte, and D. Garcia, ''Multivariate Analysis of Heavy Metal contents in soils, sediments and water in the region of Meknes (Central Morocco),'' *Environmental Monitoring and Assessment*, n°. 102, pp. 405–417, 2005.

[13] D. Baize, Guide des analyses courantes en pédologie : Choix–expression–présentation-interprétation, *INRA*, Paris, 272p, 1988.

[14] P. Hilavackova,. Evaluation de la mobilité du Zn et Cu dans une matrice de type sol à l'aide des différentes méthodes. Thèse de doctorat, *ISAL de Lyon*, 207p, 2005.

[15] Y-K. Marcellin, S-M. Bernard, A. Trokourey, and B. Yobou, ''Assessment of Sediments Contamination by Heavy Metals in a Tropical Lagoon Urban Area (Ebrié Lagoon, Côte d'Ivoire),'' *European Journal of Scientific Research*, Vol. 34, n° 2, pp. 280 -289, 2009.

[16] A. Dekayir, Z. Ould Arby, and M. El Maataoui, "Origins of trace elements in cultivated soils irrigated by sewage, Ourzirha Area (Meknes, Morocco),'' *Agriculture and Biology Journal of North America*, vol. 1, n°. 6, pp. 1140-1147, 2010.

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Recognition of plants by Leaf Image using Moment Invariant and Texture Analysis

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ABSTRACT: This paper presents a simple and computationally good method for plant species recognition using leaf images. Recognition of plant images is one of the research topics of computer vision. The use of shape for recognizing objects has been actively studied since the beginning of object recognition in 1950s. Several authors suggest that object shape is more informative than its appearance properties such as texture and color vary between object instances more than the shape. Initially we have scanned leaf images which are two dimensional in nature and segmented the images by mathematical morphological segmentation and then extracted the high frequency feature of image. For removing the noise, the image has been converted into binary, than complemented and multiplied by filtered image. We quantitatively establish the use of texture for detection various leaf images of same tree that are difficult by other classical methods of image processing. Further we use Nearest Neighborhood classification method to classify plant leaf. In this paper we focuses mainly on image enhancement, image segmentation, high frequency feature extraction, noise remove from background, volume fraction, inverse difference moment, moment invariant and morphological feature such as area convexity.

KEYWORDS: Plant leaf classification, Moment Invariants, Image Processing, PNN, PCA, Texture analysis, neural networks.

1 INTRODUCTION

Plant is one of the most important forms of life on earth. Plants maintain the balance of oxygen and carbon dioxide of earth's atmosphere. The relations between plants and human beings are also very close. In addition, plants are important means of livelihood and production of human beings. Ayurveda [17] is considered a form of alternative to allopathic medicine in the world. This system of medicine has a rich history with a number of ayurvedic leaves which can't be recognized by a human being. Plants can be classified according to the shapes, colours, textures and structures of their leaf, bark, flower, seedling and morph. Nevertheless, if the plant classification is based on only two dimensional images, it is very difficult to study the shapes of flowers, seedling and morph of plants because of their complex three dimensional structures. Plant leaves are two dimensional in nature and hold important features that can be useful for classification of various plant species. Therefore, in this research, the identification of different plants species is based on leaf features.

Research on the utilization of moments for object characterization in both in- variant and non-invariant tasks has received considerable attention in recent years [8, 9]. A substantial amount of work has been done on leaf shape based plant classification and recognition. Wu et al. [1] extracted 12 commonly used digital morphological features which were orthogonalized into 5 principal variables using PCA [24]. They used 1800 leaves to classify 32 kinds of plants using probabilistic neural network system [23]. Wang et al. [2] employed centroid contour distance (CCD) curve, eccentricity and angle code histogram (ACH). Fu et al. [3] also used centroid-contour distance curve to represent leaf shapes in which an integrated approach for an ontology-based leaf classification system is proposed. For the leaf contour classification, a scaled

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CCD code system is proposed to categorize the basic shape and margin type of a leaf by using the similar taxonomy principle adopted by the botanists. Then a trained neural network is employed to recognize the detailed tooth patterns.

Du et al. [4] an efficient computer-aided plant species identification (CAPSI) approach is proposed, which is based on plant leaf images using a shape matching technique. Firstly, a Douglas-Peucker approximation algorithm is adapted to the original leaf shapes and a new shape representation is used to form the sequence of invariant attributes. Then a modified dynamic programming (MDP) algorithm for shape matching is proposed for the plant leaf recognition. Finally, the superiority of our proposed method over traditional approaches to plant species identification is demonstrated by experiment.

Gu et al. [5] used the result of segmentation of leaf's skeleton based on the combination of wavelet transform (WT) and Gaussian interpolation. It is a a new approach for leaf recognition also using the classifiers, a nearest neighbour classifier (1-NN), a k -nearest neighbor classifier (k-NN) and a radial basis probabilistic neural network (RBPNN) are used, based on run-length features (RLF) extracted from the skeleton to recognize the leaves. Finally, the effectiveness and efficiency of the proposed method is demonstrated by several experiments. Wang et al. [6] extracted several geometric features like rectangularity, circularity, eccentricity and seven moment invariants for classification. He introduces a method of recognizing leaf images based on shape features using a hypersphere classifier.

Some [1],[3],[7] approaches employed artificial neural network for its fast performance. Others [5],[6] employed k-nearest neighbor (k-NN) classifier to classify plants. Du et al. [7] introduced shape recognition based on radial basis probabilistic neural network which is trained by orthogonal least square algorithm (OLSA) and optimized by recursive OLSA. Historically, Hu[8] published the first significant paper on the utilization of moment invariants for image analysis and object representation in 1961. Hu's approach was based on the work of the nineteenth century mathematicians Boole, Cayley and Sylvester on the theory of algebraic forms. Hu's Uniqueness Theorem states that if f(x, y) is piecewise continuous and has nonzero values only in the finite part of the f(x, y) plane, then geometric moments of all orders exist. It can then be shown that the moment set $\{ m_{pq} \}$ is uniquely determined by f(x, y) and conversely f(x,y) is uniquely determined by $\{ m_{pq} \}$.

T.H.Resis [9] stated that moment invariant for pattern recognition presented by hu is incorrect. The four moment absolute invariant under general linear transformation is in error. So he presented the revised fundamental theorem and gave the corresponding absolute moment invariant under general linear transformation. Sidhartha Maître [10] consider the change of effect of contrast in an image and modified the seven moment invariant given by M.K.HU which are independent of change of transformation, scale, rotation and contrast also.

Dr Dinesh P Mital[11] proposed an unsupervised texture segmentation technique using multi channel filtering. This simplicity is due to direct result of decomposition of the original image into several filtered images with limited spectral information. Somkait Udomhunsakul and Pichet Wongsita[12] proposed a feature extraction approach in medical magnetic resonance imaging (MRI).

Jan Fusser [19] proposed a new set of moment invariants with respect to rotation, translation, and scaling suitable for recognition of objects having -fold rotation symmetry. Du and Zhang [13] approach to a new classification method, named as move median centers (MMC) hyper sphere classifier, for the leaf database based on digital morphological feature is proposed. In particular, by comparing with the nearest neighbor (1-NN) and k-NN classifiers, it can be found that the MMC classifier can not only save the storage space but also reduce the classification time. The proposed method is more robust than the one based on contour features since those significant curvature points are hard to find.

An uncomplicated and computationally effective technique for plant species recognition by means of leaf image is recommended by Hossain and Amin [20]. A new technique for feature extraction from natural image like plant leaf is developed by Prasad et al. [21] for automated living plant species identification which would be helpful for botanical students to carry out their research for plant species identification. A novel multi-resolution and multidirectional Curvelet transform is executed on sub segmented leaf images to obtain leaf information, precisely in order that the orientation of the object in the image does not taken into account and which also enhance the accuracy rate. Abdul kadir [22] build a foliage plant identification system for 60 kinds of leaves. It was dedicated to handle two or more plants that have similar/same shape but the colour patterns on the leaves were different. In this case, Zernike moments were combined with other features: geometric features, colour moments and gray-level co-occurrence matrix (GLCM).

This paper presents an easy leaf recognition algorithm. Section 2 discusses image preprocessing and acquisition which includes the image enhancement and segmentation and high frequency feature extraction of a leaf images. Section 3 introduces the texture analysis and extraction of feature descriptors to classify leaf images i.e. parametric calculations as shown in Fig. 1 The plant classifier is presented in section 4 and section 5 discusses the result. Section 6 concludes this paper.

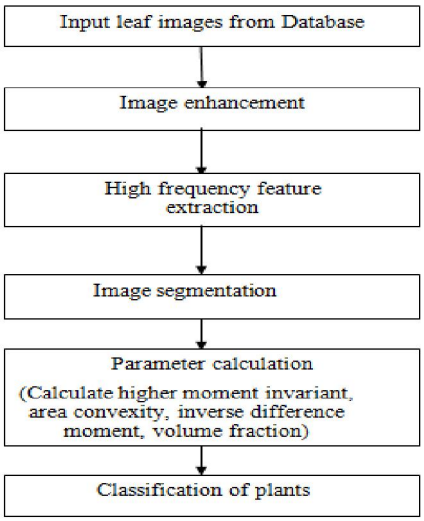

Fig. 1. Flowchart of our proposed Algorithm

2 IMAGE ACQUISITION AND PRE-PROCESSING

2.1 IMAGE ENHANCEMENT AND SEGMENTATION

The first thing which comes in our mind is that the margin of leaf which is essential for our preprocessing algorithm. We enhance our images by first converting into gray scale and then make 3*3 window and move this window from left to right and top to bottom calculates average of window in every move from left to right and top to bottom. If average of window pixel is greater than gray image pixel value d(x,y) then replace pixel value with average value otherwise value obtained by Gaussian function which is obtained by:

$$y = y + (y*c) / (1+ (1/ (2.71828^y)) \quad (1)$$

The purpose of segmentation is separation of leaf objects from background so that we can properly use the image features. The output of image segmentation is a binary image in which the leaf objects are numerically displayed with 1 and the background with 0. For segmentation we applied binary mathematical morphological algorithm [16],[18] based on shape of image. In morphological operation, opening in which erosion followed by dilation using 8 connected neighborhood has been performed. After applying above operation we get leaves of image shown in Fig. 2 of the complete image. Again to get branch we have performed dilation followed by erosion to segment image. The result is shown in Fig. 3.

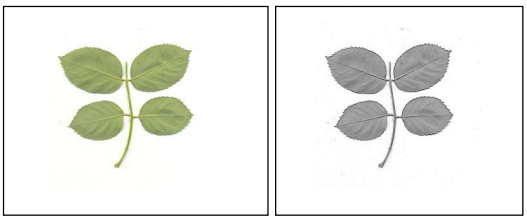

Fig. 2. Original Image (left) Enhanced Image (right)

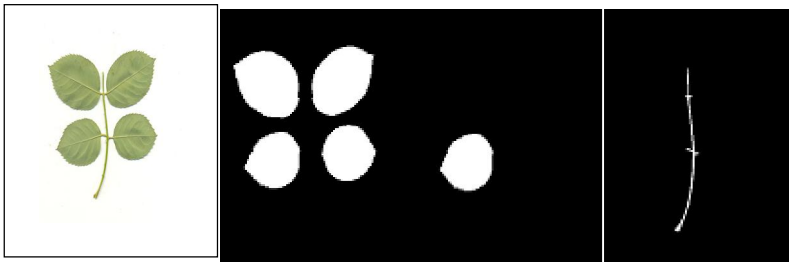

Fig. 3. Image Segmentation after Opening and Closing

2.2 HIGH FREQUENCY FEATURE EXTRACTION

In a leaf image, edges and sharpness of image contribute significantly to high-frequency content which contains an internal structure or texture of leaf `image which is same for that plant leaf. A high pass filter yields edge detection in the spatial domain, because edges contain many high frequency components. Areas of rather constant gray level consist of mainly low frequencies and are therefore suppressed.

For extraction of high frequency components of leaf images we take Fourier transform [14] and shift all low frequency components to center of the image. Further it is passed through Butterworth high pass filter and re-transform into the spatial domain. Then we attenuate low frequency components in leaf image as shown in the Fig. 4 and Fig. 5 and the pictorial representation of image preprocessing is given in Fig. 6.

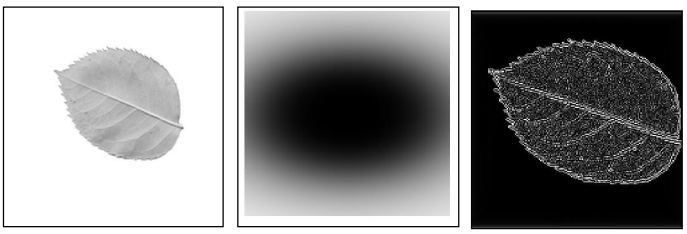

Fig. 4. Original image (left) Butterworth filter (middle) Filtered image (right)

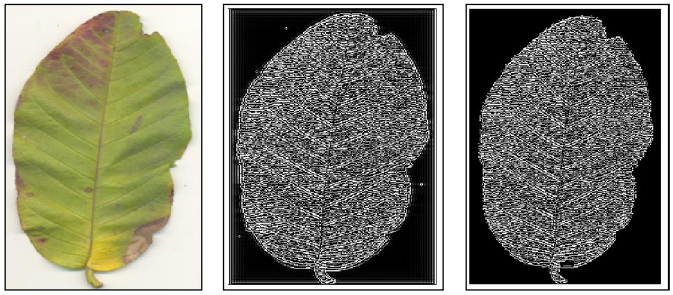

Fig. 5. Original image (left) filter image with noise (middle) Filtered image without noise (right)

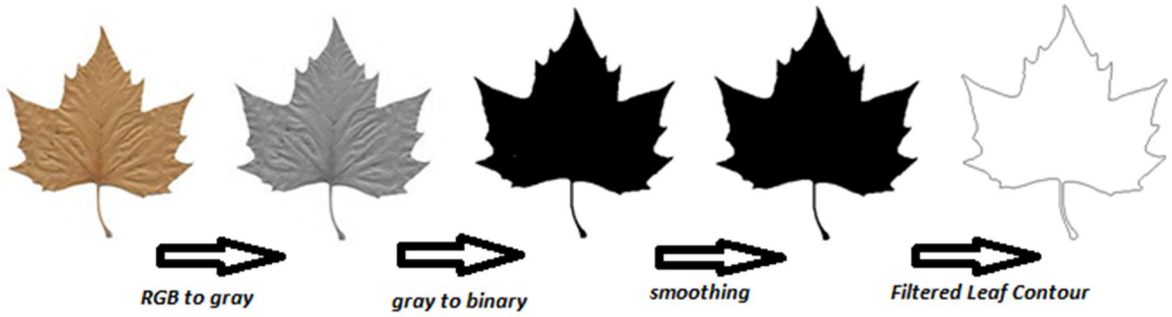

Fig. 6. A pre-processing example

3 DIFFERENT MORPHOLOGICAL FEATURE EXTRACTION AND PARAMETRIC CALCULATIONS

3.1 SMOOTH FACTOR

The effect of noises to image area is used to illustrate the smoothness of leaf image. Smooth factor is the ratio between area of leaf image smoothed by 5 × 5 rectangular averaging filter and the one smoothed by 2 × 2 rectangular averaging filter.

3.2 ASPECT RATIO

It is the ratio of length L to width W i.e. L/W.

3.3 LEAF AREA

Area is the actual number of pixels in the region. The area of leaf in a preprocessed image is the number of white or '1' pixels.

3.4 RECTANGULARITY

Rectangularity illustrates the similarity between a leaf and a rectangle. It is defined as LW/A, where L represents length, W denotes the width and A is the leaf area.

3.5 CIRCULARITY

Circularity is ratio involving area of the leaf A and square of perimeter P of the leaf. It can be defined as A/P^2.

3.6 ECCENTRICITY

A scalar value which specifies the eccentricity of the ellipse has the same second moments as the region. The eccentricity is the ratio of the distance between the foci of the ellipse and its major axis length. The value ranges between 0 and 1.

3.7 SOLIDITY

Solidity is defined as ratio between the area of the leaf and the area of its convex hull. It is defined as the S (area of leaf/ area of convex).

3.8 MOMENT INVARIANT

Moments and functions of moments have been extensively employed as invariant global features of images in pattern recognition. Image moment is a certain particular weighted average (moment) of the image pixel' intensities, or a function of such moments, usually chosen to have some attractive property or interpretation. The idea of using moments in shape recognition gained prominence when Hu, derived a set of seven invariants using algebraic invariants [8]. Here we calculate all seven moment invariants derived by Hu for different leaves of particular plant.

In particular, moment functional have attracted greet attention due to their mathematical simplicity and numerous physical interpretations. Let $\{\mu_n\}$ be a real sequence of numbers and let us define by (2)

$$\Delta^m \mu_n = \sum_{i=0}^{m} (-1)^i \left(\frac{m}{i}\right) \mu_n + i \tag{2}$$

Note that $\Delta^m \mu_n$ can be viewed as the m^{th} order derivative of μ_n.

A necessary and sufficient condition that there exists a monotonic function $F(x)$ satisfying the system is given by (3)

$$\mu_n = \int_0^1 x^n dF(x), \qquad n = 0,1,2,..... \tag{3}$$

It is that the system of linear inequalities.

$$\Delta^m \mu_n \geq 0 \qquad k = 0,1,2,..... \tag{4}$$

Should be satisfied i.e., if $f(x)$ is a positive function (which is the case in image processing), then the set of functional is given by (5)

$$\int_0^1 x^n f(x)dx, \qquad n = 0,1,..... \tag{5}$$

Completely characterizes the function.

Hu defines the following seven functions, computed form central moments through order three, that are invariant with respect to object scale, translation and rotation:

$$\phi_1 = \mu_{20} + \mu_{02}$$
$$\phi_2 = (\mu_{20} - \mu_{02})^2 + 4\mu_{11}^2$$
$$\phi_3 = (\mu_{30} - 3\mu_{12})^2 + 3(\mu_{21} + \mu_{03})^2$$
$$\phi_4 = (\mu_{30} - \mu_{12})^2 + (\mu_{21} + \mu_{03})^2$$
$$\phi_5 = (\mu_{30} - 3\mu_{12})(\mu_{30} + \mu_{12})[(\mu_{30} + \mu_{12})^2 - 3(\mu_{21} + \mu_{03})^2] + (3\mu_{21} - \mu_{03})(\mu_{21} + \mu_{03})[3(\mu_{30} + \mu_{12})^2 - (\mu_{21} + \mu_{03})^2]$$
$$\phi_6 = (\mu_{20} - \mu_{02})[(\mu_{30} + \mu_{12})^2 - (\mu_{21} + \mu_{03})^2] + 4\mu_{11}(\mu_{30} + \mu_{12})(\mu_{21} + \mu_{03})$$
$$\phi_7 = (3\mu_{21} - \mu_{03})(\mu_{30} + \mu_{12})[(\mu_{30} + \mu_{12})^2 - 3(\mu_{21} + \mu_{03})^2] - (\mu_{30} - 3\mu_{12})(\mu_{21} + \mu_{03})[3(\mu_{30} + \mu_{12})^2 - (\mu_{21} + \mu_{03})^2]$$

3.9 VOLUME FRACTION

Volume fraction can be used as a feature descriptor to identify plant. Let w be the raster grid of pixels and ϕ be the pixel with value one. Then volume fraction is estimated by using (6)

$$\rho = \frac{v(\phi)}{v(w)} \tag{6}$$

Where v the number of the pixel having value one and $v(w)$ is the total number of pixels. This feature can be used for distinguishing between various leaf images from different plants.

3.10 INVERSE DIFFERENCE MOMENTS

An image texture is a set of metrics computed in image processing intended to enumerate the apparent texture of a leaf image. Leaf Image Texture gives information regarding the spatial arrangement of color or intensities in a leaf image or selected region of a leaf image. The recognition of explicit textures in an image is achieved principally by modeling texture as a two dimensional gray level variation. The resultant two dimensional arrays are called as Gray Level Co-occurance Matrix (GLCM).Inverse difference moment is one of the feature descriptor of GLCM use to identify texture image. This parameter is also called Uniformity. Inverse Difference Moment is also called the "Homogeneity". Mathematically, it can be written as:

$$\sum_{i,j} \frac{P(i,j)}{1+|i-j|} \tag{7}$$

3.11 AREA CONVEXITY

Convexity is any line drawn through the object (and not tangent to an edge or corner) meets its boundary exactly twice and area convexity is related to the geometry of the shape. Area convexity defines that how many times a single line can cut the closed inner or outer geometry of the shape; whether it is the simple closed region or complex closed region. It is the ratio of the perimeter of the convex hull of the sample (Pconvex Hull) over the actual perimeter of the sample (*P*).

4 PLANT CLASSIFIER

In our experiment, the seven features that are potentially insensitive to changes in image size, shape are searched and extracted from the images. We used the nearest neighborhood classifier in our study. We measure seven features descriptor of different plant leaves and stored in dynamic matrix M. further we generate an xls sheet and write this matrix in xls sheet which is stored in our current program directory. After that enter a test image which is also from one of them plant but not

that leaf which we have taken. In our experiment we find the Euclidean distance of test image from all stored image into M and search which image has minimum distance from test image that image is our matched image. We perform our experiment on more than 300 leaves of 14 different plants.

Let M is our matrix where we stored features vectored of different images

$$M = \begin{bmatrix} m_{11} & m_{12} & .... & .... & m_{1j} \\ m_{21} & m_{22} & ..... & ..... & m_{2j} \\ ..... & .... & ..... & ..... & ..... \\ ..... & .... & ..... & ..... & ..... \\ m_{i1} & m_{i2} & ..... & ..... & m_{ij} \end{bmatrix}$$

Where m_{ij} is j^{th} feature vector of i^{th} image

Parameter of test image is measure and is represented by

$$A = \begin{bmatrix} a_{11} & a_{12} & ..... & ..... & a_{1j} \end{bmatrix} \quad (8)$$

Where a_{1j} is jth feature vector of test image

For recognition of leaves Euclidean distance are measure from the stored parameter in the xls sheet of program directory with the test image and minimum distance show the possible matching with test image

$$R(1)=(a11-m11)^2+(a12-m12)^2+(a13-m13)^2+(a14-m14)^2+(a15-m15)^2 \quad (9)$$

$$R(2)=(a11-m21)2+(a12-m22)2+(a13-m23)2+(a14-m24)2+(a15-m25)2 \quad (10)$$

$$R(3)=(a11-m31)2+(a12-m32)2+(a13-m33)2+(a14-m34)2+(a15-m35)2 \quad (11)$$

$$R(4)=(a11-m41)2+(a12-m42)2+(a13-m43)2+(a14-m44)2+(a15-m45)2 \quad (12)$$

$$R(5)=(a11-m51)2+(a12-m52)2+(a13-m53)2+(a14-m54)2+(a15-m55)2 \quad (13)$$

$$R(6)=(a11-m61)2+(a12-m62)2+(a13-m63)2+(a14-m64)2+(a15-m65)2 \quad (14)$$

5 RESULT AND DISCUSSION

We prepare our database for the experimental use. The database contains various leaves with various shapes, colors and size. Experiment was done with these different leaves of different classes and tested in our classifier. First we read different leaf images of plant and finally match the new input image with our previous class or tree. We checked the accuracy that it matches the actual image or not. For all the 320 leaves of different 14 plants taken, which are completely different in their shape, color. The various parameters like volume fraction are found to be from 0.30528 to 0.38267 which is within 10 percent variation as shown in Fig. 7. Like all previous image feature descriptor parameter, inverse difference moment also have same value or variation within 10 percent as shown in Fig 8. Hence, this feature can be distinguishing plant leaf images. We calculate area convexity of more than 20 leaf of one plant shown in Fig. 9 which is different in size and color and value of area convexity of each leaf of same plant is coming out to be same or variation within 5 percent.

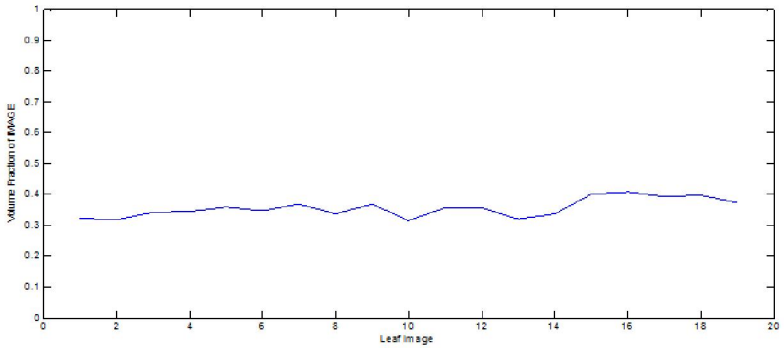

Fig. 7. Volume Fraction of Different Leaf of same plant image

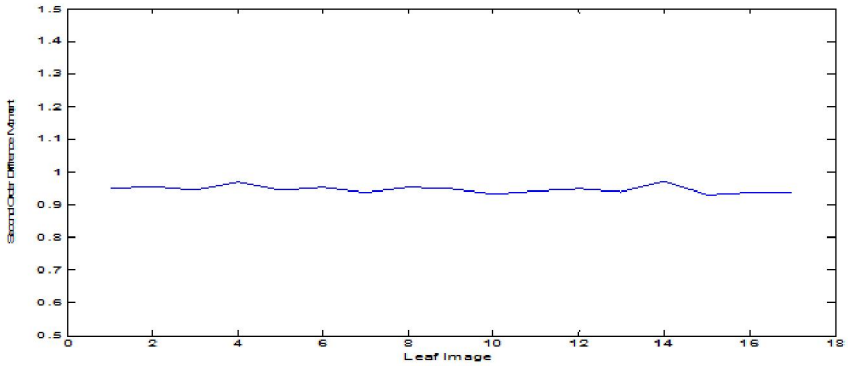

Fig. 8. Inverse Difference Moment of Different Leaf of Same Plant Image

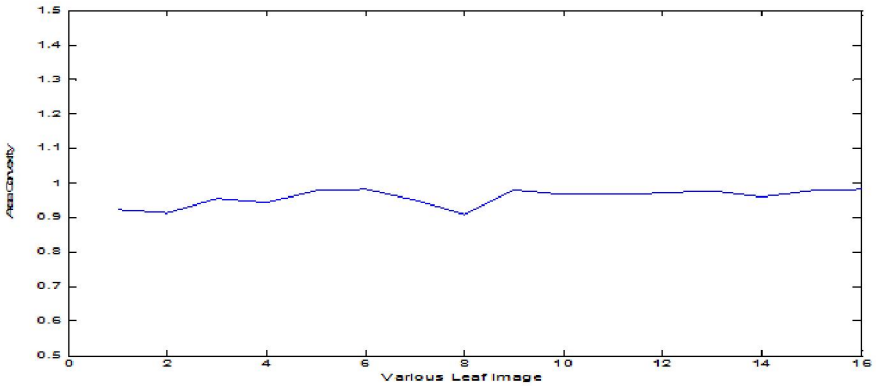

Fig. 9. Area Convexity of Different Leaf of Same Plant Image

All the experiments are programmed by Matlab[15] and run on Intel(R) core i-3 with the clock of 2.40 GHz and the RAM of 2GB under windows 7 environment. The database subset of some leaf images are shown in Fig. 10 and the experimental work done can be understand by Fig. 11, Fig. 12 and Fig. 13. The Details about the Leaf Numbers of Different Types of Plants are given in Table 1.

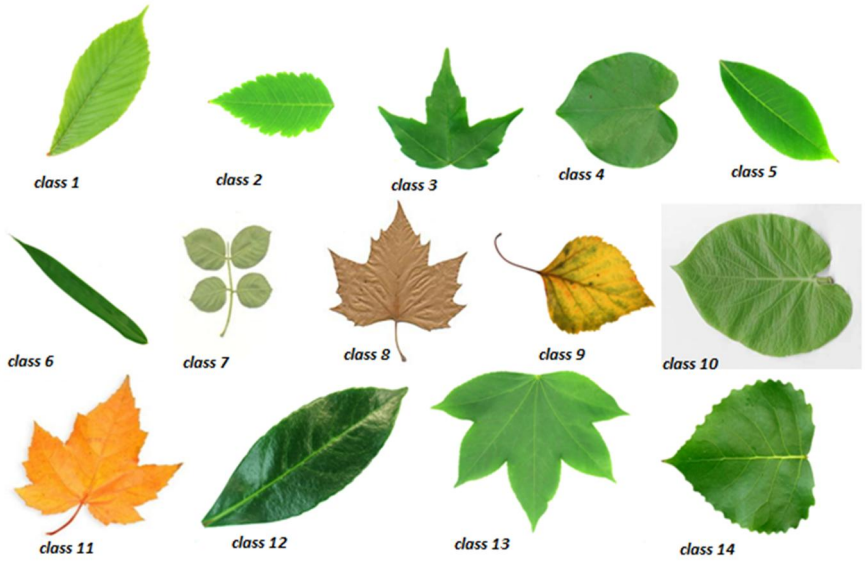

Fig. 10. Samples of leaf images belonging to the 14 classes

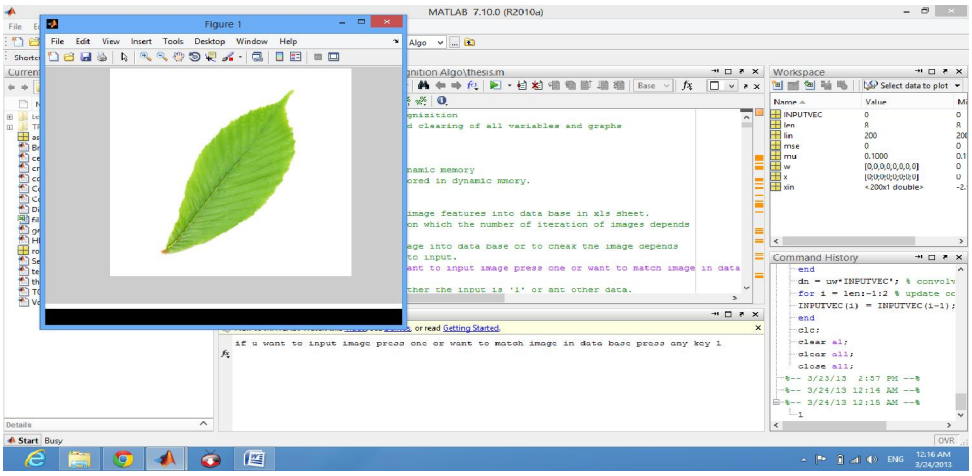

Fig. 11. Input processing with one leaf in experiment

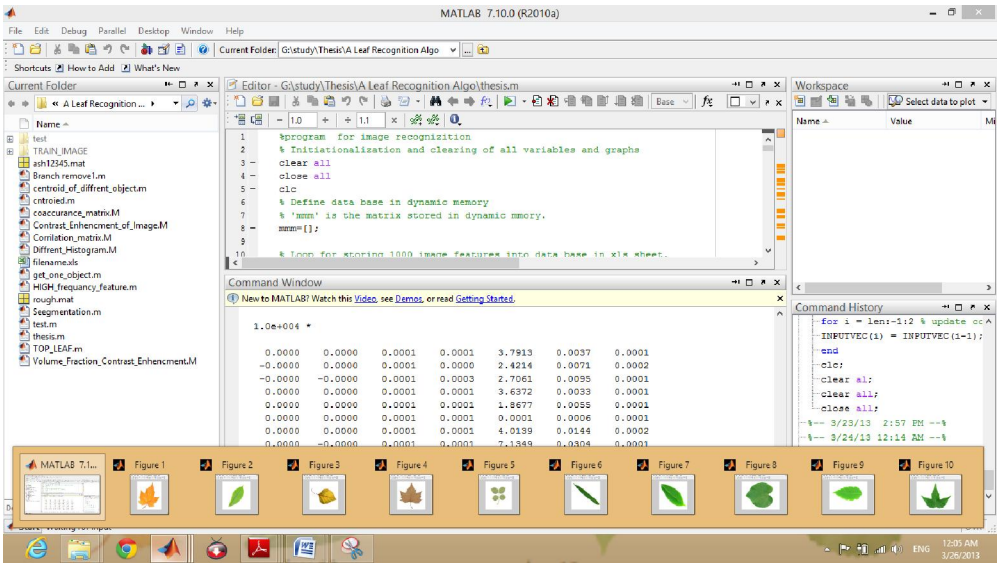

Fig. 12. Experimental process with different leaf

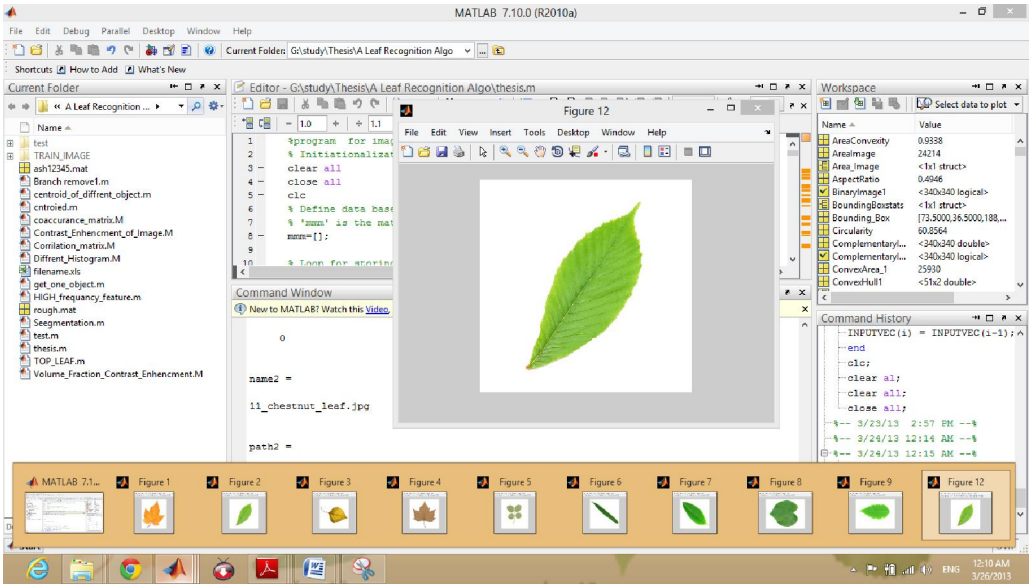

Fig. 13. Experimental result with the matched leaf

The following result will be displayed on the MATLAB command window, like this:

(Minimum distance of all calculated data base image into test image) sawq = 0.002

name2 = chestnut_leaf.jpg

path2 = G:\study\Thesis\A Leaf Recognition Algo\Leaves_IMAGE\

Table 1. Details About the Leaf Numbers of Different Types of Plants

Class	Common Name	No. of leaf samples	No. of incorrect recognition
Class 1	Chestnut leaf	20	2
Class 2	Golden rain tree	22	0
Class 3	Trident maple	23	4
Class 4	Chinese redbud	25	3
Class 5	Horse chestnut	25	1
Class 6	Bamboo	25	1
Class 7	Rose	20	3
Class 8	Eenbruinigherfstblad	5	1
Class 9	Autumn leaf	15	0
Class 10	Pipe	30	2
Class 11	Golden Maple Leaf	25	4
Class 12	Japan Arrowwood	22	1
Class 13	Castor aralia	28	2
Class 14	Canadian poplar	25	3

The experiment is designed to illustrate the performance of two feature extraction methods, Gray Level Co-occurrence Matrix (GLCM) and Moment Invariant. GLCM method in leaf recognition for the degrees 0° and 90° gave the same accuracy and same result. Here the poor result is in the 45° degree. Because any changes in the neighboring distance or the neighboring degree it will change the value of extracted texture feature. The GLCM method is very sensitive for the any changes in the images such rotation, scale and etc. Image processing techniques are used for extracting the morphological parameters that are having some significance and effect on the classification of the leaves. Out of total sample of 320 leaves of 14 kinds of plants 293 were classified and 27 were misclassified, that is, a recognition accuracy of 91.5%.

6 CONCLUSION

In this paper we propose an automated system for plant identification using shape features of their leaves. It has been found that four parameters that are area convexity, volume fraction, moment invariant, inverse difference moment, provide better results. We conclude that it is a feasible alternative for classifying structurally complex images. They offer exceptional invariance features and reveal enhanced performance than other moment based solutions. The experimental results explained that the proposed method is effective. However, some other works will be explored to obtain better performance. Our future research works will include how to classify the leaves with deficiencies and combine adaptive neural networks to increase the more correct recognition rate.

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REFERENCES

[1] S. Wu, F. Bao, E. Xu, Y. Wang, Y. Chang, and Q. Xiang, "A Leaf Recognition Algorithm for Plant Classification Using Probabilistic Neural Network," IEEE 7th International Symposium on Signal Processing and Information Technology, December 2007.

[2] Z. Wang, Z. Chi, and D. Feng, "Shape based leaf image retrieval," IEEE Proceedings Vision, Image and Signal Processing, vol. 150, no. 1, February 2003.

[3] H. Fu, Z. Chi, D. Feng, and J. Song, "Machine learning techniques for ontology-based leaf classification," IEEE 2004 8th International Conference on Control, Automation, Robotics and Vision, Kunming, China, 2004.

[4] J. Du, D. Huang, X. Wang, and X. Gu, "Computer-aided plant species identification (CAPSI) based on leaf shape matching technique," Transactions of the Institute of Measurement and Control. 28, 3 (2006) pp. 275-284.

[5] X. Gu, J. Du, and X. Wang, "Leaf recognition based on the combination of wavelet transform and gaussian interpolation," in Proceedings of International Conference on Intelligent Computing 2005, ser. LNCS 3644. Springer, 2005.

[6] X. Wang, J. Du, and G. Zhang, "Recognition of leaf images based on shape features using a hypersphere classifier," in Proceedings of International Conference on Intelligent Computing 2005, ser. LNCS 3644. Springer, 2005.

[7] J. Du, D. Huang, X. Wang, and X. Gu, "Shape recognition based on radial basis probabilistic neural network and application to plant species identification," in Proceedings of 2005 International Symposium of Neural Networks, ser. LNCS 3497. Springer, 2005.

[8] M K HU, "Visual pattern recognition by moment invariants," IRE Trans. Info Theory, vol IT-8, pp. 179-187, Feb. 1962.

[9] T.H. Reiss, "The Revised Fundamental Theorem of Moment Invariants", IEEE Trans. Pattern Anal. Machine Intell., Vol. PAMI-13, No. 8, August 1991, pp 830-834.

[10] Sidhartha Maître, "Moment invariant ",IEEE Preceding vol. 67, no. 4,april 1979.

[11] Cho-Huak Teh, and Roland T. Chin, "On Image Analysis by the Methods of Moments", IEEE transaction on pattern analysis and machine intelligence vol.10 no.4 july 1988.

[12] Somkait Udomhunsakul, Pichet Wongsita," Feature Extraction in Medical MRI Images" Proceedings of the 2004 IEEE Conferenc on Cybernetics and Intelligent Systems Singapore, 1-3 December, 2004.

[13] J.-X. Du, X.-F. Wang and G.-J. Zhang, "Leaf shape based plant species recognition," Applied Mathematics and Computation, vol. 185, 2007.

[14] R. N. Bracewell, "The Fourier Transform and Its Applications". New York: McGraw Hill, 1978.

[15] www.mathwork.com

[16] Pge. Bonanova and Barcelona. Spain," Unsupervised morphological segmentation of objects in contact", Seizieme Colloque Gresti —15-19 Septemeber 1997 —Grenoble.

[17] Sandeep kumar E. "Leaf, colour, Area and Edge Features Based Approach for Identification of Indian Plants" Indian Journal of Computer Science and Engineering (IJCSE), ISSN: 0976-5166, Vol. 3 No.3 Jun-Jul 2012.

[18] R. C. Gonzalez, R. E. Woods, "Digital Image Processing". Prentice Hall, 2004.

[19] Jan Flusser, "Rotation Moment Invariants for Recognition of Symmetric Objects," IEEE Trans. On image processing, vol. 15, no. 12, pp. 3784-3790, December 2006.

[20] J. Hossain and M.A. Amin, "Leaf shape identification based plant biometrics", 13th International Conference on Computer and Information Technology (ICCIT), Pp. 458-463, 2010.
[21] S. Prasad, P. Kumar and R.C. Tripathi, "Plant leaf species identification using Curvelet transform", 2nd International Conference on Computer and Communication Technology (ICCCT), Pp. 646–652, 2011.
[22] Abdul Kadir, L.E. Nugroho, A.susanto, P.Insap Santosa, "Experiments of Zernike Moments for Leaf Identification", Journal of Theoretical and Applied Information Technology, 15 July 2012. Vol. 41 No.1.
[23] V. Cheung and K. Cannons, "An Introduction to Probabilistic Neural Networks", [Online] Available: http://www.psi.toronto.edu/~vincent/research/presentations/PNN.pdf, (2003).
[24] J. Slens, "A Tutorial on Principal Component Analysis", [Online] Available: http://www.snl.salk.edu/~shlens/pca.pdf (2009).

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Introduction to the Extreme Value Theory applied to operational risk

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ABSTRACT: This paper aims to present the main lines of the Extreme Value Theory applied to the operational risk. The idea is to present a methodology which allows to identify a threshold by type of risk, and to feign the losses below the threshold with the classical laws, and the losses above with a Generalized Pareto Distribution (GPD).
The adequacy of the data to the law GPD allows to consider an extreme quantile, as minimal strategy, sensitive to the size of samples, and to plan random costs whose probability of occurrence is very low, but the choice of the threshold beyond of which the observation will be judged extreme, is a point to be handled with precaution, even if we propose a technique to quantify this threshold.
Furthermore, the costs of extreme losses do not lend themselves to modeling; by definition this type of costs is rare, and the forecasts or the estimations must be often established with a big distrust, and outside the available data. The models must be used in a supple way, without believing completely to the limit.
The adoption of this method could allow the risk managers to observe the extreme events with a certain objectivity, to check the hierarchical organization of the classes of operational risks, and in the other hand, establish reserves to face these risks.

KEYWORDS: Extreme Value Theory, operational risk, threshold, GPD, extreme losses, extreme events.

1 INTRODUCTION

The everyday life of the practitioner of the statistics or the econometrist in company is to work on data which are often rebellious to the analysis. Data are missing, atypical; errors of seizure, hostility, coding, bad voluntary or involuntary statements. The location of all these imperfections is probably not the most rewarding aspect of the work, even though the methodological aspects can be completely interesting. Anyway, it is essential to the production of reliable and robust indicators.

The classic Extreme Value Theory, or based on the law of Generalized Pareto does not solve all these difficulties at once, but it provides binoculars through which practitioners can observe the extreme events with a certain objectivity, on the one hand in order to control the hierarchical organization of the classes of risk, and on the other hand, to establish reserves to cope with these extreme risks.

Thus, the Extreme Value Theory provides a number of tools probabilistic and statistical modeling of rare events [1], that we may be useful for modeling serious operational risks. In this paper, we present the main lines of this theory, and we will see how it can be applied to operational risk.

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2 PRESENTATION OF THE APPROACHES

There are two main approaches:

- The maxima approach, or Block Method, which consists in observing and in modelling the values of maximal losses. If we argue about the whole sample, we shall have only one maximum.

  To have a number of observations of maximum, It is necessary to cut the sample and to set maximum for every block. We so obtain a number of maxima equal to the number of blocks.

  The theorem of Fisher Tippett supplies us the limit theorem for the maximum of normalized. This law is the law of the Generalized Extreme Value. It is necessary to use then our observed Maxima to calibrate it.

- The approach said « Peaks Over Threshold (POT) », Which consists in considering the values beyond a threshold and either only the maximum. All the difficulty comes in choosing an appropriate threshold, which will allow to apply the Pickands theorem.

  This theorem allows to model the excess by Generalized Pareto Distribution (GPD). This approach is more usually used than the approach of maxima, because she allows to exploit more information supplied by the selected sample.

3 MAXIMA APPROACH

Let $(x_1, x, \dots x_n)$ a given sample representing the cost of losses.

In practice, the maximum sample size $x_{(n)}$ represent only one observation, it is not possible to rely on a single observation to our modeling.

The idea is to split the sample into m samples of size n / m obtaining m maximum values.

Then the Fisher-Tippett theorem gives us the law of maximum.

The Fisher-Tippett theorem :

Let $(X_1, X, \dots X_n)$ be a sequence of independent random variables and identically distributed with distribution function F_X.

Let us note: $X_{n:n} = max\left(X_1, X_{1,} \dots X_n\right)$.

If there are two sequences of reals $(a_n) \in R\ et\ (b_n) > 0$ and a law Non-degenerate distribution function G such as $\frac{X_{n:n} - a_n}{b_n} \rightarrow G$

Then G is necessarily in one of these three forms:

Fréchet	Weibull	Gumbel
$\Phi_\alpha(x) = \begin{cases} 0 & if\ x \le 0 \\ \exp(-x^{-\alpha}) & if\ x > 0 \end{cases}$	$\Psi_\alpha(x) = \begin{cases} \exp(-(-x)^{-\alpha}) & if\ x \le 0 \\ 1 & if\ x > 0 \end{cases}$	$\Lambda(x) = \exp(-e^{-x}) \quad for\ x \in \Re$

These three distributions are the special case of the GEV (Generalized Extreme Value):

$$G_{\mu,\sigma,\xi}(x) = \begin{cases} \exp\left(-(1+\xi.\frac{x-\mu}{\sigma})^{-1/\xi}\right), & if\ (1+\xi.\frac{x-\mu}{\sigma})^{-1/\xi} > 0 \quad and\ \xi \neq 0, \\ exp\left(-exp\left(-\frac{x-\mu}{\sigma}\right)\right), & if\ (1+\xi.\frac{x-\mu}{\sigma})^{-1/\xi} > 0 \quad and\ \xi = 0. \end{cases}$$

- ξ represents the index of extreme values. The more it will be higher in absolute value, the more the weight of extremes in the initial distribution will be important.
- μ the location parameter. It indicates approximately the heart of the distribution.
- σ the scale parameter. It shows the spread of extremes.

Fréchet	Weibull	Gumbel
$\xi = \alpha^{-1} > 0$ $\mu_n = 0$ $\sigma_n = F^{-1}\left(1 - \frac{1}{n}\right)$	$\xi = -\alpha^{-1} < 0$ $\mu_n = x_F$ $\sigma_n = x_F - F^{-1}\left(1 - \frac{1}{n}\right)$	$\xi = 0$ $\mu_n = F^{-1}\left(1 - \frac{1}{n}\right)$ $\sigma_n = \frac{1}{S(\mu_n)} \int_{\mu_n}^{\infty} S(t)dt$

Where $S(X) = 1 - F(X)\ and\ x_F = sup\{x\ as\ \ F_X(x) < 1\}$

The F_X distribution function affects the limit distribution G, that is to say on parameters, it is called in the domain of attraction of G.

The Extreme Value Theory allows us to know the laws that belong the three domains of attractions:

- The laws of Cauchy, Pareto, Student and LogGamma belong to the domain of attraction of the Fréchet distribution : they are laws to « thick tails »,
- The laws of Weibull, Normal, Exponential, Gamma and Log-Normal belong to the domain of attraction of the Gumbel distribution : they are laws to « fine and medium tails »,
- Uniform and Beta laws belong to the domain of attraction of the Weibull distribution : they are laws to « fine tails ».

Thus, if we know the law claims, we can deduce the law of maximum. However, in practice we do not know the law of our theoretical sample and the parameters must be estimated by statistical methods. There are several methods to estimate the parameters: we can distinguish parametric and nonparametric approaches.

Parameter estimation by the method of maximum likelihood:

Let us consider the sample of maxima on the m samples created, noted : $(M_1, M_2 \dots, M_m)$.

The log-likelihood can be written:

For $\xi \neq 0$,

ln $L(M_1, \dots, M_m;\ \xi, \mu, \sigma) = \sum_{i=1}^{m} \ln(h_{\xi,\mu,\sigma}(M_i))$

$$= -m\ ln\ \sigma - (\frac{1+\xi}{\xi}) \sum_{i-1}^{m} \ln(1 + \xi \frac{M_i - \mu}{\sigma}) - \sum_{i=1}^{m} \ln(1 + (\xi \frac{M_i - \mu}{\sigma})^{-1/\xi})$$

Where $h_{\xi,\mu,\sigma}$ is the density of the Generalized Extreme Value (GEV).

$$h_{\xi,\mu,\sigma} = \begin{cases} \frac{1}{\sigma}\left[1 + \xi(\frac{x-\mu}{\sigma})\right]^{-\left(\frac{1+\xi}{\xi}\right)} \exp(-(1 + \xi\left(\frac{x-\mu}{\sigma}\right)^{-\frac{1}{\xi}}), & if (1 + \xi\left(\frac{x-\mu}{\sigma}\right)^{-\frac{1}{\xi}}) > 0, \xi \neq 0, \\ \frac{1}{\sigma}\exp\left(-\frac{x-\mu}{\sigma} - \exp\left(\frac{x-\mu}{\sigma}\right)\right), & if\ \xi = 0. \end{cases}$$

The solution of this equation can be done by numerical methods (Quasi-Newton algorithm). In practice, we can use the predefined functions of the statistical software such as R[1] software.

Note: When the sample size is small, the estimator of the maximum likelihood provides a biased estimate.

In the case ξ = 0, the log-likelihood can be written :

ln $L(M_1, \dots, M_m;\ \xi, \mu, \sigma)$= -n ln $\sigma - \sum_{i=1}^{m} \exp(-\frac{M_i-\mu}{\sigma}) - \sum_{i=1}^{m} \frac{M_i-\mu}{\sigma}$.

The resolution is still by numerical methods.

Maxima approach is used in cases where we have periodic observations. In the context of operational risk, this method cannot be applied to the extent that we do not necessarily observations every months and not much recoil.

4 « PEAKS OVER THRESHOLD (POT) » APPROACH

This method [2] aims to model the distribution of the observations beyond a threshold by the Generalized Pareto distribution through the following theorem:

Pickands theorem-Balkema-de Haan:

Let X be a random variable of distribution function F_X. .

$$\lim_{n\to\infty} P(\frac{X_{n,n} - b_n}{a_n} \leq x) = G(x) \Leftrightarrow \lim_{u\to X_F} sup_{[0,X_F]} \left\| F_X^u(x) - G_{\xi,\sigma(u)}(x) \right\| = 0$$

With $x_F = sup\{x\ as\ F_X(x) < 1\}, F_X^u(x) = P(X - u \leq x | X > u)$ and $G_{\xi,\sigma}$ is the distribution function of the Generalized Pareto Distribution:

$$G_{\xi,\sigma}(x) = \begin{cases} 1 - (1 + \xi x/\sigma)^{(-1/\xi)} & if\ \xi \neq 0 \\ 1 - e^{(-x/\sigma)} & if\ \xi = 0 \end{cases}$$

Note: the tail index involved in the maximum limit is identical to the ξ parameter of the GPD.

For a fixed threshold u, the Excess distribution function over this threshold may be written:

$$F_X^u(x) = P(X - u) \leq x | X > u) = \frac{P(X \leq x+u \cap X > u)}{P(X>u)} = \frac{F_X(x+u) - F_X(u)}{1 - F_X(u)}$$

u must be sufficiently large so that we can apply the above result, but u should not be too large in order to have enough data to obtain good estimators. Typically, u is determined graphically. For sample sizes less than 500, the number of excess is between 5 and 10% of the sample.

Methods to determine the threshold u:

Let us define the Mean Excess Function, it is about the expectation of excess, knowing that the losses exceed the threshold:

$$e(u) = E(X - u | X > u) = \int_u^{x_F} (y - u) \frac{dF_X(y)}{1 - F_X(u)}\ with\ x_F = \{x\ as\ F_x(x) < 1\}$$

[1] R is a software environment for statistical computing and graphics. It compiles and runs on a wide variety of UNIX platforms.

This function can be estimated by the Mean Excess Function:

$$e_n(u) = \frac{\sum_{i=1}^{n}(X_i - u)}{\sum_{i=1}^{n} I_{\{X_i > u\}}}$$

For $v \geq u, E\{X - v | X > v\} = \frac{\sigma(u) + \xi \times (v-u)}{1-\xi}$ if the excess over the threshold follow a GPD.

The conditional expectation of excess is a linear function of v, where v is greater than the reference threshold u. This provides a way to test if the empirical u threshold chosen for the calculations is sufficiently high, the expectations of the excesses over higher thresholds must be aligned on a straight line of slope $\frac{\xi}{1-\xi}$.

Hill estimator : it is an estimator of the tail index which is only valid for $\xi > 0$, is written :

$$\hat{\xi}_{k,n}^{H} = \frac{1}{k(n)} \sum_{i=n-k(n)+1}^{n} lnX_{(i,n)} - lnX_{(n-k(n)+1,n)}$$

An alternative approach to the « mean excess plot » is to calculate the Hill estimator of the tail index for different thresholds, and look from what threshold this estimator is approximately constant.

It is also possible to calculate, an estimate of the tail index by method of maximum likelihood, for different thresholds, and search from what point this estimator is approximately constant.

Parameter estimation:

When u is determined, the parameters can be estimated by maximum likelihood method.

The density of the Generalized Pareto Distribution can be written:

$$g_{\xi,\sigma}(x) = \begin{cases} \frac{1}{\sigma}(1 + \xi \frac{x}{\sigma})^{-(1+\xi)/\xi} & if\ \xi \neq 0 \\ \frac{1}{\sigma} e^{(-x/\sigma)} & if\ \xi = 0 \end{cases}$$

Parameter estimation by maximum likelihood method :

The log-likelihood is written $\ln L(X_1, X_2, \dots, X_{n_u}; \xi, \sigma) = \sum_{i=1}^{n_u} \ln(g_{\xi,\sigma}(X_i))$ avec n_u the sample size naked $X_1, X_2, \dots, X_{n_u}$ which contains the losses above the threshold u.

- For ξ ≠ 0, the log likelihood is equal to:

$$\ln \ln L(X_1, X_2, \dots, X_{n_u}; \xi, \sigma) = -n_u \ln(\sigma) - (\frac{1}{\xi} + 1) \sum_{i=1}^{n_u} \ln(1 + \frac{\xi}{\sigma} X_i).$$

In this case, the maximization of the log-likelihood is effected by numerical methods.

- For ξ = 0, the log likelihood is equal to:

$$\ln L(X_1, X_2, \dots, X_{n_u}; \xi, \sigma) = -n_u \ln(\sigma) - \frac{1}{\sigma} \sum_{i=1}^{n_u} X_i$$

In this case, the maximization gives an analytical form of the estimator $\hat{\sigma}_{n_u} of\ \sigma$:

$$\hat{\sigma}_{n_u} = \sum_{i=1}^{n_u} \frac{X_i}{n_u}$$

There are other methods for estimating the parameters of a GPD. Hosking and Wallis [3] showed that for samples of size less than 500, Methods of Moments and Weighted Moment Method, are more effective than the Maximum Likelihood Method. However, the main problem is the domain of validity of $\xi: \xi < 1/2$.

Jean Diebolt, Armelle Guillou and Imen Rached [4], found a method to extend the domain of validity to : $\xi < 3/2$. It is the Generalized Method of Moments.

For a sufficiently high threshold, the frequency of excess is modeled by the Poisson Distribution.

5 CONCLUSION

This method is very interesting in the context of operational risk. In fact, the idea is to find a threshold type of risk, and simulate losses below threshold with classical laws, and losses above with a GPD. Then to aggregate them by assuming that, the severe losses are independent from attritional losses[2], which is an assumption commonly used. If the number of severe losses is too low by risk, we shall consider our base and shall consider the threshold of severe losses on all the base.

The adequacy of the data to the law GPD allows to consider an extreme quantile, as minimal strategy, sensitive to the size of samples, and to plan random costs whose probability of occurrence is very low, but the choice of the threshold beyond of which the observation will be judged extreme, is a point to be handled with precaution, even if we propose a technique to quantify this threshold. This technique, based on decrease of the variance, seems to be a good empirical compromise between the FEM (Finite Element Method) and that of the GPD.

The costs of extreme losses do not lend themselves to modeling ; by definition this type of costs is rare and the forecasts or the estimations must be often established with a big distrust, and outside the available data. The models must be used in a supple way, without believing completely to the limit. The approach must be opened and multi-form, and in this sense, there is no method for a problem.

REFERENCES

[1] E. Planchet, « Using the theory of extreme values in the context of solvency 2 », Course material, April 2008.

[2] Alexender, McNeil, T. Saladin, « The peaks over thersholds for estimating high quantiles of loss distribution », International ASTIN Colloquium, pp. 70-94, 1997.

[3] J. Wallis, JRM Hosking, « Parameter and quantile estimation for the Generalized Pareto Distribution », Technometrics, Volume 29, Issue 3, pages 339-349, 1987.
DOI: 10.1080/00401706.1987.10488243

[4] J. Diebolt, A. Guillou et I. Rached, "Approximation of the distribution of excesses using a generalized probability weighted moment method", Comptes rendus - Mathematiques, Volume 340, issue 5, pp. 383-388, 2005.
DOI: 10.1016/j.crma.2005.01.017

[2] The risk of loss events with a low potential, but with a high probability of occurrence.

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Innovation Process from the Perspective of Measurement

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ABSTRACT: Innovation process is one of crucial activity in the innovation implementation of an organization. It is the heart in managing the whole process innovation management. Numerous studies have been conducted and this indirectly established reliable measurement for innovation research. In simple terms, innovation process would describe the 'how' innovation is undertaken into organization which involved the management, employees and also collaboration between organization with suppliers and customers. Some may refer it as process, activities, phases, stages, creative circle, cyclic, or technical progress. Nevertheless, it is indeed strategic and highly integrated process. Due to the complexity, researcher is required to determine suitable measurement. Previous studies have produced various measures which is independent and complex. Therefore, in order to confront with this issue, innovation process requires a balance set of innovation metrics. These metrics would assist research process turn out to be systematic. This paper has proposed two kinds of measurements: objective and subjective innovation process measures. The objectives measures establish result oriented style while subjective measures refer to the how to manage each process in innovation. Some reviews on innovation process definitions, characteristics and activities are presented so that it would be easy for management, practitioners as well as academicians to tailor with their innovation management and research objective.

KEYWORDS: Innovation, innovation process, measurement, output, input, objective and subjective measures.

1 INTRODUCTION

Innovation is everybody matters. Importance of innovation discourse leaps out from the organization mission, innovative team, value creation to customer, survival and growth, competitiveness and to the consumption of everyday gadgets ranging from products and services. Although much has been argued by scholars and practitioners, the innovation process become the heart of the success of innovation implementation. Innovation process is viewed as a sequence of activities involved in turning ideas and possibilities into reality [1]. Due to the crucial role of innovation process, organization needs to accentuate the measurement of innovation process so that the result of innovation is managed and observable. Emphasize to measure innovation is always be the priority task and is proven by most of the high achievers companies [2].

This paper reviewed the innovation process measures from the perspective of objective and subjective measurement. The following discussions will point out why we need to measure innovation process and highlighted several measures that would contribute to innovation research. Furthermore, the highlights would be beneficial points to ponder when researcher intent to embark on a study. The need to measure innovation process occur because the strategic intend of innovation itself varies across organization [3]. It is reported that organization with high growth generated from the innovation projects measured their innovation portfolio and use metric across the whole innovation process [2].

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2 LITERATURE REVIEW

The complexity of innovation process demand researcher to understand the details of innovation process [4]. In this context, understanding definitions of innovation process is essential since this would assist researcher to apply on whether objective or subjective measures. According to Gerybadze, Hommel [5], innovation process is describes as a phases of processes started from strategy planning, idea generation, screening, project development, market test, production, market introduction and innovation controlling. It is noted that the definition has showed the long route of innovation process. Among others, innovation process is also referred as cyclic process [6, 7] and integrate organization mechanism [8]. However, this definition is described in a more simplified view by other scholars such as [9] and [1]. These authors have identified three main stages of innovation process: generate, select and implement. As innovation process involved several stages about development in innovation activities [10], a procedure is needed to evaluate, screen the ideas, establish process from their inception to commercialization [11]. Therefore, by identified and utilized proper definition of innovation process, it might be easier for researcher to use a better measurement in their research.

In establish the working measures for innovation process, common characteristics, inter-relationship of innovation process and deliverables must be identified [4]. Gupta [4], has proposed three measures to show innovation performance at various stages: CEO Recognition of Employees for Exceptional Value Creation, Employee Ideas for Improvement and Innovation Sales for new products, services or solutions. Other measures are also included such as allocation of time in percentage for research innovation management, new idea deployment degree of differentiation, time to innovate, and rate of innovation. Besides the characteristics, the measurement for innovation process is explored through different types of innovation process generation. This has been simplified into five types of innovation process generation: technology push, need pull, coupling model, integrated model and system integration and networking model [12]. The open innovation (six generation of innovation process) is later add to this category where the internal and external of ideas and paths to market is combined for new technology development [13]. In this context, objective measurements cover the science and technology indicators such as patent while the subjective measurement cover the soft factors that related to the management such as organizational integration and user-producer relationship [12].

According to Organisation for Economic Co-operation and Development [OECD] [14], there is are enormous variation in innovation process measurement from the perspective of objectives, organization, cost, used of research and others. This is because the tendency of firm to innovate depended on technological opportunity, technological capability (labor force) and firm characteristics. Hence, three importance areas to measure innovation process are strategic, R&D and non R&D [14]. A study of how firms influence capacity to innovate and resulted performance, has proposed input indicators to measure the resources for innovation process and process indicators to reflect the innovation process management system [15]. Another approach is focused on the input, process and output measures of the innovation implementation however this only limited to objective measurements which are divided into financial, customer perspectives, resources, learning and specific service measures [9].

Due to the strategic intend of innovation itself varies across organization, innovation process is defined as ideation, evaluation, selection, development and implementation of new or improved products or services that must tie with the intended objective. These objectives include an increment numbers of new ideas, its quality, efficiency in the implementation of quality ideas as well as improvement in result achieved from the new ideas implementated [3]. From the perspective of common accounting practices, Return on Product Development Expense (RoPDE) is used to measure those intended objectives. In this context, RoPDE is derived from the percentage of gross margin (GM) from expenses that fully burdened enterprise [3].

A survey which is responded by senior executives acknowledged to measure innovation process rigorously [16]. The survey has used the 'innovation-to-cash' process which considered all efforts required from to take an idea and turn it into cash (inputs, processes and output) [16]. Other approach used to visualize the innovation activity is the funnel approach which consist of nine stages: strategic thinking, portfolio management, research, ideation, insight, targeting, innovation development, market development and sales [17]. Principally, this approach works in an organization but require extensive attention to matters inside the funnel. Although the method portrayed nine elements, the one that referred to innovation process is from the research process to the market development stage whereby each of the stages is proposed with suitable measures [17].

The characteristic of innovation process is identified as one area alongside with strategic leadership, competitive intelligence and management of technology that will determine the innovation success [18]. In this context, innovation process is viewed as the extent to which companies support the desired innovation activities. As a result, innovation process measures is established through ten areas by using the seven-point Likert type scale [18]. In a study of product innovation,

Parthasarthy and Hammond [8] has elaborated innovation process through three types of integration mechanism: functional integration, tool integration and external integration. This is because a high degree of integration and innovation input will benefit innovation frequency. Functional is an operational activities such as job design, task goals, procedures and rules of work routine. Tool integration connected the operation of design and manufacturing tools via computer. External integration link firm operation with suppliers and customers for product development activities [8]. In addressing the measure for technological innovation firm, Flor and Oltra [19] has reviewed several indicators which is based on inputs or output of the innovation process and sources of primary or secondary information. It is found that the information from manager's self assessment is useful for product and process innovation and the literature-based innovation output is best method to identify product innovator [19].

3 DISCUSSION

Based on the arguments from previous studies, the innovation process measurement is summarized into the following table. From the perspective of objective measurement, Table 1 indicated that most of the measures would emphasize on the physical number or output at the end of each stage These output include number of employees, ideas, products, services, solutions, projects, working time and patents occurred. In addition, measurements were also established in terms of percentage and allocation of R&D expenditure, cost, sales and training hours involved during each stages and acquisition of machinery and external knowledge. This information was prepared in numerical value, dichotomous scale and ratio scale.

Table 1. Innovation Process – Objective Measurement

Author/s	Innovation Process Measures
Gupta [4]	1. CEO Recognition of Employees for Exceptional Value Creation 2. Employee Ideas for Improvement and Innovation 3. Sales for new products, services or solutions
Chan, Musso [2]	1. Number of idea or concepts in the pipeline 2. R&D spending as a percentage of sales 3. Number of R&D projects 4. Number of people actively devoted to innovation
Organisation for Economic Co-operation and Development [OECD] [14]	**Dichotomous scale : Yes or No** During the three years (e.g: 2002-2004), did your enterprise engage in the following innovation activities: 1. In-house R&D – Creative work undertaken within your enterprise to increase the stock of knowledge and its use to devise new and improved products and processes (including software development) 2. Extramural R&D – Same activities as above but perform by other companies, public or private research organization of purchased by your firm. 3. Acquisition of advanced machinery, equipment and computer hardware or software. 4. Acquisition of other external knowledge such as purchase or licensing patent and non-patented invention and other types of knowledge from other organization. 5. Internal and external training for personnel for new or improved products and processes. 6. Market introduction of innovations 7. Other preparation in implementing new product and processes. **Ratio Scale** Please estimate the amount of expenditure for each of the following four innovation activities in 2004 only (include personnel and related cost): 1. In-house R&D (include capital expenditures on building and equipment) _____ (in RM'000) 2. Acquisition of extramural R&D _____ (in RM'000) 3. Acquisition of machinery, equipment and software (exclude expenditures on equipment for R&D)_____(in RM'000) 4. Acquisition of other external knowledge _____(in RM'000) 5. Total of these four innovation expenditure categories____ (in RM'000)

Author/s	Innovation Process Measures
Carayannis and Provance [15]	**Ratio Scale** Innovation Process Inputs: 1. Sales of share of R&D expenditure (%) 2. Sales share of internal venture capital (%) 3. Average training days for employees (%) 4. Average training days for employees (%) 5. Top management working time on Innovation (%)
Malinoski and Perry [3]	Return on Product Development Expenses (RoPDE) RoPDE = (GM – PDE) / PDE Where: GM = gross profit by subtracting cost of sales from revenue or cost of goods sold (material, labor and overhead associated with delivering a production unit) PDE= include engineering, technician, product marketing and associated management labor expenses (benefits, facilities, IT, depreciation).
Andrew, Haanaes [16]	Input measures: 1. Number of new ideas 2. Business unit investments by type of innovation 3. R&D as a percentage of sales 4. Full-time technical staff and how (and where)it is used Processes measures 1. Idea to decision time 2. Decision to launch time 3. Project type and launch date 4. Sum of projected net present value Outputs 1. Patents granted 2. Launches by business segment 3. Percentage of sales and profit from new products Innovation ROI
Morris [17]	Research Stage: 1. Number of customer groups that have been examined 2. Application of research result in new products, services and processes 3. Extent of participation from throughout organization in the research process 4. Time invested in research 5. Money invested in research Ideation Stage: 1. Number of idea developed 2. Number of ideas contributed by our staff 3. Number of idea introduced 4. Percentage of ideas from outside 5. Number of people inside the organization who are participating in the ideation process 6. Number of ideas collected in the idea gathering system 7. Number of collected ideas that were developed further 8. Number of collected ideas that were implemented Insight Stage: 1. Unsuccessful technology and customer mash-ups attempted 2. Successful technology and customer mash-up achieved Targeting Stage: 1. Percent of investment in non-core innovation projects. 2. Total funds invested in non-core innovation projects 3. Senior management time invested in growth innovation

Author/s	Innovation Process Measures
	Innovation Development Stage: 1. Prototyping speed 2. Number of prototypes per new product 3. Average time it takes to get from Stage 1 to Stage 5 4. Number of patents applied for 5. Number of patents granted 6. Percent of ideas that are funded for development 7. Percent of ideas that are killed Market Development Stage: 1. Return on marketing investment 2. Number of new customers added 3. Growth rate of customer base

From the perspective of subjective measurement, Table 2 indicated that measures of innovation process were established by structured questions on how each activity was performing in each stage. It is noted that the details of innovation process are reflected in terms of how the new idea is managed, how to control innovation project, employee participation and communication, how the new product developed and marketed and finally the integration between internal organization mechanisms, external (customers and suppliers) and manufacturing processes (tools and materials). One important point that could be observed from both Table 1 and Table 2 is the tendency of objective measurement to depict the result oriented style in terms of input, processes and output measures while the subjective measurement deliberated the descriptive style which elaborates each of the activity into the innovation management approach. This argument is in line with the proposed study conducted on integrated metric for innovation measurement [20]. Although it is limited to the R&D innovation, the subjective measurement for innovation process lies on the R&D Management Capability, Integration, Openness and R&D Environment. These measures are analyzed towards the impact on products and delivery to the organization.

Table 2. Innovation Process – Subjective Measurement

Author/s	Innovation Process Measures
Gupta [4], Carayannis and Provance [15]	Ordinal Scale – 5 point Likert Scale ranging from is always done / clearly organized to seldomly used Process oriented measures: Design of innovation management 1. Idea evaluation 2. Concept test 3. Profitability Analysis 4. Innovation strategy 5. Construction / development 6. Ex post analysis Project management and controlling 1. Project management employed 2. Project controlling employed Involvement of marketing in innovation process
Guimaraes [18]	Using 7 point Likert-type scale ranging from extremely below average to extremely above average. 1. All significant innovation must conform to company objectives 2. All affected departments participate in the innovation process 3. Individual employee input is important 4. Customer input is considered important 5. Business partners input is considered important 6. Ability to balance risk taking with cost/benefit 7. Clearly define measures to monitor progress 8. Innovation objectives and progress are clearly communicated 9. Responding quickly to required change 10. Responding effectively to required change

Author/s	Innovation Process Measures
Parthasarthy and Hammond [8]	Functional integration: How are your product development activities organized? (1: strongly disagree, 4: somewhat agree, 7: strongly agree). 1. Our product teams are always organized with diverse functional specialists. 2. In our firm, communication amongR&D,manufacturing, and marketing groups is always formal and in writing (reverse coded). 3. In our firm, R&D single-handedly decides what new technologies will be pursued (reverse coded). 4. In our firm, manufacturing engineers actively participate in product design. 5. We rotate design and manufacturing engineers frequently. 6. We always undertake product development sequentially, from R&D to production to marketing, to achieve better control over each activity (reverse coded). 7. In our firm, top management plays a supportive role in product development. 8. Our reward system is more group-based than individual-based. 9. Our structure and control mechanisms strongly promote cooperation among R&D, production, and marketing groups. External integration Describe your unit's relationship with suppliers and customers (1: strongly disagree, 4: somewhat agree, 7: strongly agree). 1. We always consult suppliers/customers on new product ideas. 2. We always include suppliers in our product development teams. 3. We always include customers in our product development teams. 4. We freely share technical ideas with suppliers and customers. 5. We always seek supplier/customer collaboration for developing new technologies. 6. We always assist suppliers in improving component quality. Tool integration To what extent are the following manufacturing processes computer-integrated? (1: not integrated, 4: moderately integrated, 7: completely integrated). 1. Product design/development and production planning. 2. Product planning and component manufacturing. 3. Component manufacturing and assembly. 4. Assembly and quality control. 5. Quality control and materials handling. 6. Materials handling and storage/distribution.

4 CONCLUSION

Based on the above reviews and arguments, it is noted that innovation process is one of important part that contribute to the success of the whole implementation of organizational innovation. Due to its combination of complex activities, the need to come out with a good measurement is highly appreciated in the innovation research. One of the approaches is to divide between the objective and subjective kind of measurement. In establishing these indicators, researcher needs to identify the suitable operational definition of innovation process, characteristics (firm level, departmental level, group level or individual level) and innovation process generation. Nevertheless, being a researcher the rule of parsimonious must be applied due to the cost and time constraint. Hence, it is good to decide the measurements that are suitable, sufficient and efficiently used within the context of study.

REFERENCES

[1] Bessant, J. and J. Tidd, *Innovation and Entrepreneurship*2007, England: John Wiley & Sons, Ltd.

[2] Chan, V., C. Musso, and V. Shankar, *Assessing innovation metrics*, M.G.S. Results, Editor 2008, McKinsey & Company: Philadelphia.

[3] Malinoski, M. and G.S. Perry *How Do I Measure "Innovation"?!?* 2011. 1-5.

[4] Gupta, P. *Firm Specific Measures of Innovation*. Measures of Innovation Proposal, 2007. 1-10.

[5] Gerybadze, A., et al., *Innovation and International Corporate Growth*, ed. s. edition2010, Heidelberg: Springer. 452.

[6] Bernstein, B. and P.J. Singh, *Innovation generation process.* European Journal of Innovation Management 2008. 11(3): p. 366-388.

[7] Björk, J., P. Boccardelli, and M. Magnusson, *Ideation Capabilities for Continuous Innovation.* Creativity And Innovation Management, 2010. 19 (4): p. 385-396.

[8] Parthasarthy, R. and J. Hammond, *Product innovation input and outcome: moderating effects of the innovation process.* Journal of Engineering and Technology Management, 2002. 19(1): p. 75-91.

[9] Goffin, K. and R. Mitchell, *Innovation Management* Strategy And Implementation Using the Pentathlon Framework2005, New York: Palgrave Macmillan.

[10] Ortt, J.R. and P.A.v.d. Duin, *The evolution of innovation management towards contextual innovation.* European Journal of Innovation Management, 2008. 11(4): p. 522-538.

[11] Desouza, K.C., et al., *Crafting organizational innovation processes.* Innovation: management, policy & practice 2009. 11: p. 6-33.

[12] Dodgson, M. and S. Hinze, *Indicators used to measure the innovation process: defects and possible remedies.* Research Evaluation, 2000. 9(2): p. 101-114.

[13] Preez, N.D.d. and L. Louw. *A Framework for Managing the Innovation Process*. in *PICMET 2008 Proceedings*. 2008. Cape Town, South Africa.

[14] Organisation for Economic Co-operation and Development [OECD], *The Measurement Of Scientific And Technological Activities*, 2005, Organisation for Economic Co-operation and Development: Paris. p. 92.

[15] Carayannis, E.G. and M. Provance, *Measuring Firm Innovativeness: Towards a Composite Innovation Index Built On Firm Innovative Posture, Prospensity and Performance Attributes.* International Journal of Innovation and Regional Development, 2007: p. 1-30.

[16] Andrew, J.P., et al., *Measuring Innovation 2009: The Need for Action*, in *A BCG Senior Management Survey* T.B.C. Group, Editor 2009, The Boston Consulting Group: Boston. p. 1-23.

[17] Morris, L. *Innovation Metrics: The Innovation Process and How to Measure It*. An InnovationLabs White Paper, 2008. 1-20.

[18] Guimaraes, T., *Industry clockspeed's impact onbusiness innovation success factors.* European Journal of Innovation Management, 2011. 14(3): p. 322-344.

[19] Flor, M.L. and M.J. Oltra, *Identification of innovating firms through technological innovation indicators: An application to the Spanish ceramic tile industry.* Research Policy 2004. 33: p. 323-336.

[20] Choi, G. and S.-S. Ko. *An intergrated metric for R&D innovation measurement*. in *Technology Management for Global Economic Growth (PICMET), 2010 Proceedings of PICMET '10*. 2010. Phuket.

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Interoperability in Healthcare: Benefits, Challenges and Resolutions

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ABSTRACT: Information and Communication Technologies (ICTs) play significant roles in the improvement of patient care and the reduction of healthcare cost by facilitating the seamless exchange of vital information among healthcare providers. Thus, clinicians can have easy access to patients' information in a timely manner, medical errors are reduced, and health related records are easily integrated. However, as beneficial as data interoperability is to healthcare, at present, it is largely an unreached goal. This is chiefly because electronic Health Information Systems used within the healthcare organizations have been developed independently with diverse and heterogeneous ICT tools, methods, processes and procedures which result in a large number of heterogeneous and distributed proprietary models for representing and recording patients' information. Consequently, the seamless, effective and meaningful exchange of patients' information is yet to be achieved across healthcare systems. This paper therefore appraises the concepts of interoperability in the context of healthcare, its benefits and its attendant challenges. The paper suggests that the adoption of a standardized healthcare terminology, education strategy, design of useable interfaces for ICT tools, privacy and security issues as well as the connection of legacy systems to the health network are ways of achieving complete interoperability of electronic based Health Information Systems in healthcare.

KEYWORDS: Interoperability, Information Communication Technologies, electronic Health Information System, healthcare, patient care.

1 INTRODUCTION

Since the 1990s, advances in Information and Communication Technologies (ICTs) in healthcare have created new ways of managing patients' information through the digitization of health-related information. The use of ICTs in healthcare has the potential of reducing medical errors, improving collaboration between healthcare providers, reducing the cost of healthcare and dramatically improving the delivery and quality of healthcare [1]. The enhancement of ICTs in healthcare has also led to the generation of huge amount of information relating to the diagnosis, testing, monitoring, treatment and health management of patients, billing for healthcare services and asset-management of healthcare resources [2]. These information are stored in heterogeneous distributed Health Information Systems, in different file formats which are mainly proprietary [3]. These information need to interact and be accessed by healthcare practitioners in a uniform and transparent way, anywhere and anytime, as required by the treatment path of the patients. For instance, healthcare providers need to exchange information, such as clinical notes, observations, laboratory tests, diagnostic imaging reports, treatments, therapies, drugs administered, allergies and letters, x-rays, and bills. However, these information may be heterogeneous in terminologies, schema, syntax, semantics, data types, data formats and data constraints. This heterogeneity often results in

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severe data interoperability problems [4]. Consequently, the healthcare system is characterized by increased costs, high error rate, and knowledge mismanagement. Thus, this could result in high rate of mortality.

Numerous solutions have been proposed to achieve total interoperability in the healthcare with degrees of success. These include the use of standards, archeytpes, web services, healthcare service bus, and interface engines and ontologies. However, in spite of these diverse solutions, interoperability within the healthcare domain is yet to be completely achieved [5]-[7]. Consequently, this paper discusses the concept of interoperability, the benefits and barriers of interoperability and also suggests ways in which complete interoperability can be achieved within the context of healthcare.

2 CONCEPT OF INTEROPERABILITY

In broad terms, interoperability is the ability of different information and communications technology systems and software applications to communicate, to exchange data accurately, effectively, and consistently, and to use the information that has been exchanged [8]. Data interoperability is the ability to correctly interpret data across systems or organizational boundaries [9]. The key points are illustrated below in Figure 1. In the scenario below, it is assumed that the people on the left have information needed by the people on the right, and that data in one system is accessible to the other. Hence, interoperability will only be achieved if the receiving system and users properly understand the meaning of information they receive and they are able to use this information [10].

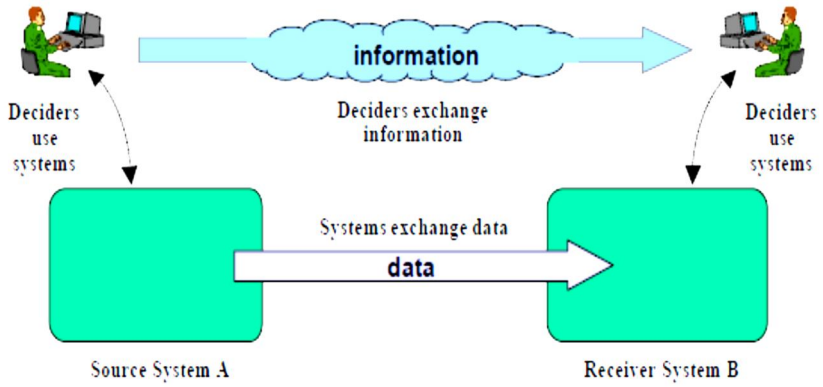

Fig. 1. Concept of Interoperability [1]

In general, there are seven basic levels of different levels of interoperability [11]. These levels include:

- Level 0 or No Interoperability: This is usually characterized by stand-alone systems which have no interoperability.
- Level 1 or Technical Interoperability: This level of interoperability involves the use of a communication protocol for the exchange of data between systems. Technical interoperability establishes harmonization at the plug and play, signal and protocol level.
- Level2 or Syntactic interoperability: This is the ability of two or more systems to exchange data and services using a common interoperability protocol such as the High Level Architecture (HLA).
- Level3 or Semantic Interoperability: Semantic interoperability refers to the ability of two or more systems to automatically interpret the information exchanged meaningfully and accurately in order to produce useful results as defined by the end users of the systems [12]. Semantic interoperability is also used in a more general sense to refer to the ability of two or more systems to exchange information with an unambiguous and shared meaning [13]. Semantic interoperability implies that the precise meaning of the exchanged information is understood by the communicating systems. Hence, the systems are able to recognize and process semantically equivalent information homogeneously, even if their instances are heterogeneously represented, that is, if they are differently structured, and/or using different terminology or different natural language [7]. Semantic interoperability can thus be said to be distinct from the other levels of interoperability because it ensures that the receiving system understands the meaning of the exchange information, even when the algorithms used by the receiving system are unknown to the sending system.

- Pragmatic Interoperability: This level of interoperability is achieved when the interoperating systems are aware of the methods and procedures that each other are employing. This implies that the use of the data or the context of its application is understood by the participating systems.
- Dynamic Interoperability: Two or more systems are said to have attained dynamic interoperability when they are able to comprehend the state changes that occur in the assumptions and constraints that they are making over time, and they are able to take advantage of those changes.
- Conceptual Interoperability: Conceptual interoperability is reached if the assumptions and constraints of the meaningful abstraction of reality are aligned.

However, in the context of healthcare, there is no standard definition of interoperability [14]. Nevertheless, the National Alliance for Health Information Technology defined interoperability in the context of healthcare as the ability of different information technology systems and software applications to communicate, to exchange data accurately, effectively, and consistently, and to use the information that has been exchanged [14]. Interoperability in healthcare can be investigated in different categories such as the interoperability of the messages (information) exchanged between healthcare applications, interoperability of Electronic Healthcare Records (EHRs), interoperability of patient identifiers, coding terms, clinical guidelines and healthcare business processes. However, all these categories of interoperability can be classified in two major layers which are syntactic interoperability layer and the semantic interoperability layer [8]. Syntactic interoperability also referred to as the messaging layer involves the ability of two or more systems to exchange information.

Syntactic interoperability in e-health involves several layers which include the following:

- Network layer: The network layer provides the functional and procedural means of transferring variable length data sequences from a source host on one network to a destination host on a different network while maintaining the quality of service requested by the transport layer.
- Transport layer: The successful exchange of health-related information amongst healthcare applications requires the transport protocols, such as Internet. At present, the Transport Communication Protocol /Internet Protocol (Internet) is the de-facto communication standard for the exchange of health-related messages.
- Application protocol layer: This layer supports application and end-user processes. The functions of this layer typically include the identification of communicating systems, user authentication and privacy. This layer also identifies any constraints on data syntax. It also provides application services for file transfers and e-mail. Example of protocols at this layer is the File Transfer Protocol.
- Message protocol and messaging format layer: The message layer defines the structure and format for the messages that are exchanged between end-points. An example of a protocol used at this layer is the Simple Object Access Protocol (SOAP).
- Sequencing of the messages: There is a need to standardize the sequencing of the messages in healthcare. For example, in Health Level 7 standards, when "I05 RQC Request Clinical Information" message is sent, the expected return message is "I05 RCI Return Clinical Information". There are also different types of messages. These messages could be a message with the intent of action or an acknowledgment message indicating the successful exchange of a message or an error message. However, for the message content to be processed correctly by the receiving application, the message content structure and the data items in the message must be standardized [8].

Syntactic interoperability only ensures that the message is received by the receiving system. It does not guarantee that the content of the received information will be processable by the receiving system. Hence, it can be said that without syntactic interoperability, data and information cannot be handled properly with regards to its formats, encodings, properties, values and data types. Therefore, to guarantee total interoperability in healthcare, semantic interoperability must be provided. Semantic interoperability is the ability for information shared by systems to be understood at the level of formally defined domain concepts [15]. Semantic interoperability can also be defined as the ability of two or more computer systems to exchange information in such a way that the meaning of that information can be automatically interpreted by the receiving system accurately enough to produce useful results to the end users of both systems [16]. From the definition above, it can be deduced that semantic interoperability is yet to be achieved in healthcare. This is because 'being useful to end users' in the definition refers to end users who are human beings and who have the capacity to make sense of the data exchanged even when it is incomplete, contains errors, redundant, full of duplications, ambiguous and lack adequate formalization. Computers, however, do not such capacity. This is because the computer does not capture the semantics of information and it has no pre-existing repository of contexts, but instead requires a semantic representation that is simpler and more precise [17]. In recent times, the challenge of semantic interoperability is to ensure that information exchanged are understood not only by the human beings on both ends of the ICT communication channel, but also, the exchanged information must be understood by the computer systems and their associated software. Hence, it can be said that, without

semantic interoperability, the meaning of the used language, terminology and metadata values cannot be negotiated or correctly understood. The levels of semantic interoperability in healthcare according to [7] include:

- Full semantic interoperability: This level of interoperability also referred to as co-operability is the highest level of semantic interoperability. It is reached if users of system B are able to use information acquired automatically from system A with equivalent meaning to its local data, and the information can be processed homogenously with data captured natively within System B, as if they were entered by a user B directly into system. At this level, neither language nor technological differences prevent the system to seamlessly integrate the received information.
- Partial semantic interoperability: In partial semantic interoperability, the users of system B are able to access the information from system A and are able to detect, interpret and meaningfully present to the information to the attending physician.

3 THE CRITICAL NEEDS FOR INTEROPERABILITY IN HEALTHCARE

The healthcare domain currently is undergoing a fundamental change in its approach to delivering care as ICTs is becoming an indispensible component of healthcare. However, with the rising cost of healthcare, incessant inefficiencies and healthcare quality failures experienced by healthcare providers and patients, there is a need to understand the critical role that interoperability plays in data sharing and re-use among disparate healthcare applications and devices, reduction of healthcare costs and the improvement in the quality of care. Thus, this section critically appraises the benefits of complete interoperability in healthcare.

3.1 EASY ACCESS TO PATIENTS RECORDS

Patients usually get care from a wide range of care givers (such as hospitals, laboratory, pharmacy, urgent care centers, physician group, solo physicians and nurses, school clinics, and public health sites) based on their proximity, bedside manner, quality of care received and cultural attitude [18]. This has led to the fragmentation of the patients' information in proprietary heterogeneous systems across healthcare organizations. Consequently, vital information stored in these systems cannot be easily accessed to present a clear and complete picture of the patient. For instance, a study in an outpatient clinic found that pertinent patient data were unavailable in 81% of cases, with an average of four missing items per case. The entire medical record was unavailable 5% of the time [19]. In addition, the patients' information are often in a non-standard, non-structured and non-coded (text) form which makes the exchange of information a challenge [20]. Hence, the healthcare's current fragmented state results in injury, wasted resources, and loss of lives. In addition, avoidable deaths and injuries occur because of poor communication between healthcare practitioners annually. In spite of these challenges, healthcare practitioners are required to have access to the detailed and complete records of their patients across heterogeneous systems in order to manage the safe and effective delivery of healthcare services. However, through healthcare information exchange and interoperability, clinicians can have access to longitudinal patients' records stored in proprietary heterogeneous systems in a timely manner. This will improve healthcare processes by giving care providers the patient-specific information they need to effectively consult on a case. Also, with complete interoperability in healthcare, patients can also have full access to fragmented medical records maintained by each of their healthcare providers which will enable to better manage their health. Thus, interoperability establishes a seamless continuum of healthcare. The major benefit of interoperability in healthcare is to facilitate the easy access to health-related information that are stored in heterogeneous systems irrespective of the geographical locations of the healthcare providers as well as the patients. This concept is depicted in Figure 2.

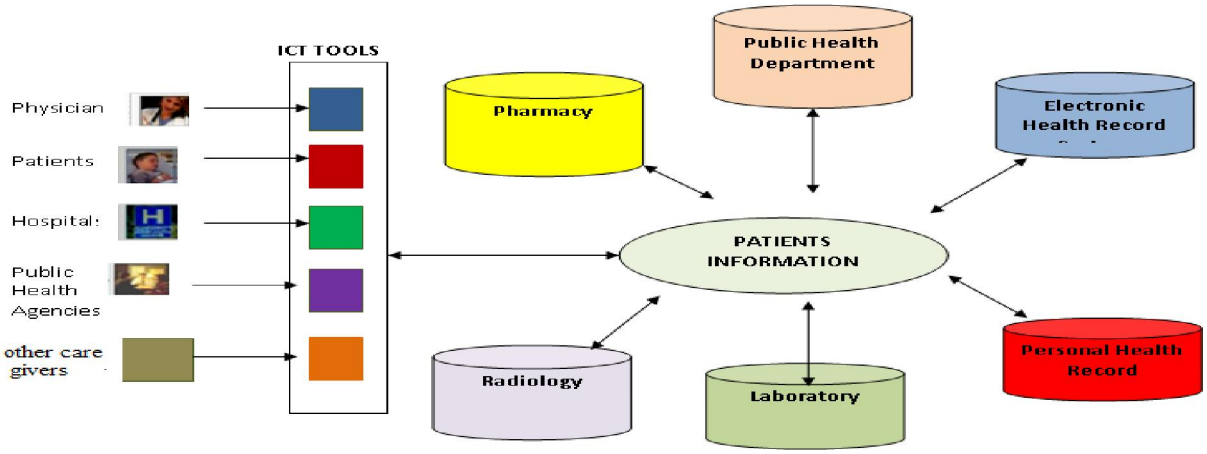

Fig. 2. Easy Access to Patients Information

3.2 Easy Comprehension of Medical Terms

The application of interoperability in the healthcare domain will provide care givers with the ability to better understand terms and concepts as data is transmitted from one system to another, while preserving the meaning of the content. Thus, interoperability will contribute to the improvement of healthcare because it ensures that the right meanings of medical terminology are delivered to communicating systems. Hence, physicians can easily analyze data from all collaborating systems for diagnosis and decision making.

3.3 Reduction of Medical errors

The delivery of healthcare often involves moving the locus of care among diverse sites and providers. Hence, patients' records are scattered across several physicians' offices, laboratories and hospitals. This process is usually fraught with errors as a result of lack of interoperability among healthcare systems. For instance, a study conducted in an inpatient setting estimated that 18% of medical errors that result in an adverse drug event were due to inadequate availability of patients' information [19]. Thus, medical errors are of great concern to healthcare because they are the sixth leading cause of death in hospitals [2]. Also, it was reported in [2] that at least 44,000 and perhaps as many as 98,000 Americans die in hospitals each year as a result of medical errors, which results in considerable loss of life. Also, more than one million patients are injured each year as a result of broken health care processes and system failures [19]. One of the ways of avoiding medical errors is to ensure complete interoperability in healthcare by ensuring that health related data are formatted in a way that allows disparate computer systems to understand both the structure and content of the exchanged information.

3.4 Reduced Healthcare Cost

One of the major challenges that the healthcare industry is facing is increasing costs [2]. For instance it was estimated that healthcare costs in the United States of America were about 14.9 % of the Gross Domestic Product, which accounted for $1.6 trillion in 2002, and $1.9 trillion in 2005 [2]. Furthermore, healthcare is projected to rise to $3.6 trillion by 2014 in the United States of America [2]. Interoperability among healthcare ICT systems would deliver a national savings of $77.8 billion dollars every year [2]. Hence, the effective sharing and communication of data, information, and knowledge among various stakeholders in the healthcare network is an essential factor for reducing healthcare cost.

3.5 Integration of health-related records

The healthcare system is an information-intensive activity that produces enormous data from its diverse sub systems such as laboratories, wards, operating theatres, primary care organizations, and from wearable and wireless devices. However, integrating information from autonomously developed applications is a difficult task, as individual applications usually are not designed to cooperate and they often based on differing conceptualizations [21]. Nevertheless, the management of information across healthcare systems and organizations requires collaboration, portability and data integration. Interoperability ensures that disparate applications within diverse healthcare facility "talk to and understand" one another. With this benefit of interoperability, healthcare organizations can integrate the information in disparate applications such as

registration systems, laboratory systems, core measure tracking and surgical software suites. In addition, interoperability allows a healthcare system to seamlessly integrate with other healthcare vendors, organizations, providers and national level organizations.

3.6 ENHANCED SUPPORT FOR THE MANAGEMENT OF CHRONIC DISEASES

The treatment of chronic diseases often involves multiple physicians and healthcare providers. In recent times, half the U.S. population lives with chronic disease [19]. An interoperable healthcare system however, will make it easier for patients to find information to help them prevent such conditions, since many chronic illnesses are preventable. Thus, individuals can improve their lifestyle to avoid chronic diseases.

4 BARRIERS TO INTEROPERABILITY IN HEALTHCARE

There is no doubt that interoperability has a major positive impact on healthcare. However, the lack of interoperability in healthcare systems and services has long been identified as one of the major challenges in healthcare. For instance, a practitioner in a private practice may have difficulty obtaining complete information about a patient who is currently being hospitalized; also a practitioner may repeat tests and procedures because he or she does not have prior information about the patient. Consequently, this section appraises the barriers impeding interoperability in healthcare.

4.1 COMPLEXITY OF THE HEALTHCARE DOMAIN

The healthcare domain is a very complex one because it involves a lot of actors such as doctors, radiologists, nurses, pharmacists, laboratory technicians who collaboratively participate in the treatment of patients. Each of these actors generates information that is needed by one another. The information in the healthcare domain is also enormously complex, because it covers different types of data such as patient administration, organizational information, clinical data and laboratory/pathology data [4]. However, safe and effective healthcare relies heavily on the ability to exchange data from one software to another, and from one person to another, and also on the ability to understand that information so that it can be used. However, care givers may be unwilling to share health-related information, but even when they are in agreement to share information, individual entities may have their customized or vendor-driven software that is incompatible and not interoperable with other systems.

4.2 STANDARDIZATION PROBLEMS IN HEALTHCARE

The operational goal of standardization is to provide sets of consistent specifications called “standards” to be shared by all parties manufacturing the same products, or providing the same services [17]. Standards are agreed-upon specifications that allow independently manufactured products, whether physical or digital, to work together, or in other words, to be interoperable. The major goal of standards in the healthcare domain is to improve patient care by allowing interoperability among disparate systems. However, standards are often too general and subject to local interpretation and implementation. For instance, there is a “standard” that every patient admitted to a U.S. hospital undergoes nursing assessment processes which are not uniform or standardized from one hospital to the other. A serious error or omission in this process can lead to the untimely death of a patient [19]. In addition, abbreviations are barely standardized within the healthcare domain. Moreover, there are a lot of standards used in healthcare. These include the Health level 7 standards, OpenEHR, Digital imaging and communications in medicine (Dicom), CEN/ISO EN13606, International Classification of Disease etc. Healthcare institutes however do not conform to a single standard, and the use of multiple standards breeds confusion [20]. Thus, the pursuit of high patient care and safety is futile in the absence of uniformity or standardization of the basic means of communication.

4.3 USE OF INCOMPATIBLE CLINICAL ONTOLOGIES/TERMINOLOGIES

Existing efforts aimed at achieving semantic interoperability within the healthcare domain rely on agreements about the understanding concepts stored in terminology systems such as nomenclatures, vocabularies, thesauri, or ontologies. This is based on the fact that all computer systems would understand one another perfectly if they use the same terminology or ontologies, or mutually compatible ones [17]. However, the growth of incompatible terminologies and ontologies within the healthcare domain is exponential. Thus, the use of incompatible and heterogeneous terminology and ontologies in healthcare contribute to the problem of interoperability. This is because heterogeneous terminologies and ontologies consist of multiple representations for the same clinical concept.

4.4 LEGACY SYSTEMS

Legacy systems (usually electronic medical record systems) with limited interoperability capabilities are those systems implemented prior to the introduction of common national standards. These systems are still in use today. Their data storage, input, and inventory of data items are unique and often proprietary. The problem associated with legacy systems is that they are designed for a particular task or facility. Moreover, many of these systems are designed to prevent interoperability with other vendors' applications to protect market share and to encourage purchases by hospitals or clinic chains .

4.5 RESISTANCE TO CHANGE

The healthcare industry unlike most industries (e.g. banking industry) still relies on piles of papers/ handwritten notes (paper records) for patients care. This is because most healthcare providers are resistant to change from their traditional paper based system to electronic health system because of the following reasons which were emphasized in [22].

- Large number of physicians in individual or small group practices with very limited administrative support for IT and related practice changes;
- The lack of uniformity and interoperability of IT systems from different vendors;
- Regulatory limitations on hospital funding of IT for physicians;
- Lack of trust and other legal concerns with respect to joint IT solutions; and
- Privacy and security concerns

Thus, the transition from a paper-based system to an electronic interoperable system in healthcare still remains a challenge for healthcare providers. The paper based process is inherently error-prone, as the multiple actors involved in the patients care may not communicate complicated results appropriately, leading to medical errors. The paper based system also adversely affects the management of medical information and the secure sharing of information across the continuum of care.

5 THE WAYS FORWARD

The achievement of a fully interoperable healthcare delivery system is a daunting task that is characterized by numerous barriers. However, the following solutions can be adapted to achieve complete interoperability in healthcare.

5.1 ADOPTION OF A STANDARDIZED TERMINOLOGY IN HEALTHCARE

The establishment and adoption of a standard terminology/vocabulary, that is, a common language for the description and exchange of data is essential for the achievement of complete interoperability in healthcare. This is because interoperability in healthcare requires standardization of the format and content of health-related data so that they can be understandable to computer programs as well as to the patients and care givers.

5.2 CONNECTION OF LEGACY SYSTEMS TO HEALTH NETWORK

The connection of legacy systems to the healthcare network, either temporarily or permanently is one of the solutions to complete interoperability in healthcare. This is because legacy systems are critical to medicine and thus they cannot be shut down from interoperable systems. Interoperating legacy systems with the healthcare network can be achieved via the use of a middleware software or hardware which translates the input and output of the system so it can interact with other connected healthcare systems.

5.3 EDUCATION STRATEGY

Healthcare providers should be taught the use of ICT tools in healthcare and their importance. Healthcare providers should be made to acquire the technical skills and knowledge needed to make full use of electronic systems in healthcare. Healthcare providers should be made to realize that adopting interoperable electronic healthcare information is in their best interest in terms of time and professional convenience. In addition, opportunities for health informatics training and introductory virtual courses on topics such as standards, application development and eHealth are essential for healthcare providers.

5.4 PRIVACY AND SECURITY POLICIES

Privacy and security policies should be considered as a part of design of an interoperable healthcare system. Healthcare Policies must be widely agreed by patients and practitioners on the terms and conditions for access to and dissemination of patient data. Adequate protection for the privacy of health information should also be considered in the development of interoperable healthcare system. Legislation and regulation should be frequently considered to reevaluate emerging technologies and capabilities. Also, authentication techniques such as passwords, fingerprints, retina scans and biometric devices such as fingerprint readers and voice-scanning systems should be used to help ensure data and networks are secure.

5.5 USABILITY ISSUES

The ability of care givers to use ICTs successfully depends on how well the technologies have been designed at the level of human-computer interaction (i.e. the user interface). The display of health-related information in a disorderly, illogical, or confusing manner leads to decreased user performance and satisfaction. Moreover, a poorly designed user interface contributes to medical errors. Addressing user interface issues requires greater attention to the cognitive and social factors influencing clinicians in their daily workflow and interaction with technologies

6 CONCLUSION

The major goal of interoperability in healthcare is to facilitate the seamless exchange of health-related information amongst caregivers and patients for clinical decision making. However, interoperability within the context of healthcare is yet to be realized. Thus, the lack of interoperability amongst healthcare systems further strengthens the information silos that exist in today's paper-based medical files, which results in proprietary control over health information. This has resulted in increased healthcare cost, declining quality of patients care, and the inability to integrate patients' information across healthcare systems. Consequently, this paper appraised the concepts of interoperability and its relevance to healthcare and attendant challenges. The paper also suggests solutions to achieving interoperability in healthcare.

REFERENCES

[1] Institute for Alternative Futures, "Health Information Systems 2015," Background Report for Biomonitoring Futures Project., Institute for Alternative Futures, Alexandria, pp. 1-15, March, 2006.

[2] C. Bock, L. Carnahan, S. Fenves, M. Gruninger, V. Kashyap, B. Lide, J. Nell, R. Raman and R. Sriram, "Healthcare Strategic Focus Area: Clinical Informatics," National Institute of Standards and Technology, Technology Administration, Department of Commerce, United States of America, pp.1-33, September, 2005.

[3] A. Kokkinaki, I. Chouvarda and N, Maglaveras, "Integrating SCP-ECG files and Patient Records: An Ontology Based Approach," The Medical School, Aristotle University of Thessaloniki, Greece, pp. 1-7, July, 2006.

[4] A. Ryan, "Towards Semantic Interoperability in Healthcare: Ontology Mapping from SNOMED-CT to HL7 version 3"., Conferences in Research and Practice in Information Technology (CRPIT)," vol. 72, pp.1-6, 2006 .

[5] T. Beale and M. D Heard, "An Ontology-based Model of Clinical Information," MEINFO 2007, pp.760-766, 2007.

[6] C.G. McLeod, "Interface Engines for Healthcare: 21st Century Trends, " McLeod C.G., USA, pp. 1-14, March 2006.

[7] Semantic Health Report "Semantic Interoperability for Better Health and Safer Healthcare," European Commission, Information Society and Media, pp. 1-34, January, 2009.

[8] D. Asuman, N. Tuncay, O. Alper, L. Gokce, K. Yildiray and E Marco, "Key Issues of Technical Interoperability Solutions in eHealth and the RIDE Project," Software Research and Development Center, Department of Computer Engineering, Middle East Technical University, Ankara, Turkey" pp. 1-11, 2006.

[9] S.A. Renner, "A Community of Interest Approach to Data Interoperability," Federal Database Colloquium San Diego, pp. 1-7, August 2001.

[10] Trans Atlantic Consumer Dialogue, "Resolution on Software Interoperability and Open Standards", Trans Atlantic Consumer Dialogue, pp. 1-6, July, 2008.

[11] A. Tolk, Y. Saikou and D.T Charles, "Support of Integratability, Interoperability, and Composability for System-of-Systems Engineering," Journal of Systemic, Cybernetics and Informatics, vol.5, n°. 5, pp. 65-74, 2007.

[12] Institute of Electrical and Electronics Engineers Standard Computer Dictionary," A Compilation of IEEE Standard Computer Glossaries, Institute of Electrical and Electronics Engineers, USA," 1999.

[13] A.S. Gregory, R.B. Kushel and Y. William, "Supporting Interoperability Using the Discrete-Event Modeling Ontology (Demo)," Proceedings of The 2009 Winter Simulation Conference M. D. Rossetti, R. R. Hill, B. Johansson, A. Dunkin And R. G. Ingalls, Eds, pp.1399-1410, 2009.

[14] K. Heubusch, "Interoperability: What it Means, Why it Matters," Journal of AHIMA, vol.77, n°. 1, pp. 26-30, January, 2006.
[15] B. Veli, B.L. Gokce, D. Asuman and K. Yildiray, "Artemis Message Exchange Framework: Semantic Interoperability of Exchanged Messages in the Healthcare Domain", Software Research and Development Center, Middle East Technical University (METU), Ankara Turkiye, pp. 1-3, 2006.
[16] W. Ceusters and B. Smith," Semantic Interoperability in Healthcare State of the Art in the US", New York State Center of Excellence in Bioinformatics and Life Sciences Ontology Research Group", pp.1-33, March 2010.
[17] P. Groen and M. Wine,"Medical Semantics, Ontologies, Open Solutions and EHR Systems", Computer & Information Science Department, Shepherd University, West Virginia, August 2009.
[18] T. Thompson, D. Brailer, "The decade of health information technology: delivering consumer-centric and information-rich health care: framework for strategic action," Department of Health and Human Services, National Coordinator for Health Information Technology," 2004.
[19] E. Pan, D. Johnston, J. Walker, J. Adler-Milstein, D. W. Bates and B. Middleton, "The Value of Healthcare Information Exchange and Interoperability," Center for Information Technology Leadership, Wellesley, pp. 1-176,2004.
[20] L. M. Lau, S. Shakib, "Towards Data Interoperability: Practical Issues in Terminology Implementation and Mapping", 77th AHIMA Convention and Exhibit, October 2005.
[21] R. Lenz, M. Beyer, and A. Kuhn, "Semantic Integration in Healthcare Networks", Connecting Medical Informatics and Bio-Informatics", pp. 385-390, 2005.
[22] K. Rosati, M. Lamar, "The Quest For Interoperable Electronic Health Records: A Guide to Legal Issues in Establishing Health Information Networks," American Health Lawyers Association, pp. 1-107, July 2005.

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Règle de Taylor et conduite de la politique monétaire en Tunisie

[Taylor rule and the conduct of monetary policy in Tunisia]

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ABSTRACT: Following the failure of monetary targeting theory in the eighties, several authors have proposed alternatives. The Taylor rule is commonly accepted in recent years for the determination of interest rates in order to achieve the final goal of the central bank. The present study tends to lead an analysis of the compatibility of behavior of central bank of Tunisia (CBT) in the monetary policy conduct with the Taylor rule. The results obtained from quarterly data ranging from 1997 to 2011 showed that the original Taylor rule has a low explicative power of the monetary authorities' behavior in Tunisia. The proposed forward-looking rule describes plausibly interest rates dynamics. In this rule, the money market rate (MMR) is dependent on its past level, the output gap between current and potential output, the deviation of expected inflation from the implicit target, the differential of money market rate between Tunisia and the euro area and the inflation differential between Tunisia and France. Therefore, the Tunisian monetary policy can follow a rule based on two main aggregates taken as targets, whose names are inflation and economic growth. The reaction function can be considered as a proposal for a new reform of the monetary policy of the Central Bank.

KEYWORDS: Monetary policy, price stability, Taylor rule, Tunisia, GMM.

RESUME: Face à l'échec de la théorie de ciblage monétaire dans les années quatre-vingt, plusieurs auteurs ont proposé des solutions de rechange. La règle de Taylor représente la règle communément admise ces dernières années pour la détermination du taux d'intérêt afin de réaliser l'objectif final de la banque centrale. La présente étude tend à mener une analyse sur la compatibilité du comportement de la Banque Centrale de Tunisie (BCT) en matière de conduite de la politique monétaire avec la règle de Taylor. Les résultats obtenus à partir de données trimestrielles s'étalant de 1997 à 2011 montrent que la règle de Taylor originale présente un faible pouvoir explicatif du comportement des autorités monétaires tunisiennes. La règle prospective proposée décrit d'une manière plausible la dynamique du taux d'intérêt. Cette règle fait dépendre le niveau du taux de marché monétaire (TMM) de sa valeur passée, de l'écart de production à son potentiel, de l'écart de l'inflation anticipée à la cible implicite, du différentiel des taux du marché monétaire entre la Tunisie et la zone euro et du différentiel d'inflation entre la Tunisie et la France. Par conséquent, la politique monétaire tunisienne peut suivre une règle fondée sur deux grands agrégats pris comme cibles, à savoir l'inflation et la croissance économique. La fonction de réaction estimée peut être considérée comme une proposition d'une nouvelle réforme de la politique monétaire de la BCT.

MOTS-CLEFS: Politique monétaire, stabilité des prix, règle de Taylor, Tunisie, MMG.

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1 INTRODUCTION

Dans un régime de contrôle de la quantité de monnaie, avec un contexte de croissance irrégulière et d'innovations technologiques et financières, il n'est pas facile de satisfaire l'objectif de la stabilité des prix en essayant de régler la croissance d'un agrégat monétaire particulier. La règle communément admise ces dernières années, pour la détermination du taux d'intérêt afin de réaliser l'objectif final de la banque centrale, est celle énoncée par [1] aux termes de laquelle la banque centrale fixerait son taux d'intérêt en réaction à l'écart du taux d'inflation à sa valeur cible ainsi qu'à l'écart de production. Il s'agit de chercher à la fois à obtenir la stabilité des prix et à se situer au niveau potentiel du taux de croissance [2].

Nous allons dans cette étude proposer une nouvelle réforme pour la politique monétaire en Tunisie en envisageant l'étude de l'opportunité pour la Banque Centrale de Tunisie (BCT) de suivre une règle de type Taylor. Nous allons chercher si la politique monétaire suivie par la BCT pouvait être résumée en une règle simple, à savoir une règle se caractérisant par une cible d'inflation et une autre de production. De façon commode, d'après [3], le test de la règle de Taylor consiste à vérifier la liaison du taux de court terme avec les principales variables économiques supposées influencer son niveau. Lorsque les écarts entre les taux observés et les taux calculés suivant la règle de Taylor sont faibles voir nuls, la règle estimée peut être considérée puissante.

2 LA CROISSANCE ECONOMIQUE ET LA FONCTION OBJECTIF DE LA POLITIQUE MONETAIRE TUNISIENNE

La Tunisie a été toujours considérée l'un des pays les plus stables économiquement. Cependant, il s'est avéré que la façade des chiffres économiques satisfaisants présentés par l'Etat n'a pas réussi à cacher l'autre face du mécontentement des tunisiens, principalement dû au problème de chômage. Aujourd'hui l'Etat tunisien doit s'efforcer de résoudre ce problème néfaste. Pour accroître le besoin de travail en Tunisie, il est peut être logique de faire face à la nécessité d'un accroissement de la production. La croissance économique, signifiant un accroissement de richesses produites et donc un accroissement de la production, représente la solution de ce problème.

Malgré que la croissance économique soit une condition nécessaire mais non suffisante de la réduction du taux de chômage, elle représente un élément capital pour l'offre d'emplois. Pour pouvoir réduire le taux de chômage, il est avantageux pour la Tunisie de s'engager dans une stratégie de croissance économique. Généralement, lorsque la croissance économique est faible, le taux de chômage augmente. Face à cette situation de récession en Tunisie, il est peut être préférable que les autorités monétaires tunisiennes accordent plus d'importance à la croissance économique, voire l'introduire dans leur fonction objectif. Si nous revenons au cas de la Fed, l'objectif de stabilité des prix entre en concurrence directe avec le soutien de la croissance économique. Le mandat dual de la Fed a été représenté par [1] par une fonction de réaction connu sous l'appellation règle de Taylor.

D'après [4], la règle de politique monétaire la plus pragmatique est celle qui arbitre entre l'inflation et le chômage, mais avec une manière prévisible, facilement comprise par tous. Il s'agit de la règle de Taylor. Selon [5], directeur général de la politique monétaire de la BCT, les autorités monétaires tunisiennes tentent à réaliser un arbitrage entre inflation et croissance. La BCT peut suivre, en conséquence, une règle de type Taylor.

3 PROPOSITION D'UN EXEMPLE DE REGLE DE TAYLOR POUR LA POLITIQUE MONETAIRE DE LA TUNISIE

En nous référant à [1] et à [6], nous définissons la règle de Taylor du type "*backward-looking*" sous la forme suivante :

$$r_t = r^* + \pi_t + \alpha\,(\pi_t - \pi_{cible}) + \beta(y_t - \ddot{y}_t) \quad (1)$$

avec :

r_t: taux d'intérêt nominal de court terme ou taux de Taylor ;

r^*: taux d'intérêt réel d'équilibre ;

π_t: taux d'inflation;

π_{cible}: taux d'inflation cible ;

$y_t - \ddot{y}_t$: écart de production représentant la différence entre le PIB réel effectif (y) et le PIB réel potentiel$(\ddot{y}\,)$;

α : coefficient de pondération de l'écart d'inflation ;

β: coefficient de pondération de l'écart de production.

3.1 LA QUESTION DE MESURE DES VARIABLES ET FONCTIONNEMENT DE LA REGLE DE TAYLOR

La règle de Taylor retrace succinctement l'ajustement d'un instrument, à savoir le taux d'intérêt, lorsque les variables cibles de l'inflation et/ou de la production s'écartent de leurs niveaux cibles. De ce fait, selon la règle, l'ajustement du taux d'intérêt est prescrit par des considérations à la fois de long terme, relatives à la stabilité des prix (écart d'inflation) et de court terme, en rapport avec des variations conjoncturelles de l'écart de production [7]. Ainsi, trois principales variables sont intervenues dans la règle de Taylor classique telle que définie dans l'équation (1) : le taux d'intérêt réel d'équilibre, l'écart de l'inflation et l'écart de la production. La règle de Taylor est sensible aux choix de ces variables et des coefficients retenus dans l'équation.

Dans la règle originale de Taylor proposée aux Etats-Unis, le taux d'intérêt réel d'équilibre a été fixé à 2%. Ref. [8] a retenu un taux égal à 3.5% pour les pays du G7. Ref. [9] a déduit le taux d'intérêt réel d'équilibre, pour les pays de l'union monétaire, à travers une équation de régression simple faisant intervenir le taux de change nominal vis-à-vis du Deutsche Mark. Ses résultats montrent un taux d'intérêt d'équilibre égal à 3.55%. Selon [6], [3] et [10], le taux d'intérêt réel d'équilibre peut être calculé par la moyenne de l'écart entre le taux d'intérêt nominal et le taux d'inflation durant la période donnée.

Concernant l'écart d'inflation, il représente la différence entre le taux d'inflation courant par rapport à la cible. Il s'agit de l'écart entre le taux d'inflation anticipée et la cible dans le cas des règles "*forward-looking*". Cette inflation objectif est généralement définie par les autorités monétaires et/ou par l'Etat. D'après [3], dans la mesure où le ciblage d'inflation n'a commencé qu'à partir des années quatre-vingt-dix, les études empiriques ont généralement retenu pour cible d'inflation soit la dernière valeur cible connue, soit la moyenne du taux d'inflation de la période étudiée. Cette dernière option s'appuie sur l'hypothèse selon laquelle la banque centrale présente un objectif de stabilisation du taux d'inflation autour de sa moyenne.

L'*output gap* ou l'écart de production est défini par l'écart entre le Produit Intérieur Brut (PIB) effectif réel et le PIB potentiel. Ref. [11] signale que la production "normale" définie par la production potentielle, peut être conçue par deux voies distinctes. La première est une approche statistique. Elle vise à extraire, a postériori, la tendance déterministe ou stochastique d'une série de PIB. La deuxième approche est économique. Elle tente à définir le niveau maximal d'activité compatible avec la stabilité du rythme d'inflation. Elle est mesurée dans plusieurs travaux à partir d'un filtre de Hodrick et Prescott. Cette technique permet de minimiser les fluctuations de la croissance de la production autour de sa valeur tendancielle.

Les coefficients α et β utilisés dans la règle de Taylor reflètent les préférences de la banque centrale concernant l'arbitrage entre l'inflation et la production. Selon [12], un tel choix des paramètres de la règle de Taylor, conditionne la politique monétaire de la banque centrale. Dans la règle originale de Taylor telle que présentée auparavant, les deux objectifs de court terme sont affectés chacun à un coefficient de pondération égal à 0.5 sans aucune argumentation de ce choix.

La règle de Taylor permet de calculer un taux d'intérêt de court terme, supposé pour Taylor optimal, cohérent avec les données économiques d'un pays. Afin d'évaluer l'adéquation de la politique monétaire aux données économiques fondamentales, le taux de Taylor, obtenu par la règle, est comparé au taux d'intérêt à court terme observé. En outre, certaines règles de Taylor sont considérées optimales, mais cela dépend des variables retenues et des coefficients de pondération utilisés dans la règle.

3.2 DESCRIPTION ET SOURCE DE DONNEES

Afin d'effectuer une estimation d'une règle de type Taylor pour la Tunisie, nous recourons à une base de données trimestrielles s'étalant de 1997 T1 à 2011 T4. Le choix de cette période est basé sur son homogénéité puisque nous allons chercher la réaction des autorités monétaires au taux de change et au comportement des autorités monétaires françaises. En effet, les réformes de libéralisation financière ont commencé dès 1987, mais leurs effets, à l'échelle interne et externe, ne se font sentir que plus tard, à partir de la deuxième moitié des années quatre-vingt-dix. Déjà, afin de développer les mesures de libéralisation financière externe, un marché de change au comptant et un marché de change à terme ont été créés, par les autorités monétaires tunisiennes, respectivement en 1994 et en 1997. Leur objectif était la décentralisation progressive de la gestion de devises et la détermination du taux de change, qui étaient le monopole de la BCT [13]. De plus, depuis la signature de l'accord de libre-échange avec l'Union Européenne (UE) en 1996, les liens économiques n'ont cessé de se développer avec l'Europe. Dès lors, l'économie tunisienne est devenue plus intégrée dans l'espace euro-méditerranéen. Une forte relation s'est créée avec l'économie européenne, notamment en matière de change. Cette intégration monétaire de l'UE a, désormais, des implications importantes sur le comportement des autorités monétaires tunisiennes.

Notre base de données est obtenue auprès de l'IFS (International Financial Statistics) et de la Banque de France. En outre, les taux d'inflation, le Taux de Change Effectif Réel (TCER), l'Indice de Production Industrielle (IPI) et le TMM de la Tunisie sont obtenus auprès de l'IFS. Le taux d'intérêt de la zone euro est obtenu auprès de la Banque de France.

Dans la présente étude, le taux d'intérêt nominal est mesuré par le TMM. Concernant le taux d'inflation, il est mesuré au moyen de l'indice des prix à la consommation (IPC). En nous référant à [14] et à [15], nous retenons un taux d'inflation cible implicite égal à 3%. Le choix de cette valeur découle de la politique de la BCT qui vise à préserver la valeur de la monnaie nationale en se rapprochant du niveau d'inflation observé chez les pays partenaires et concurrents. Concernant l'écart de production, il est mesuré par la différence entre la production effective et celle potentielle. Nous mesurons la production effective de la Tunisie par l'Indice de Production Industrielle (IPI). L'IPI est utilisée comme une variable proxy du PIB puisque les données concernant le PIB ne sont disponibles qu'à partir de 2000. La production tendancielle est obtenue à partir d'un filtre Hodrick-Prescott avec un degré de lissage 1600.

3.3 METHODOLOGIE DE L'ESTIMATION

Selon les tests de Dickey et Fuller, quelques variables utilisées ne semblent pas être stationnaires (TMM et différentiel du taux d'intérêt). En d'autres termes, économétriquement, ces résultats nous suggèrent de différencier ces variables en vue de les rendre stationnaires. En nous référant à [16], en faisant un arbitrage entre les aspects économétriques et les fondements économiques, nous privilégions la deuxième puisque les autorités monétaires surveillent les variables en niveau pour manipuler le TMM en niveau. Selon [16], les fondements économiques, nous incitent, lors de l'estimation de la règle de Taylor, à opter pour l'introduction des variables en niveau. Toutefois, pour confirmer la fonction de réaction exprimée dans la règle proposée, sur le plan économétrique, il faut vérifier la stationnarité des termes résiduels.

Conformément à [17], les Moindres Carrés Ordinaires (MCO) ne sont pas indiqués pour estimer ce type d'équation surtout dans les règles *"forward-looking"*, étant donné que l'inflation anticipée mesurée par l'inflation réalisée *expost* est inobservable. De surcroit, nous nous heurtons dans ce type d'équation, au problème d'endogénéité de l'inflation future aux chocs de la politique monétaire. Dès lors, l'estimateur des MCO est biaisé et non convergent. L'estimation de la règle de Taylor par la Méthode des Moments Généralisés (MMG) permet d'éviter certains inconvénients relatifs aux autres méthodes. Par exemple, l'estimation par les MCO se heurte au problème de corrélation entre les variables contemporaines et les termes d'erreurs, qui aboutit à un biais dans les coefficients.

Cependant, le test de Hausman est préconisé dans le cas des estimations par MMG. Ce test cherche la présence d'une corrélation entre les effets spécifiques et les variables explicatives, sous l'hypothèse nulle d'exogénéité des régresseurs. L'élaboration de ce test se fait en deux régressions MCO. La première régression consiste à régresser la variable que nous soupçonnons endogène en fonction des autres variables explicatives et des variables instrumentales. La deuxième régression consiste à reprendre la régression initiale en ajoutant le résidu de la régression précédente comme une variable explicative supplémentaire. Si le coefficient accordé au résidu est significatif, nous concluons que la variable est endogène, sinon elle est considérée comme exogène.

En effectuant ce test, nous remarquons que les résultats durant toutes les fonctions de réaction estimées, sont en faveur du problème d'endogénéité de l'inflation puisque le résidu estimé montre une significativité remarquable. L'estimation de la fonction de réaction par la MMG présente, par conséquent, l'avantage de tenir compte du problème d'endogénéité d'une part et de celui de l'hétéroscédasticité et de la corrélation ayant des formes inconnues d'autre part.

Les résultats présentés, lors des estimations par la méthode MMG, correspondent pour un ensemble d'instruments comprenant les retards 1 à 6 pour toutes les variables utilisées. Suite à ce choix d'instruments, leur nombre devient plus élevé que celui des coefficients estimés. La performance de l'estimation par la méthode MMG dépend crucialement de la validité de ces instruments choisis. Leur validité ne peut être confirmée qu'à partir des tests de sur-identification tels que ceux de Hansen et Sargan. Le test de Hansen et Sargan suit une loi de Khi deux. Sous l'hypothèse nulle, les instruments sont valides suivant un degré de liberté de $n - p$ avec n représentant le nombre d'instruments et p le nombre de paramètres. Les valeurs présentées par ce test ne rejettent pas l'hypothèse nulle de validité des instruments.

3.3.1 LA REGLE ORIGINALE DE TAYLOR

Nous commençons notre étude par l'estimation de la règle originale de Taylor, telle que présentée dans l'équation (1) :

$$r_t = \bar{\bar{r}} + \alpha\,(\pi_t - \pi_{cible}) + \beta(y_t - \ddot{y}_t) \qquad (2)$$

avec $\bar{\bar{r}}$: le taux d'intérêt nominal désiré lorsque l'inflation et la production sont à leurs niveaux cibles [18] ($\bar{\bar{r}}$ *est supposé constante*).

Les résultats de l'estimation de la règle traditionnelle de Taylor sont présentés dans le tableau 1.

Tableau 1. Estimation de la règle traditionnelle de Taylor selon l'équation 2

Variable	Coefficient	Std Error	T-Stat	Signif
constante	5.234940496	0.085973109	60.89044	0.00000000
$\pi_t - \pi_{cible}$	-0.131214836	0.059703764	-2.19776	0.02796587
$(y_t - \ddot{y}_t)$	0.07739049	0.034364205	2.25207	0.02431804

Les résultats économétriques obtenus montrent que le coefficient associé à l'inflation n'est pas conforme à la théorie (coefficient négatif). Déjà, en présentant, dans un graphique (Figure 1), l'évolution du TMM et du taux de Taylor obtenu, nous observons une nette incompatibilité entre les deux courbes. Cette forte différence entre elles, montre le faible pouvoir explicatif de l'équation estimée. En conséquence, l'équation 2 ne peut pas être considérée comme une fonction de réaction de la BCT. Ce faible pouvoir explicatif peut être justifié par l'absence de l'aspect prospectif dans la règle estimée. Pour atténuer cette insuffisance, nous allons essayer d'intégrer une anticipation de l'inflation dans la règle de Taylor.

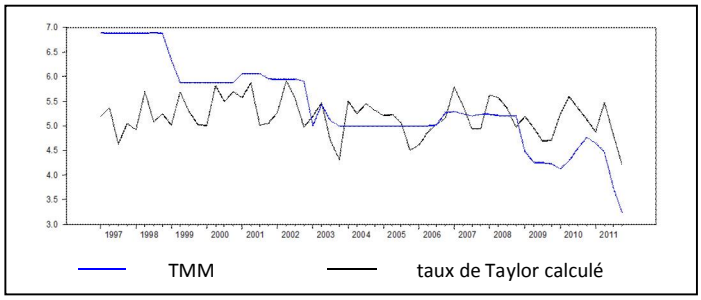

Fig. 1. Evolution du TMM et du taux de Taylor calculé selon l'équation 2 (1997-2011)

3.3.2 LA REGLE DE TAYLOR AVEC INFLATION ANTICIPEE

Ref. [8] a développé la règle de Taylor en introduisant les anticipations de l'inflation ; il l'a reformulée sous la forme "*forward-looking*". Nous présentons la règle de Taylor prospective dans l'équation (3) :

$$r_t = \bar{\bar{r}} + \alpha\,(E(\pi_{t,j} / \Omega_t) - \pi_{cible}) + \beta(y_t - \ddot{y}_t) \quad (3)$$

avec :

$E(\pi_{t,j} / \Omega_t)$: représente l'inflation anticipée ;

E : représente l'opérateur d'espérance mathématique ;

j : la période ou l'horizon pour laquelle le taux d'inflation est anticipé ;

Ω : l'ensemble des informations disponibles à la date t.

Notre approche consiste à considérer que le délai d'action de la politique monétaire est de quatre trimestres. nous supposons que la BCT réagit à π_{t+4}. Nous pouvons réécrire l'équation (3) sous la forme suivante :

$$r_t = \bar{\bar{r}} + \alpha\,(\pi_{t+4} - \pi_{cible}) + \beta(y_t - \ddot{y}_t) \quad (4)$$

avec π_{t+4} : l'inflation anticipée dans un an.

Tableau 2. Estimation de la règle de Taylor selon l'équation 4

Variable	Coefficient	Std Error	T-Stat	Signif
constante	5.277967930	0.063012198	83.76105	0.00000000
$\pi_{t+4} - \pi_{cible}$	-0.086840063	0.029024400	-2.99197	0.00277186
$(y_t - \ddot{y}_t)$	0.063516823	0.024356021	2.60785	0.00911132

Le coefficient α associé à l'écart entre l'inflation anticipée dans un an et la cible implicite de l'inflation, ne présente pas le signe attendu. La figure 2 illustre l'évolution du TMM et du taux de Taylor obtenu avec inflation anticipée. Le graphique présente encore des divergences entre les deux courbes. L'équation 4 ne peut pas aussi être considérée comme la fonction de réaction des autorités monétaires tunisiennes.

Afin d'essayer de pallier cette déficience, nous allons introduire le coefficient de lissage du taux d'intérêt. Ref. [3] stipule que le lissage part de l'hypothèse qu'une banque centrale a tendance à lisser les modifications de taux d'intérêt pour éviter une instabilité des taux qui peut toucher la confiance des agents économiques.

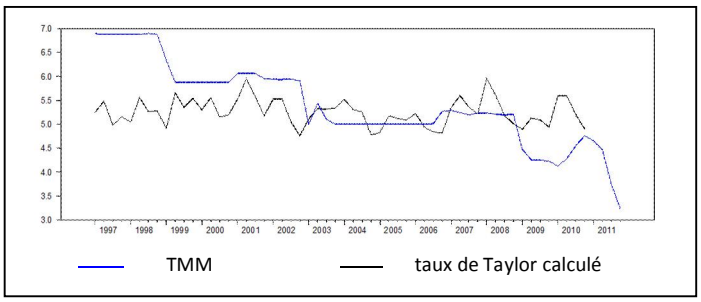

Fig. 2. Evolution du TMM et du taux de Taylor selon l'équation 4 (1997-2011)

3.3.3 LA REGLE DE TAYLOR AVEC LISSAGE DU TAUX D'INTERET

3.3.3.1 LE LISSAGE DU TAUX D'INTERET

Ref. [6] stipule que « le lissage peut également indiquer la réaction des actions politiques aux écarts de l'inflation et de la production observée durant plusieurs trimestres, plutôt que juste durant un seul trimestre ». D'après [6], le lissage peut être incorporé à une règle de type Taylor en supposant qu'au moment de la décision sur le niveau actuel du taux d'intérêt, la banque centrale met un poids sur le niveau précédent du taux d'intérêt, en plus des écarts de l'inflation et de la production.

Selon [17], le lissage du taux d'intérêt peut s'expliquer par le souci de la banque centrale de préserver sa crédibilité en évitant une forte volatilité du taux directeur. D'après [3], la fonction de réaction de la banque centrale peut, par conséquent, être décrite en termes d'ajustement partiel du taux d'intérêt. A chaque période, celui-ci s'ajuste à la moyenne pondérée du taux d'intérêt désiré et du taux d'intérêt réalisé durant la période précédente.

D'après [6], la valeur du paramètre du lissage du taux d'intérêt (ρ) est comprise entre 0 et 1. En outre, si $\rho = 0$, la règle de Taylor estimée sera celle proposée par [1] pour les Etats-Unis. Si $0 < \rho < 1$, la règle recommande, dans ce cas, une série de lissage des taux d'intérêt dans le sens que les changements dans les taux d'intérêt recommandés arriveraient progressivement.

En introduisant le coefficient de lissage dans la règle de Taylor "*forward-looking*" présentée dans l'équation (4), nous obtenons :

$$r_t = \rho r_{t-1} + (1-\rho)\,\bar{\bar{r}} + (1-\rho)\,\alpha\,(\pi_{t+4} - \pi_{cible}) + (1-\rho)\beta(y_t - \ddot{y}_t) \qquad (5)$$

avec ρ : le coefficient de lissage du taux d'intérêt.

3.3.3.2 ESTIMATION D'UNE REGLE DE TAYLOR POUR LA TUNISIE AVEC LISSAGE DU TAUX D'INTERET

Les résultats économétriques présentent les signes attendus avec une significativité remarquable des termes résiduels. Cependant le coefficient associé à l'écart d'inflation semble être relativement faible.

Tableau 3. Estimation de la règle de Taylor selon l'équation 5

Variable	Coefficient	Std Error	T-Stat	Signif
constante	0.3158831155	0.1196114482	2.64091	0.00826836
r_{t-1}	0.9363769194	0.0221147150	42.34180	0.00000000
$\pi_{t+4} - \pi_{cible}$	0.0190230402	0.0077197381	2.46421	0.01373164
$(y_t - \ddot{y}_t)$	0.0149975533	0.0057507178	2.60794	0.00910877

Les coefficients α et β déduits de l'équation estimée, sont présentés dans le tableau 4.

Tableau 4. Les principaux paramètres de la fonction de réaction selon l'équation 5

ρ	α	β	Nombre d'instruments	P-value
0.9363	0.2986	0.2353	15	0.6667

La figure 3 montre que la fonction de réaction des autorités monétaires tunisiennes selon la règle "*forward-looking*", qui tient compte du lissage du taux d'intérêt, illustre d'une manière acceptable la dynamique du taux d'intérêt estimée selon l'équation 5. Le graphique montre bien que la prise en compte du taux d'intérêt retardé détermine mieux la fonction de réaction de la banque centrale. Nous pouvons expliquer ce résultat par le souci de la BCT de préserver sa crédibilité en évitant une forte volatilité du taux directeur. Au moment de la décision sur le niveau actuel du taux d'intérêt, la banque centrale met beaucoup de poids sur le niveau précédent du taux d'intérêt, en plus des écarts de l'inflation et de la production.

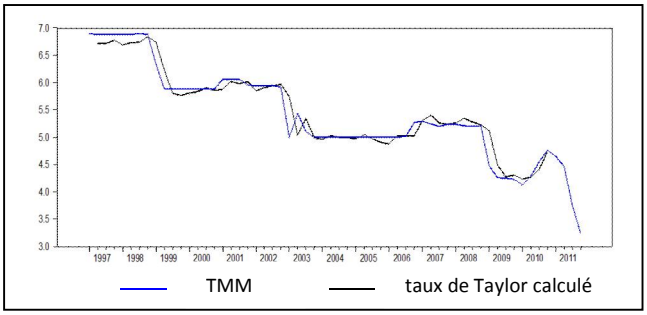

Fig. 3. Evolution du TMM et du taux de Taylor selon l'équation 5 (1997-2011)

Malgré que la figure 3 illustre bien la dynamique du taux d'intérêt avec une fonction de réaction prospective tenant compte du lissage du taux d'intérêt, nous remarquons, d'après les tableaux 3 et 4, que le poids associé à l'écart de l'inflation semble être faible par rapport à la réalité économique et par rapport aux études effectuées sur la règle de Taylor. Cela peut s'expliquer par l'absence d'autres variables susceptibles d'agir sur les décisions de la BCT lors de la détermination des taux directeurs.

3.3.4 LA PRISE EN COMPTE D'AUTRES VARIABLES EXPLICATIVES DANS L'ESTIMATION DE LA REGLE DE TAYLOR

3.3.4.1 Introduction du taux de change

La règle classique de Taylor ne comprend pas une allocation explicite pour les effets du taux de change. Cela est considéré, par plusieurs économistes, comme une faiblesse de la règle. En outre, dans une petite économie ouverte comme la Tunisie, où le taux de change peut jouer un rôle majeur dans l'évolution économique, son incorporation à la règle présente une importance primordiale. D'après [19], dans une économie ouverte, les mouvements du taux de change peuvent avoir des effets directs sur le niveau des prix, sur les attentes de l'inflation et sur la dynamique inflationniste. De surcroit, le taux de change pourrait s'attendre à avoir un certain impact sur les conditions de la demande pour les biens et les services, et par conséquent, à avoir des effets indirects sur les pressions inflationnistes. Selon [19], sans aucun doute, dans une économie ouverte, la meilleure façon de prendre des décisions en politique monétaire, revient à la prise en compte explicitement, des changements sur le taux de change et de leur effet sur l'économie. Toutefois, la prédiction des effets du taux de change n'est

pas toujours facile. Ref. [19] stipule que, l'expérience récente en Nouvelle-Zélande par exemple, suggère que le taux de change n'est pas toujours un indicateur fiable de l'état futur, son effet sur l'économie n'est, en aucun cas, prévisible.

La reconnaissance explicite des préférences de la banque centrale sur le taux de change pourrait renforcer la crédibilité de sa cible d'inflation. Lorsque le taux de change fluctue fortement, la banque centrale intervient, sous pression, pour agir. Son respect de la cible d'inflation devient moins crédible [20]. Autrement dit, les fortes volatilités du taux de change peuvent avoir des conséquences sur l'inflation, ce qui mine la crédibilité de la banque centrale.

Ref. [21] estime que la règle de Taylor s'est imposée comme l'un des instruments privilégiés pour décrire empiriquement le comportement des banques centrales. Nonobstant, la règle de Taylor, formalisée à partir de la situation américaine, retrace la politique monétaire d'une économie pourvue d'un taux de change flexible. Dans une telle situation, la banque centrale possède vraiment la possibilité de s'intéresser exclusivement aux variables internes, les variations du taux de change s'assurant théoriquement de l'équilibre externe. Au contraire, lorsque les autorités monétaires visent la préservation d'une parité plus ou moins fixe, elles ne peuvent plus s'arrêter aux seules considérations intérieures : le niveau du taux de change devient un objectif et parfois prioritaire sur toute autre considération, et notamment sur celle de la stabilisation conjoncturelle.

Certaines études économiques sur la règle de Taylor ont montré la perte significative du pouvoir explicatif de la règle par rapport au modèle de base. Si la règle de Taylor incorporant le taux de change, ne présente pas une significativité remarquable, [19] l'explique d'une autre façon : « Bien que la règle de Taylor ne tienne pas compte directement du taux de change, elle le fait implicitement. Lorsque le taux de change se déprécie, la production cyclique et l'inflation généralement augmentent. Comme ces deux variables sont incorporées à la règle de Taylor, cette dernière prend un peu de compte des effets des fluctuations des taux de change. Il est donc juste de dire que, bien que la règle de Taylor ne réponde pas directement au taux de change, elle répond indirectement à ses effets ». Nous introduisons, dans notre étude, un écart du taux de change effectif réel.

3.3.4.2 Intégration du différentiel du taux d'intérêt et du différentiel d'inflation

Ref. [22] déclare qu'en proposant une règle de référence en 1992, il a suggéré que cette règle soit utilisée en conjonction avec un portefeuille de règles : « L'idée était d'apprendre en utilisant les règles politiques, et ce processus d'apprentissage pourrait bénéficier du même type d'analyse de robustesse que bénéficie actuellement la recherche économétrique d'évaluation de la politique elle-même».

La Tunisie est créditée d'une moyenne de 1149 millions de dollars d'évasion de capitaux par an dans la période s'étalant de 1999 à 2008. Cette hémorragie de capitaux représente un problème auquel les pouvoirs publics devraient s'atteler. La politique des taux d'intérêt peut limiter cette fuite des capitaux. En effet, la politique peut s'orienter à inciter les détenteurs de capitaux à maintenir sur place leurs liquidités. En conséquence, la fixation des taux d'intérêt à des niveaux compétitifs par rapport à ceux des pays partenaires peut être bénéfique pour les autorités monétaires.

Nous coordonnons, dans la règle, le niveau du taux d'intérêt de court terme de la Tunisie à celui de la zone euro qui représente son premier partenaire. En effet, lors du choix de la base de données, nous avons signalé que, depuis la signature de l'accord du libre-échange en 1996, l'économie tunisienne est devenue relativement dépendante du comportement des autorités monétaires européennes. En outre, la fixation du taux d'intérêt par les autorités monétaires est estimée être liée à celui de la zone euro. En observant l'évolution du TMM en Tunisie, nous remarquons qu'il suit souvent la trajectoire du TMM européen (Figure 4).

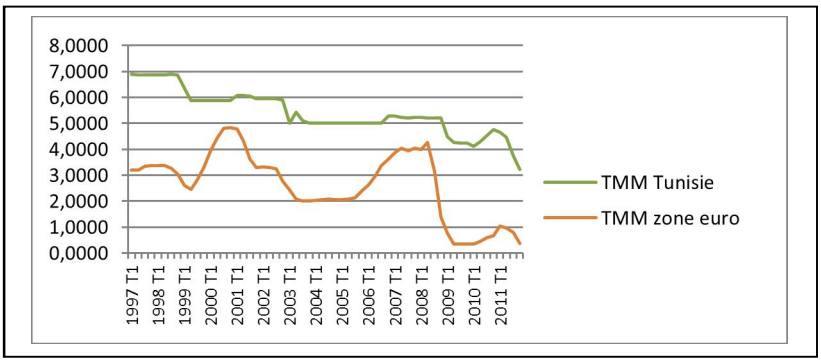

Fig. 4. Evolution du TMM de la Tunisie et du TMM de la zone euro (1997-2011)

Par conséquent, nous introduisons une nouvelle variable dans la règle de Taylor proposée pour la Tunisie. Cette variable représente le différentiel du taux d'intérêt entre la Tunisie et la zone euro :

$$dint = TMM\ de\ la\ Tunisie - TMM\ de\ la\ zone\ euro \quad (6)$$

La politique monétaire de la BCT, vise à stabiliser l'inflation qui doit être à un niveau proche de celui des principaux pays partenaires et concurrents. Les autorités monétaires tunisiennes essayent de compenser le différentiel d'inflation avec ces pays. Nous estimons que le différentiel d'inflation entre la Tunisie et la France, principal pays partenaire, est une autre variable explicative du taux d'intérêt en Tunisie. En effet, nous considérons que ce différentiel des taux d'inflation est déterminant de l'évolution du taux d'intérêt en Tunisie eu égard les relations monétaires et économiques entre la France et la Tunisie.

$$dinf = inflation\ en\ Tunisie - \ inflation\ en\ France \quad (7)$$

3.3.4.3 Estimation d'une règle de Taylor augmentée

L'estimation de la règle de Taylor pour la Tunisie part de l'équation (5). Nous introduisons le TCER, le différentiel du taux d'intérêt et le différentiel d'inflation. La règle proposée est présentée par l'équation 8.

$$r_t = \rho\, r_{t-1} + \ (1-\rho)\, \bar{\bar{r}} \ + (1-\rho)\ \alpha\ (\ \pi_{t+4} - \pi_{cible}) + \ (1-\rho)\beta(y_t - \ddot{y}_t) + \ (1-\rho)\ \delta e_t + (1-\rho)\gamma dint_t + (1-\rho)\lambda\ dinf_t \quad (8)$$

avec e_t : la variation du taux de change effectif réel ($\mathrm{TCER}_t - \mathrm{TCER}_{t-1}$).

Pour simplifier l'équation, nous pouvons représenter l'équation (8) sous la forme suivante :

$$r_t = A(1) r_{t-1} + \ A(2)\ (\ \pi_{t+4} - \pi_{cible}) + \ A(3)(y_t - \ddot{y}_t) + \ A(4) e_t + A(5)\ dint_t + A(6) dinf_t + \ A(7) \quad (9)$$

avec :

$A(1) = \rho$

$A(2) = (1-\rho)\ \alpha$

$A(3) = (1-\rho)\beta$

$A(4) = (1-\rho)\delta$

$A(5) = (1-\rho)\gamma$

$A(6) = (1-\rho)\lambda$

$A(7) = (1-\rho)\bar{\bar{r}} = constante$

En nous référant à [6], nous avons retardé quelques variables explicatives du taux d'intérêt afin de tenir compte de la disponibilité des données, vu que la banque centrale dispose à l'instant t des informations retardées. De ce fait, nous avons retardé le taux de change et le différentiel du taux d'intérêt d'une période. Nous obtenons l'équation suivante :

$$r_t = A(1) r_{t-1} + \ A(2)\ (\pi_{t+4} - \pi_{cible}) + \ A(3)(y_t - \ddot{y}_t) + \ A(4) e_{t-1} + A(5)\ dint_{t-1} + A(6)\ dinf_t + \ A(7) \quad (10)$$

avec :

$\rho = A(1)$

$\alpha = \frac{A(2)}{(1-A(1))}$

$\beta = \frac{A(3)}{(1-A(1))}$

$\delta = \frac{A(4)}{(1-A(1))}$

$\gamma = \frac{A(5)}{(1-A(1))}$

$\lambda = \frac{A(6)}{(1-A(1))}$

$\bar{\bar{r}} = \frac{constante}{(1-A(1))}$

D'après l'estimation économétrique de l'équation (10) telle que présentée dans le tableau 5, nous trouvons que toutes les variables présentent des signes compatibles avec la théorie.

Tableau 5. Estimation de la règle de Taylor selon l'équation 10

Variable	Coefficient	Std Error	T-Stat	Signif
constante	0.163406415	0.104059782	1.57031	0.11634234
r_{t-1}	0.962565832	0.018608883	51.72615	0.00000000
$\pi_{t+4} - \pi_{cible}$	0.015445763	0.005388371	2.86650	0.00415039
$(y_t - \ddot{y}_t)$	0.025395240	0.007232829	3.51111	0.00044624
e_{t-1}	-0.027898939	0.014355152	-1.94348	0.05195829
$dint_{t-1}$	-0.026026812	0.013163891	-1.97714	0.04802617
$dinf_t$	0.025187500	0.007089804	3.55264	0.00038139

Les coefficients α, β, δ, γ et λ déduits de l'équation estimée, sont présentés dans le tableau 6.

Tableau 6. Les principaux paramètres de la fonction de réaction selon l'équation 10

ρ	α	β	δ
0.9625	0.4106	0.6746	-0.7413
γ	λ	**Nombre d'instruments**	**P-Value**
-0.6933	0.6693	30	0.4499

La stationnarité des termes résiduels confire l'équation proposée sur le plan économétrique. En conséquence, nous pouvons écrire la règle de Taylor pour la Tunisie sous la forme suivante :

$$r_t = 0.9625\, r_{t-1} + 0.0154\, (\pi_{t+4} - \pi_{cible}) + 0.0253(y_t - \ddot{y}_t) - 0.0278\, e_{t-1} - 0.0260\ dint_{t-1} + 0.0251\ dinf_t - 0.1634 \quad (11)$$

La règle de Taylor estimée pour la Tunisie peut être réécrite sous la forme :

$$r_t = 0.9625 r_{t-1} + 0.0375 * [\ 0.4106\, (\pi_{t+4} - \pi_{cible}) + 0.6746(y_t - \ddot{y}_t) - 0.7413\, e_{t-1} - 0.6933\, dint_{t-1} + 0.6693\ dinf_t + 4.3573) \quad (12)$$

Durant a période qui s'étale de 1997 à 2011, nous remarquons que le coefficient de lissage est proche de 1 ($\rho = 0.9625$). La règle recommande, par conséquent, une série de lissage des taux d'intérêt dans le sens que les changements dans les taux d'intérêt recommandés arriveraient progressivement. La valeur du coefficient de lissage dénote la tendance des autorités monétaires tunisiennes à fixer le taux d'intérêt courant à partir de celui du dernier trimestre. Nous en déduisons aussi que le TMM est sensible à l'inflation anticipée et à l'écart de production, avec des poids proches de ceux proposés par [1]. Par conséquent, la BCT tient compte à la fois de la stabilité des prix et de la production. Déjà, [5] a annoncé que la BCT cherche aujourd'hui à concilier les deux objectifs, soit une meilleure croissance économique sans pression inflationniste.

Concernant l'inflation anticipée, nous pouvons dire que les autorités monétaires tunisiennes réagissent à l'inflation anticipée dans quatre trimestres. L'inflation anticipée dans un an présente le signe escompté. Son coefficient suppose une réaction des autorités monétaires dans l'ajustement du taux d'intérêt face à un risque d'inflation. En effet, face à une anticipation d'une hausse de l'écart d'inflation de 1%, la BCT augmente son taux d'intérêt de 0. 41%.

En ce qui concerne l'écart de production, son coefficient de sensibilité ($\beta = 0.6746$) est proche à celui de l'inflation anticipée ($\alpha = 0.4106$). L'écart de production en Tunisie contribue à l'explication de la variabilité des taux d'intérêt. Suite à une augmentation de l'écart de production de 1%, les autorités monétaires tunisiennes augmentent le TMM de 0.67%. De même, toute diminution de la croissance économique par rapport à celle potentielle est suivie d'une diminution du TMM pour encourager l'investissement et stimuler, par conséquent, la relance économique.

Pour la variation du taux de change retardé d'un trimestre, son coefficient présente le signe négatif attendu. En outre, la dépréciation de la monnaie nationale est généralement suivie par une augmentation des prix des produits importés. Cela pourrait, en conséquence, enclencher l'inflation. Face à cette hausse des prix, les autorités monétaires tunisiennes vont certainement augmenter le TMM pour la contrecarrer.

Le différentiel du taux d'intérêt ($TMM\ de\ la\ Tunisie - TMM\ de\ la\ France$) présente, de sa part, un coefficient relativement plus élevé que les autres variables ($\gamma = -0.6933$). Ce coefficient présente le signe négatif attendu. En effet, une diminution du différentiel du taux d'intérêt retardé d'un trimestre, résultant d'une hausse du TMM de la zone euro (du trimestre précédent), est suivie d'une hausse du taux d'intérêt en Tunisie. De même une baisse du TMM de la zone euro est accompagnée par une diminution du taux d'intérêt en Tunisie. Cela est déjà remarquable en observant l'évolution du TMM de la Tunisie et celui de la zone Euro (figure 4). Ce coefficient relativement élevé implique la tendance des autorités monétaires tunisiennes à ajuster le TMM de la BCT par rapport à celui de la zone Euro.

En observant le différentiel d'inflation ($inflation\ en\ Tunisie - inflation\ en\ France$), nous constatons la présence du signe positif escompté. En sus, toute augmentation remarquable de l'inflation tunisienne par rapport à son principal pays partenaire, est suivie par une hausse du taux d'intérêt afin de contrecarrer cette augmentation. De même, toute diminution de l'inflation en France, peut être suivie par une augmentation du TMM par les autorités monétaires tunisiennes dans le but de faire baisser l'inflation en Tunisie. Si ce différentiel d'inflation augmente de 1%, les autorités monétaires tunisiennes font élever le TMM de 0.66%. Dans le cadre de la fixation du taux d'intérêt, nous pouvons noter que les autorités monétaires prennent en compte l'écart de l'inflation anticipée par rapport à la cible implicite (3%) et à l'écart de l'inflation courante par rapport à celle du principal pays partenaire (France).

Nous présentons dans la figure 5, l'évolution du TMM et du taux de Taylor déduit à partir de l'estimation de la fonction de réaction présentée dans l'équation 10. La figure montre que la fonction de réaction estimée pour la BCT illustre d'une manière plausible la dynamique du taux d'intérêt observée. La faiblesse de l'écart entre le TMM et le taux d'intérêt estimé selon une règle de Taylor modifiée, prouve l'applicabilité de cette règle, dans un but descriptif et indicatif.

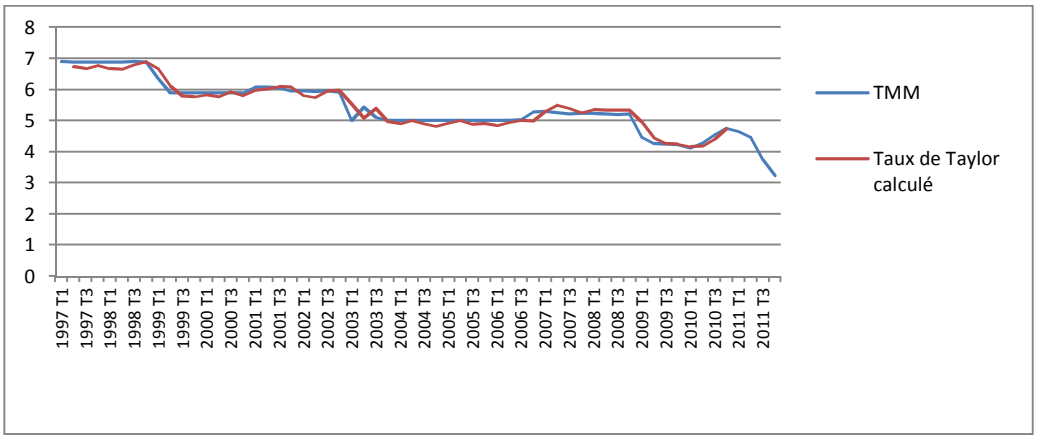

Fig. 5. Evolution du TMM et du taux de Taylor selon l'équation 10 (1997-2011)

Ce faible écart observé entre le taux directeur des autorités monétaires et le taux de Taylor permet la possibilité de caractériser la politique monétaire tunisienne. Nous parlons d'une politique monétaire expansionniste (respectivement restrictive) lorsque le TMM est inférieur (respectivement supérieur) au taux de Taylor.

Le graphique montre que la politique monétaire tunisienne, durant les périodes allant de 1997 jusqu'au deuxième trimestre de 1998, de 2004 jusqu'à 2006 et pendant 2010, est restrictive. Déjà en nous appuyant sur les rapports annuels de la BCT, nous remarquons que, durant l'année 1997 par exemple, la poursuite de la maitrise de l'évolution des prix en 1997 a été favorisée par l'application d'une politique monétaire rigoureuse. Face à la flambée sans précédent des prix de pétrole et à un taux d'inflation situé à 4.5% en 2006, les autorités monétaires tunisiennes ont annoncé que la maîtrise des prix a été assurée grâce à des mesures de politique monétaire relativement restrictives. L'aisance de la trésorerie des banques qui a caractérisé l'année 2009 s'est poursuivie durant les premiers mois de l'année 2010 et a amené la BCT à resserrer sa politique monétaire durant cette année.

Nous pouvons noter, à partir de la figure 5, que la politique monétaire suivie par la BCT peut être caractérisée par une politique expansionniste durant la période qui s'étale de 2007 jusqu'au début de 2009. En revenant au rapport annuel de 2008 par exemple, nous remarquons que le gouverneur de la BCT a souligné qu'une politique monétaire accommodante a été menée afin de soutenir l'investissement et stimuler la demande intérieure et l'exportation. De surcroit, suivant le 51ème rapport annuel, la politique de soutien d'activité économique et de relance de la croissance économique a continué durant le début de l'année 2009. Cette dernière a été accompagnée par la conduite d'une politique monétaire expansionniste. Des effets restrictifs ont été marqués à partir du deuxième trimestre.

L'évolution du résidu et de l'accroissement du TMM, présentée dans la figure 6, confirme et valide sur le plan économique l'équation 10 proposée pour la BCT. En effet, nous remarquons que, généralement, les deux courbes varient dans le même sens. Par conséquent, la variation du TMM suit bien la variation de l'amplitude de déséquilibre.

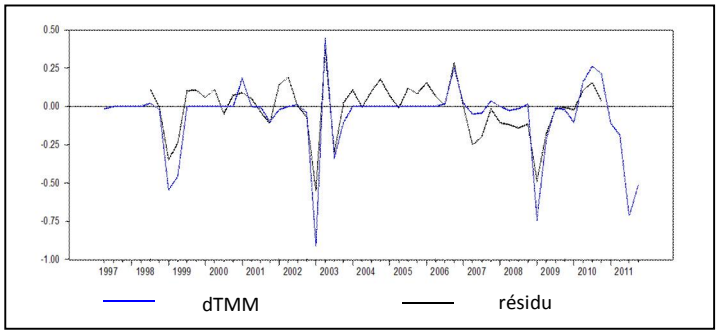

Fig. 6. Evolution du résidu et de la variation du TMM selon l'équation 10 (1997-2011)

La figure 6 confirme les mêmes périodes d'expansionnisme et de restrictivité de la politique monétaire tunisienne déduites de la figure 5. En outre, nous pouvons noter l'expansionnisme de la politique monétaire tunisienne durant la période qui s'étale de 2007 jusqu'au début de 2009, puisque le résidu est négatif. Nous remarquons la présence d'une politique monétaire restrictive (résidu positif) de 2004 jusqu'à 2006 et durant l'année 2010.

4 CONCLUSION

Notre but, lors de cette étude, est de prouver que la nouvelle règle monétaire apparue en 1993 et connue sous le nom de règle de Taylor, peut s'adapter au cas de la politique monétaire de la BCT. Cette règle annonçant un objectif d'inflation et un autre de production, a été étudiée lors de nos réflexions sur une nouvelle réforme de politique monétaire pour la Tunisie.

En s'appuyant sur une base de données trimestrielles menée depuis 1997 jusqu'à 2011, l'estimation de la fonction de réaction pour la BCT comprenant l'écart de l'inflation anticipée par rapport à la cible, l'écart de production, le taux de change, le différentiel du taux d'intérêt et le différentiel du taux d'inflation, a montré des résultats satisfaisants. Il apparaît, dès lors, que la politique monétaire tunisienne menée, depuis 1997, par la BCT réagit aux évolutions de toutes les variables explicatives utilisées mais à des degrés d'importance différents. En outre, nous pouvons conclure que, durant la période étudiée, les taux historiques du marché monétaire sont relativement bien décrits par la fonction de réaction proposée. Dans le cadre de la fixation du TMM, la BCT semble prendre sa décision en fonction d'un large panel de variables. Ainsi, il peut être normal que le taux d'intérêt s'écarte du taux de Taylor estimé pour faire face à une situation exceptionnelle.

Il en ressort que la BCT suit effectivement une règle augmentée du type Taylor. En effet, la politique monétaire tunisienne peut suivre une règle fondée sur deux grands agrégats économiques pris comme cibles, à savoir l'inflation et la croissance économique. La fonction de réaction estimée pour la BCT peut être considérée comme une proposition d'une nouvelle réforme de politique monétaire.

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REFERENCES

[1] J.B. Taylor, "Discretion versus policy rule in practice", *Carnegie-Rochester conference series on public policy*, vol. 39, pp 195-214, December 1993.

[2] J.L. Gaffard (2012), "Crise de la théorie et crise de la politique économique : des modèles d'équilibre général stochastique aux modèles de dynamique hors de l'équilibre", *Observatoire Français des Conjonctures Economiques (OFCE)*, Document de Travail, n° 2012-10, pp 1-25, Mars 2012.

[3] K. Tenou, **"**La règle de Taylor : un exemple de règle de politique monétaire appliquée au cas de la BCEAO", *Union Monétaire Ouest Africain, Banque Centrale des Etats de l'Afrique de l'Ouest*, Notes d'Informations et Statistiques, n°523, pp 1-21, Mars 2002.

[4] D. Cohen (2011), commentaire sur "Le cenral banking après la crise: deux lectures d'une enquête internationale auprès d'économistes et de banquiers centraux", de J.P. Betbèze, C. Bordes, J. Couppey-Soubeyran et D. Plihon, *Conseil d'analyse économique*, pp 185-194, Mars 2011.

[5] M. Souilem, "Pour une croissance soutenue mais sans pressions inflationnistes", LaPresse de Tunisie, Entretien avec Mohamed Salah Souilem, Directeur Général de la politique monétaire de la BCT, 2012.

[6] S. Kozicki; "How useful are Taylor rules for monetary policy ?", *Federal Reserve Bank of Kansas City*, Economic Review, Second Quarter, pp 5-33, 1999.

[7] P. Lunnemann P. et A. Rouabah, "Règle de Taylor : estimation et interprétation pour la zone Euro et pour le Luxembourg ", *Banque Centrale du Luxembourg*, Cahiers d'études, Working paper, n°9, pp 1-31, Octobre 2003.

[8] G. Sachs, "The international economic analyst", vol. 11, issue 6 ,Juin 1996.

[9] S. Gerlach et G. Schnabel, "The Taylor rule and interest rates in the EMU area: a note", *Bank of International Settlements (BIS),* Working Paper, n°73, pp 1-8, Août 1999.

[10] M. Ben Tahar et A. Rahmani**,** "Règle de Taylor, taux de change et prix des actifs : le cas de la Tunisie", *Economies et Sociétés*, n° 5, 6 et 7, pp 835-853, Juin-Juillet 2006.

[11] J.P. Cotis et H. Joly; "Croissance tendancielle potentielle et output gap : les analyses de la direction de la prévision", Economie Internationale, n°69, pp 191-207, 1er trimestre 1997.

[12] S. Haddou, "Règle de Taylor et efficacité de la politique monétaire en Tunisie", *African Review of Money Finance and Banking*, n°1, pp47-64, 2003.

[13] F.B. Gabsi F. B. et S. Kamoun, "Libéralisation financière, pouvoir prévisionnel de la courbe des taux et conduite de la politique monétaire en Tunisie", *Revue Tunisienne d'Economie et de Gestion*, vol.28, N°28, pp 65-100, 2009.

[14] A. Boughrara, M. Boughzala et H. Moussa, "Financial fetters of Tunisia's moneary policy", actes du VIème colloque international "Prospective, stratégies et développement durable", pp 1-46, 21-23 Juin 2010.

[15] S. Mouley, "Les enjeux de la libéralisation des comptes de capital dans les pays du sud de la Méditerranée", *papier présentée dans le cadre de la MEDPRO (Mediterranean Prospects)*, MEDPRO Technical Report No. 11, pp 1-89, March 2012.

[16] M. Huchet-Bourdon, "Fonctions de réaction des banques centrales européennes et convergence", *Revue d'Analyse Economique*, vol. 79, n°3, pp 297-326, Septembre 2003.

[17] Mésonnier et J.P Renne, "Règle de Taylor et politique monétaire dans la zone euro", *Banque de France*, Note d'Etudes et de Recherche, n° 117, pp 1-30, Octobre 2004.

[18] Clarida, J. Gali et M. Gertler, "Monetary policy rules and macroeconomics stability: evidence and some theory", *Quarterly journal of economics*, vol. 115, n°1, pp 147-180, Février 2000.

[19] C. Plantier et D. Scrimgeour, "The Taylor rule and its relevance to New Zealand monetary policy", *Reserve Bank of New Zealand Bulletin*, vol. 65, n°1, pp 5-13, Mars 2002.

[20] J.D. Ostry, A.R. Gerlash et M. Chamon, "Two targets, two instruments: monetary and exchange rate policies in emerging market economies", *International Monetary Fund*, IMF Staff Discussion Note, SDN/12/01, pp 1-24, Février 2012.

[21] A. Ertugrul, J. Hericourt et J. Reymand, "Fonction de réaction et politique monétaire en changes fixes : une nouvelle formulation appliqué à la Turquie", *Economie Internationale*, n°103, pp 97-119, 3ème trimestre 2005.

[22] J.B. Taylor, "The robustness and efficiency of monetary policy rule as Guidelines for interest rate setting by the European Central Bank", *Journal of Monetary Economics*, vol. 43, n°3, pp 655-679, 1999.

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Protein Level and Heavy Metals (Pb, Cr, and Cd) Concentrations in Wheat (*Triticum aestivum*) and in Oat (*Avena sativa*) Plants

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ABSTRACT: The aim of the study was to investigate heavy metal accumulation in wheat (*Triticum aestivum*) and oat (*Avena sativa*), and other physiological and biochemical parameters affected by these heavy metals. The data revealed that maximum plant fresh weight and plant dry weight was recorded for oat and minimum plant fresh weight and plant dry weight was noted for wheat (*Triticum aestivum*). The data also indicated that higher concentration of proline and DNA concentration was noted in wheat (*Triticum aestivum*) while lowest in oat (*Avena sativa*) *plant*. While DNA purity was highest in wheat (*Triticum aestivum*) and found lowest in oat (*Avena sativa*). Highest concentration of protein was recorded by wheat (*Triticum aestivum*) while lowest protein concentration was noted for oat (*Avena sativa*). The data further showed that wheat (*Triticum aestivum*) recorded maximum Cd concentration while minimum Cd concentration was noted in oat (*Avena sativa*). Highest concentration of Cr was noted in oat while minimum Cr concentration was recorded by wheat (*Triticum aestivum*). A maximum level of Pb was shown by oat (*Avena sativa*) while minimum levels of Pb were noted in wheat (*Triticum aestivum*). So oat (*Avena sativa*) plant is the higher accumulator of heavy metals i-e Cr and Pb while wheat (*Triticum aestivum*) accumulates Cd in highest concentrations.

KEYWORDS: Heavy metals, DNA, Protein content, Wheat, Oat.

1 INTRODUCTION

Wheat (*Triticum aestivum*) is usually the key feed along with a staple food intended for more than one third of the world population. It is sown about on 220 million hectares around the world wide with 564.6 million tons production; an average of 2500 kg grain feed every hectare. China sown wheat on about 30 million hectares, followed by the Russian Federation; India, the USA, Australia, Canada, Turkey and Pakistan. It is usually a new staple food plants associated with Pakistan, in addition to makes up about 36 % on the entire cropped region, 30 per cent on the importance added through important plants in addition to 76 % on the entire output associated with food grains. Among the wheat (*Triticum aestivum*) producing country, Pakistan stands at 10th place in terms of area (8.5 million hectares) and 59th in terms of yield (21.0 m ton) annually. Among the cereals, the particular wheat (*Triticum aestivum*) could be the majority of vantage and also crucial crop from the state. This specific edible foods crop accounts for about 37% from the cropped area of the state. The actual significant part of wheat (*Triticum aestivum*) throughout Pakistan is based on Punjab as well as Sindh. Nonetheless, the yield every hectare will be slightly increased throughout Sindh in comparison with Punjab as in [1].

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Heavy metals tend to be conventially defined as elements with metallic qualities (ductility, conductivity, stability as cations for example) in addition to an atomic number _ 20. The most prevalent heavy metals tend to be Cd, Cr, Cu, Hg, Pb iand Zn. Crops harvested throughout heavy metal ripe substrata consume precious metal ions throughout varying levelsUptake is basically influenced through the availability associated with metals, which can be in turn based on both external (soil associated) and also internal (plant associated) components. In a limited amount of plant kinds a heritable tolerance or level of resistance occurs, which makes it possible for these plants to cultivate on metallic contaminated soil as in [2]. Soil remediation can be eradicating threat to help people as well as the environment from deadly metals. Numerous research dealing with heavy metal hyper accumulating plants, plus they include concluded that phyto extraction connected with metals has been a feasible remediation technological innovation to the decontamination connected with metal polluted soil. Recent research considering this feasibility connected with phyto extraction, demonstrated which both precious metal hyper accumulation and also excellent biomass assure are required to help to make the procedure efficient as in [3].

Phytoremediation is surely a rising technology that uses the use of larger plant life for that clean up polluted natural environment. Phyto extraction, the use of plant to be able to acquire poisonous metals from polluted soils, has emerged as a cost-effective, and environment friendly clean up alternate.

Industrial waste items certainly are a key supply of soil pollution as well as are derived from exploration industrial sectors, chemical industrial sectors, metal processing industrial sectors yet others. These waste items include a number of chemicals such as heavy metals and phenolics etc as in [4]. Use of industrial effluents along with sewage sludge on agricultural land has turned into a common exercise in India because of which these types of toxic metals can be transferred along with concentrated straight into plant tissues on the soil. These metals have damaging effects on the plants themselves and could become some sort of health risk to safety to person and pets. Above a number of levels in addition to on the small array, the heavy metals develop into toxic compounds as in [5]. Also, these metals adversely influence natural microbial populations resulting in disruption of vital ecological processes. Presently, microorganisms are increasingly being used seeing that potential bioindicators to the assessment of chemical risk towards the ecosystem. The effects of major metals about the growth of plants in addition to microorganisms are investigated by simply several individuals as in [6]. Abiotic stresses like heavy metal stress, air pollutants stress and so on negatively have an effect on processes related to biomass generation and grain yield in nearly all major field grown crops as in [7]. Each metal in addition to plant interacts in a very specific method, which is dependent upon several factors including type regarding soil, growth conditions as well as the presence of regarding other ions.

Phytoremediation continues to be utilised properly to remediate inorganic and organic pollutants with in the earth and from groundwater. Numerous plants, such as canola (*Brassica napus L*), oat (*Avena sativa*), and also barley (*Hordeum vulgare*), tolerate and also collects metals like selenium, copper, cadmium and zinc as in [8]. *Avena sativa* (oat) is a monocot, can be a yearly as well as perennial herb and is a member of family poaceae. However, oat developed into a well known winter season fodder crop from the rice system. One of many green winter months fodders, oats were being said to be additional palatable when compared with wheat or grain. The actual production rates involving green oats is usually more than two times in which involving green wheat in addition to oats can also be a multi cut plant as in [9].

Oat straw is sweet along with nourishing, and it is the key supplement with regard to tense exhaustion. Oat straw benefits inside expresses involving major depression, anxiety, failure for a person to completely focus, melancholy, along with weakness. It's a excellent tonic natural herb, can be taken over long periods of time and is also secure for all a long time. Oats are usually high in terms of iron, manganese, zinc, calcium mineral, magnesium, and also potassium and are also well suited for people healing coming from long-term or even debilitating health issues. Benefit of white oat (*Avena sativa*) possesses increased within the last few years, with a new steep increase in grown area to meet the market place demand. On account of health positive aspects, such for the reason that reducing influence of b-glucan on blood cholesterol levels, the crops have become integrated inside the human food chain as in [10]. The integration of white oats with production systems also allows a vast improvement of garden soil physical, chemical and biological properties, lowering of pests and conditions in additional crops and allelopathic weed control as in [11],[12]. A hydroponic screening of 22 grass species indicated that oat (*Avena sativa*) and barley (*Hordeum vulgare*) tolerated th high Cu, Cd and Zinc concentrations present in the solution and also accumulated elevated concentrations of these metals in the plant shoots as in [13].

2 OBJECTIVES

The present study was aimed to find a suitable plants species for use in cleaning up the soil in industrial regions.

3 MATERIALS AND METHODS

The aim of the study was to investigate heavy metal accumulation in wheat and oat, and other physiological and biochemical parameters affected by these heavy metals. For this purpose plants from wheat and oat were collected from the field grown crops at Malakandhere Research Farms of The University of Agriculture Peshawar. Plant materials were analyzed for different physiological and biochemical parameters along with the determination of heavy metals accumulation by the collected plants. The following parameters were studied during the course of the study.

1. Plant fresh weight and Plant dry weight.
2. Proline content.
3. Protein extraction and quantification.
4. Genomic DNA extraction, DNA quantification and purity.
5. Heavy metals analysis (Cd, Cr and Pb).

3.1 PLANT FRESH WEIGHT AND PLANT DRY WEIGHT

Plant fresh weight has been registered by taking fresh weight regarding ten plants by using electric balance as well as the averages has been then determined. Plants obtained with regards to fresh weights data were being next dried with 80 ºC for 48 hours within oven as well as the dried out excess weight has been noted by making use of an electronic balance as well as averaged.

3.2 PROLINE CONTENT

Proline had been tested as in [14] with minor modifications. For this purpose, 100 mg associated with frozen plant material was homogenized inside 1ml of sterilized distilled water and the debris was removed simply by centrifugation at 5000 rpm. 250 µl of the extract was reacted with 1ml of acid Ninhydrin in addition to 1ml of Glacial acetic acid. The mixture was then positioned in a water bath for 1 hour at 100 ^{o}C, and the reaction was terminated in an ice bath. The reaction mix was mixed with 4 ml of toluene and its optical density was calculated at 520 nm. The amount of proline in unknown samples was determined from standard curve.

3.3 PROTEIN EXTRACTION AND QUANTIFICATION

Healthy proteins seemed to be extracted by means of grinding regarding 800 mg lyophilized plant material pre-cooled mortar and pestle. The slurry was homogenized with 2 ml buffer containing 100 mM Tris-HCl (pH 6.8), 1% SDS and 0.1% β-merceptoethanol and centrifuged with 15000 rpm for 10 minutes at 4^{o}C. The seemed to be collected and necessary protein seemed to be quantified via Bradford procedure making use of Bovine Serum Albumin as standards as in [15].

3.4 GENOMIC DNA EXTRACTION FROM LEAVES OF WHEAT AND OAT

Leaf samples were taken and grinded in to good powdered form and also transmitted that into eppendorf tubes. 100 mg of grinded leaf samples included with 600 µl pre-warmed DNA 2X CTAB extraction buffer (Table 1). After that 0. 6 volume of chloroform isoamylalcohol (24: 1) had been added in, mixed by shaking for 15 minutes and also centrifuged from 15000 rpm intended for 10 minutes. The supernatant had been transferred to clean tubes in addition to included 0. 6 amounts associated with iso-propanol to precipitate the DNA. The samples have been then centrifuged on 12000 rpm for 10 moments. Then the pellet had been cleaned together with 90%, 80% in addition to 70% ethanol and then dried by means of adding the tubes upside down for 10 minutes. The dried pellet had been then mixed inside distilled mineral water on 60 ºC inside water bath to help dissolution. DNA samples have been then located or stored on at -80 ºC until used. The samples have been then quantified as a result of UV-spectrophotometer on 260 nm and on 280 nm.

Table 1. Composition of 2X CTAB DNA extraction buffer

Composition of 2X CTAB DNA Extraction Buffer	
CTAB	2%
NaCl	1.4 M
EDTA	20 mM (pH 8)
Tris-HCl	100 mM
β-mercaptoethanol	2µl/ml of buffer

3.5 PROCEDURES FOR HEAVY METAL ANALYSIS

Samples collected were dried in at 80 °C with regard to 48 hrs and are next finely grinded through grinder. The dried as well as crushed shoot samples (1g) were next made up for atomic absorption spectrophotometer analysis. For this purpose, samples were then mixed having 15 ml concentrated nitric acid overnight. The samples were next warmed up for up to 250 °C until eventually when white fumes seemed, and the heating system was carried on with regard to one more hour. The samples were subsequently cooled off to room temperatures as well as diluted to help 25 ml with distilled water and were then filtered. Concentration of Pb, Cr as well as Cd had been determined by atomic absorption spectrophotometer in wavelengths of 283 nm, 357 nm as well as 228 nm respectively. Analysis of the soil before sowing revealed that the concentrations of Pb, Cr and Cd were 59.25, 28.75, 1.94 mg kg 1 respectively.

4 RESULTS AND DISCUSSION

The present research work describes the various physiological, biochemical and heavy metal concentrations of wheat and oat. These parameters are presented and discussed below.

4.1 PHYSIOLOGICAL PARAMETERS

Table 2 shows data regarding plant fresh and dry weight of wheat and oat. The data shown in Table 2 revealed that maximum plant fresh weight of 8.21 g was recorded by oat. Similarly, minimum plant fresh weight of 5.54 g was noted for wheat. This difference may be due to differences in their genetic make up. Data recorded for plant dry weight as shown in Table 2 indicated that maximum plant dry weight of 1.63 g was of oat plant recorded while minimum plant dry weight of 1.08 g was produced by wheat (Table 2).

4.2 BIOCHEMICAL PARAMETERS

The various biochemical parameters studied were proline, protein and DNA concentration of wheat and oat (Table 2). The data indicated in Table 2 showed, that higher concentration of 0.04 µg/g fresh weight proline was noted in wheat while oat produced proline concentration of 0.02 µg/g fresh weight. Data regarding DNA concentration and quality is indicated in Table 2. The result showed that maximum DNA concentration was noted in wheat (43.5 mg/ml) followed by oat with DNA concentration of 13.0 mg/ml. It is also clear from the data shown in Table 2 that wheat had the highest DNA purity (1.10) while minimum DNA purity was noted in oat (0.28). Data concerning protein concentration is indicated in Table 2. The results revealed that highest concentration of 5.82 mg/ml protein was recorded by wheat while lowest protein concentration of 3.76 mg/ml was noted for oat (Table 2).

Table 2. Physiological and biochemical characters of wheat, oat and barley

Genotypes	Plant Fresh Weight (g)	Plant Dry Weight (g)	Proline (µg/g)	Protein (mg/ml)	DNA (mg/ml)	DNA Purity
Wheat	5.54	1.08	0.04	5.82	43.5	1.10
Oat	8.21	1.63	0.02	3.76	13.0	0.28

4.3 HEAVY METAL CONCENTRATION

Table 3 presents data regarding different heavy metal concentration in wheat and oat collected from Malakandhere Research Farms of The University of Agriculture Peshawar. The data showed that wheat recorded maximum Cd concentration (2.55µg/g) and minimum Cd concentration was noted in oat (0.26 µg/g). The data in Table 3 further revealed that highest concentration of Cr was noted in oat (53.002µg/g) while minimum Cr concentration of 33.0 µg/g was recorded by wheat. The data concerning Pb levels revealed that maximum levels of Pb was shown by oat (40.10 µg/g) followed by wheat with Pb levels of 37.18 µg/g (Table 3).

Table 3. Heavy metal concentrations (µg/g) of wheat, oat and barley

Genotypes	Cadmium (Cd)	Chromium (Cr)	Lead (Pb)
Wheat	**2.55**	**33.00**	**37.18**
Oat	**0.26**	**53.02**	**40.10**

5 CONCLUSION

The present study investigates heavy metal uptake (Cd, Cr and Pb) by wheat and oat and their physiological and biochemical parameters. The data revealed that maximum plant fresh weight was recorded by oat and minimum plant fresh weight was noted for wheat. Maximum plant dry weight was recorded for oat while minimum plant dry weight was produced by wheat. The data also indicated that higher concentration of proline was noted in wheat while oat produced lowest proline concentration. Data regarding DNA concentration and quality showed that maximum DNA concentration was noted in wheat followed by oat with minimum concentration. Wheat had the highest DNA purity followed by oat.

Highest concentration of protein was recorded by wheat while lowest protein concentration was noted for oat. The data showed that wheat recorded maximum Cd concentration while minimum Cd concentration was noted in oat. Highest concentration of Cr was noted in oat while minimum Cr concentration was recorded by wheat. A maximum level of Pb was shown by oat while minimum levels of Pb were noted in wheat.

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SYED NOOR UL ABIDEEN

REFERENCES

[1] Dr. S.M. Alam, “Wheat an important edible crop of Pakistan”. [Online] Available: http://www.pakistaneconomist.com/issue2001 (April 2013)

[2] Brooks, N.H, Rohrlich, D., and Smith. W. H. Transition Probabilities and Absolute Oscillator Strengths for Transitions of Ci, Oi, and Ni Observed in Absorption in Hi Regions. *Astrophysical Journal*, 214: 328-330, 1977.

[3] Salt, d. E., M. Blaylock, kumar. N.P. B.A., V. Dushenkov, D. Ensley, Chet. I. and Raskin. I. Phytoremediation: A novel strategy for the removal of toxic metals from the environment using plants. *Biotechnology,* 13: 468-474, 1995.

[4] Van, A.F. and Clijsters. H. Effects of heavy metals on enzyme activity in plants. *Plant Cell Environ*. 13: 195-206, 1990.

[5] Babich, H., Schiffenbauer. M. and Stotzky. G. Comparative toxicity of trivalent and hexavalent chromium to fungi. *Bulletin of Environmental Contamination and Toxicology*, 28: 193-202, 1982.

[6] Baccouch, S., Chaoui, A., and Ferjani, E.E. Nickle induced oxidative damage and antioxidant responses in Zea mays shoots. *Plant Physiol. Biochem*. 36, 689-694, 1998.

[7] Agrawal, V. and Sharma. K. Phytotoxic effects of Cu, Zn, Cd and Pb on *in vitro* regeneration and concomitant protein changes in *Holarrhena antidysentrica. Biol*. *Plantar*, 50: 307-310, 2006.

[8] Banuelos, G.S., A. Zayed, N. Terry, B. Mackey, L. Wu, S. Akohoue S and S. Zambrzuski. Accumulation of selenium by different plant species grown under increasing salt-regimes. *Plant Soil*, 183: 49–59, 1997.

[9] Tshering Gyaltsen. Experiences with Oats (*Avena Sativa*) at Temperate and High Elevations of Bhutan. (Paper presented at the 5th Temperate Asia Pasture and Fodder Network Meeting held at RNRRC Bajo, Bhutan from 30 April to 4 May, 2002).

[10] Finatto T, Silva JAG, Carvalho FIF, Oliveira AC, Valério IP, Reis CES, Ribeiro G, Silveira G and Fonseca DAR. Reação de tolerância de genótipos de aveia branca a concentrações de alumínio em solução nutritiva. *Magistra* 19: 07-15, 2007.

[11] Jacobi US and Fleck NG. Avaliação do potencial alelopático de genótipos de aveia no início do ciclo. *Pesquisa Agropecuária Brasileira* 35: 11-19, 2000.

[12] Fontaneli RS, Santos HP, Voss M and Ambrisi I. Rendimento e nodulação de soja em diferentes rotações de espécies anuais de inverno sob plantio direto. *Pesquisa Agropecuária Brasileira,* 35: 349-355, 2000.

[13] Stephen D. Ebbs and Leon V. Kochian Phytoextraction of Zinc by Oat (*Avena sativa*), Barley (*Hordeum vulgare*), and Indian mustard (*Brassica juncea*). *Environ. Sci. Technol*, 32 (6), pp 802–806, 1998.

[14] Bates, L.S., R.P. Waldren and I.D. Teare. 1973. Rapid determination of free praline for water stress studies*. Plant and Soil*, 39: 205-207, 1973.

[15] Bradford, M.M. 1976. A rapid and sensitive method for quantitation of microgram quantities of protein utilizing the principle of protein-dye-binding. *Analytical Biochem,* 72: 248-254, 1976.

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Study of a proactive agent in a multichannel environment: The X-CAMPUS project

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ABSTRACT: The main characteristic of intelligent devices that compose our environment is their capability to perceive and collect relevant information (context awareness) in order to assist users in their daily tasks. However, these tasks evolve frequently and require dynamic and evolutionary systems (context-aware systems) to improve intelligent devices skills according to user's context. Some context-aware systems are described in the literature, but most of them have extremely tight coupling between the semantic used in the application and sensors used to obtained the data for this semantic interpretation. The objective of our research is to study and implement a proactive approach able to use existing sensors and to create dynamically human-machine conversational situations when needed. The system presented in this paper is named X-CAMPUS (eXtensible Conversational Agent for Multichannel Proactive Ubiquitous Services). It aims to assist user in his/her daily tasks thanks to its ability to perceive the state of the environment and interact effectively according to the user's needs. In this paper we describe our approach for proactive intelligent assistance and we illustrate it through some scenarios showing that according to a given multi-parameters context, our X-CAMPUS agent notifies the user via personalized messages (e.g., suggestion of restaurants according to menus and users' preferences) across the most appropriate channel (instant messaging, e-mail or SMS) and the most appropriate modality (text, gesture or voice). Then, we discuss our quantitative results, based on four principal hypotheses in order to evaluate our system's capability to manage many users simultaneously with different contextual information. We argue and we show that the proactive assistance is very relevant in complex situations with various criteria to take into account (user's profile, location, task, etc.).

KEYWORDS: Intelligent Interfaces, Ubiquitous Computing, Human-Computer Interaction, Proactive Assistance, Multimodal Interfaces, Multi-Channel Interfaces.

1 INTRODUCTION

Ambient Intelligence (AmI) aims at increase the comfort of users in theirs daily tasks based on context information. In our life, we often repeat usually the same tasks, for instance, consulting the weather forecast before going outside, checking appointments, controlling children's tasks, etc.).

We believe that users will appreciate hypothetical capability of intelligent systems to perceive their personal environment in order to manage some daily tasks. Therefore, AmI follows the goals of Ubiquitous Computing, a paradigm that was first suggested by Weiser in the early 1990s. His vision was to increase the welfare of a user situated in a computer everywhere environment by supporting human assistance in an intimate way [15].

One research domain that requires the computer- everywhere model of ubiquitous computing is that of the "intelligent environment" [13]. In this domain, a wide range of simple information (e.g., light sensor, audio/video sensor, temperature sensor, google calendar, information from the web, etc.) and composite information (e.g., presence sensor and preferences of users) can be collected from heterogeneous sensors in order to determine automatically users' needs based on their context's information.

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In this context-aware domain, many *ad hoc* systems exist in order to be able to perform an adaptive assistance. However, these systems present two main limits: the difficulty to develop due to the requirements of dealing directly with sensors and the difficulty to evolve because the application semantics are not separated from the sensor details (also rules).

So, building applications, depending on context-aware which can support reuse sensors and new context types stays hard tasks, which covered many context-aware features. As said by Dey in his thesis "context has the following properties that lead to the difficulty in use "[1]:

- Context is acquired from non-traditional devices (i.e., not mice and keyboards), with which we have limited experience. For example, tracking the location of people or detecting their presence may require Active Badge devices [18], floor-embedded presence sensors [19] and video image processing…
- Context must be abstracted to make sense to the application; Active Badges provide IDs, which must be abstracted into user names and locations.
- Context may be acquired from multiple distributed and heterogeneous sources. Detecting the presence of user in a room reliably may require combining the results of several techniques such as image processing, audio processing, floor-embedded pressure, etc.
- Context is dynamic; changes in the environment must be detected in real time and applications must change behavior to constant changes.
- Context information history, as shown by context- based retrieval applications [14, 8]; context history can be used to recognize user's activities and to fully exploit the richness of context information.
- These difficulties prevent to build context-aware applications the ability to support reuse of sensing technologies in new applications and evolution to use new context in new ways. In this paper, we present a system which can support new context types and evolve dynamically according to user's preferences.
- This document is organized as the following: First, we describe some previous context-aware applications. Second, we present our research problematic and how we proceeded to resolve it. Third, we describe our proposed architecture and some illustrative examples. Lastly, we state our future work and conclusion.

2 RELATED WORK

Weiser's vision in his article "The Computer for the 21st Century" [16] is to serve people's daily tasks through an intelligent environment which should acts invisibly and unobtrusively in the background and freeing users from tedious routine tasks in order to reduce users' responsibilities.

Ubiquitous computing aims to integrate each intelligent entity that can be identified and provide information about user's context such as sensors which can provide immediate information according to user's situation. Thus, user's goals and desires can be anticipated from the interaction context which is defined by Dey [3] as "any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and application themselves". In our work, to use context effectively we have decided to define context as any information that let our system initiate a conversation or change the way of interaction in order to ensure the continuity with the user.

Many projects were developed around the notion of context aware. In 1998, Coen created the Intelligent Room MIT [13]. This is a conference room equipped with 12 cameras, 2 video projectors, display devices, microphones and loudspeakers. The goal of this room is to interact with different form of modality. In the field of home automation, Mozer created the Adaptive House [12] which is an intelligent home equipped with 75 sensors in order to provide information such as temperature, ambient light, door's and window's situations. Adaptive house has also the capability to manage energy. Microsoft has also created the project named EasyLiving [5], which calculates user's position and propose service depending on his position.

In 1997 a project named Cyberguide has for goal to help a tourist in her/his visit by providing according to her/his current position the interesting sites to visit, paths to follow and other useful information. In the same domain and in the 2000 another project named Guide was created with some differences in the hardware used and web access. Each of these projects illustrates convincing results from different use cases. These architectures are *ad hoc* and very dependent to the sensors used. They do not permit the reuse of the software architecture which let the domain of use very limited. After 2000 and thanks to the emergence of new technologies able to describe more in details user's environment, new architectures appeared in order to facilitate the development of applications able to assist users in their daily tasks. In 2004 a middleware for supporting the development of context-aware applications named CASS was created [17]. It uses an object oriented model for context details and provides an important abstraction of contextual information. Context toolkit [4] is another tool

which searches also to facilitate the development of context-aware systems. It is based on context widgets which offer a good abstraction and reuse of context like graphical user interface widgets in order to hide the complexity of sensors.

Ubiquitous computing aims to change ordinary interfaces by intelligent interfaces in order to let user feeling natural communication on many levels (complexity, size, and portability). In the 70's, the technology-driven focus on interfaces was slowly changed and in the 80's the new field of Human-Machine Interaction (HCI) appeared. With the appearance of new technologies such as data mining, machine learning, speech/voice recognition, facial recognition and omnipresent computing, we can see that human computer interactions are drastically increasing. Consequently, it should change the way we interact with the ambient environment by providing new intelligent interfaces able to adapt behavior according to user's situation. Around 1994 until 1996, intelligent agents, practical speech recognition and natural language applications appeared. However, since then, intelligent user interfaces evolve slowly. We also argue that implementing and maintaining interfaces, which should be at the same time proactive and intelligent, is still far from easy.

3 RESEARCH QUESTIONS

The inference of user's requirements or proactive assistance is a very delicate problem, which we have chosen to explore through the following question, "proactive assistance: why, when and how to use it?"

The first question "Why" has for objective to search how can proactive assistance reduces user's responsibilities. As we know, we have many boring routine tasks and we search to delegate more of them to our intelligent environment in order to have more time for other more complex tasks. Thus, by the capability of the intelligent environment to perceive environment and user's habits, system based on proactive assistance could anticipate users' needs without any explicit request.

The second question "When" is devoted to determine the adequate time; when intelligent environment decide to communicate user's need. Once intelligent environment determines user's needs, it should interpret user's real situation in order to decide if service can be communicated. However, the last question "How" is interested to adapt the way we interact with our environment. Depending on context, our system should find the adequate modality (text, speech and gesture) and channel (Internet and phone channel) according to user's situation.

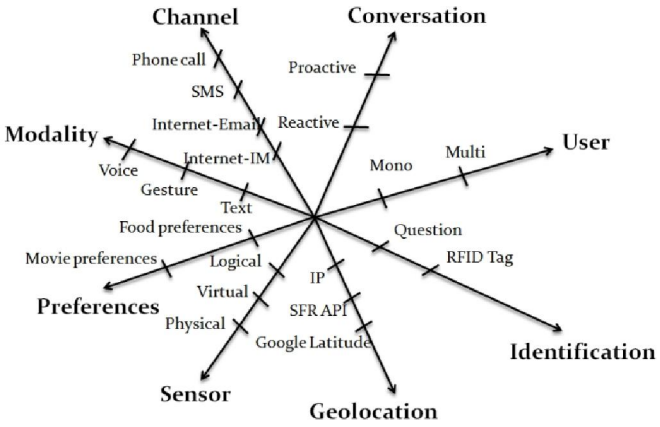

Fig. 1. X-CAMPUS's capabilities

As we can see in Figure 1, X-CAMPUS has many different skills which are represented by the different available axes. Thanks to the use of physical (e.g., RFID tags), virtual (e.g., Google calendar) and logical sensors (e.g., Google calendar combined with RFID tags), our system can interact in both reactive and proactive mode, according to user's needs.

X-CAMPUS is also capable to manage some social aspects of the context. For example, events like "Eating at restaurant" registered in the user's agenda will lead to take into account the possible guests (friends, colleagues, etc.) involved in this particular event. Thus, some relatively complex and time consuming tasks can be done directly by a software agent that is in charge to find the better choice (example: the best restaurant) according to various criteria (alimentary preferences, distances and geolocation of each person, etc.).

In order to ensure an adaptive interaction, we have decided to work on multi-channel and multi-modal interfaces and we have chosen to use two types of channels which are Internet and phone [9] and three type of modality which are text, gesture and voice.

4 PROPOSED ARCHITECTURE

To respond to our research questions, we have chosen to implement an architecture based on three principals layers (see Figure 2), which can communicate between them throw two different modes: the push and the pull modes, which are used, in our system, to provide reactive and proactive interactions. Each layer has for role to provide a service to the layer above in order to resolve user's needs. However, the mechanism of adaptation is shared between the second and third layer.

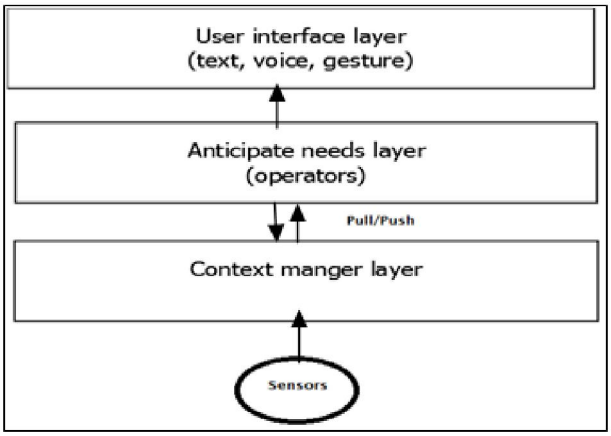

Fig. 2. Context model's architecture

Our architecture is currently deployed on a server containing a database of contextual information (based on an object oriented model for context description), supporting various constraints and rules developed in an *ad-hoc* way.

4.1 CONTEXT MANAGE LAYER

To build systems able to act differently according to context awareness, intelligent environment should perceive and control sensors networks regularly through the "context manager layer". This layer should communicate with heterogeneous sources in order to collect information and register them in the database [2, 6, 7]. This layer is based on context provider and context repository. It controls the behavior of sensors and saves new issues values (static, temporary and dynamic information) in context repository. It should also communicate directly with the second layer in order to publish information even before context repository registers information in database for later use.

An example of sensors that we used to collect information is a Radio Frequency Identification (RFID) reader accompanied with RFID tags. When RFID reader detects an RFID tag (see Figure 3 and Figure 4, left), it firstly determines the user's name in order to salute him/her (see Figure 3 and Figure 4, right) and secondly calculates the number of persons at home.

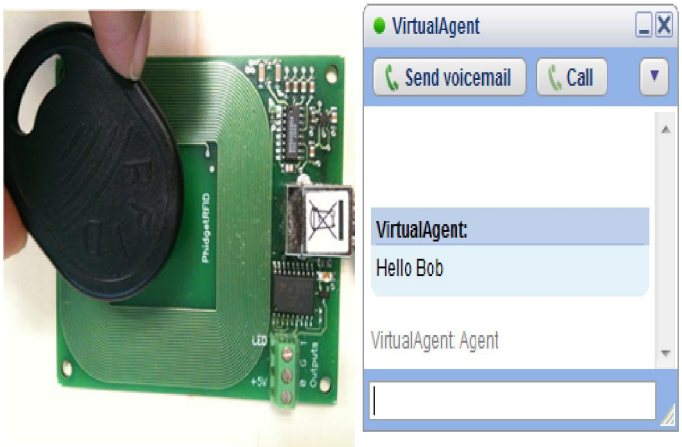

Fig. 3. (Left) Bob's RFID tag. (Right) X-CAMPUS detects Bob's RFID tag and welcomes him on GTalk.

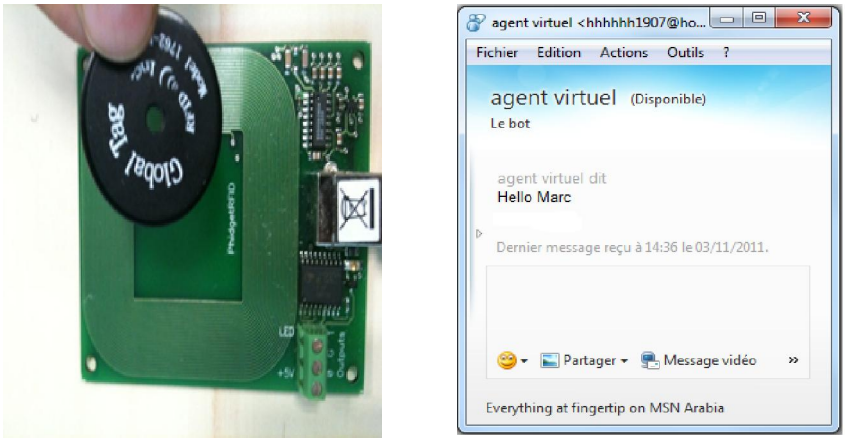

Fig. 4. (Left) Marc's RFID tag. (Right) X-CAMPUS detects Marc's RFID tag and welcomes him on MSN

To gather user's information (current activity and preferences), we have chosen to ask some questions according to the user's context as follows:

Firstly, our system have not any information about user, it learns user's information by asking a set of questions which are triggered depending on the context.

- Case one: we create an xml file which contains some questions grouped by theme.

```
<?xml version="1.0" encoding="utf-8"?>
<questionnaire id="1" theme="Tv">
  <question format="input" nom="FrequenceTv" dataType="xsd: string">
    <ennonce>Do you often watch TV? (Yes, no, sometimes)</ennonce>
  </question>
  <question format="input" nom="BestSerie" dataType="xsd:string">
    <ennonce>What is your favorite television series (put "0" if you do not have)?
</ennonce>
  </question>
  <question format="input" nom="BestBroadcastCategory" dataType="xsd:string">
    <ennonce>Which typifies of emission you like looking (put "0" if you do not
have)?</ennonce>
  </question>
  <question format="input" nom="BestBroadcast" dataType="xsd:string">
    <ennonce>What is your favorite broadcast (emission,issue) (put "0" if you do not
have)?</ennonce>
  </question>
 </questionnaire>
```

Fig. 5. TV questionnaire

According to context, system tries to collect user's knowledge. It triggers a questionnaire (see Figure 5) depending on user's situation (e.g., user is watching TV), and it stores responses in the database, thanks to a natural language multimodal dialog. As we can see in Figure 6, we have chosen four questions about user's frequency of watching TV, her favorite series, her favorite category of emission and its title.

Based on answers given by user, system will infer new decision related on her preferences such as send notification when program TV contains user's favorite category of emission.

- Case two: User can also enter data through a software entity (e.g., Website, Google calendar, Face- book, etc.) and provide access to system which can use this software in order to more help user.

This layer distinguishes three types of information: the static information, the temporary information and the dynamic information. Static information remains unchanged during the process of learning (e.g., name, age, etc.). Temporary

information can be sometimes changed (e.g., preferences, taste, etc.). However dynamic information changes frequently (e.g., location, mood). All these types of information are stored in a database in order to be used later.

4.2 ANTICIPATE NEEDS LAYER

In our research, we are based on "context manager layer" in order to anticipate user's services. In this layer, we try to exploit stored data context manager by associating a set of adaptive operators. Actually, we distinguish three types of operators:

- Conversion operator: the context manager stores a data in initial format, after that "anticipate needs layer" tries to adapt this format in order to associate a meaning manageable by the system. For example: when temperature sensor sends the raw data "2", the conversion operator interprets this value as "it's cold" or "it's hot", according to the real situation of the user.
- Extract operators: in many cases our system integrates logical sensors such as Google Calendar, RSS stream, etc. However these sources provide imprecise information. Therefore, the mission of this operator should extract only relevant information. Example: extract just the minute from the current time.
- Coupling operator: in other cases, system should aggregate various and heterogeneous (logical and/or physical) data. Thus we propose a coupling operator which tries to collect many data in order to "understand" non-trivial situations. For example detecting the location of users in a living room requires gathering information from multiple sensors throughout the intelligent home. It should also, in many cases, combine the results of several techniques such as image processing, audio processing, floor-embedded pressure sensors, etc., in order to provide valid information.

4.3 USER INTERFACE LAYER

For ubiquitous environment, the behavior of services does not just depend on explicit user interaction but also on the environment's perception. Combing these two sources of information, system can better respond to user's expectations. Our system has to provide an adaptive way of interaction according to the user's situations. The "user interface layer" should be able to define the context and choose the best way to interact by selecting the appropriate modalities and channels.

Our work tackles the ability of ambient computing to permit context-aware interactions between humans and machines. To do so, we rely on the use of multimodal and multi-channel interfaces in various fields of application such as coaching, learning, health care diagnosis, or home automation.

Using a multimodal approach allows users to employ different kinds of modalities (keyboard/mouse, voice, gesture, etc.) in order to interact with a system. The synergistic multimodality is quite natural for humans, but very difficult to implement, mainly because it requires some sharp synchronizations. Fusion mechanisms are used to interprets inputs (from user to machine) while fission mechanisms are used to generate outputs (from machine to user).

Using a multi-channel approach allows users to interact with several channels choosing the most appropriate one in order to exchange with an entity. Such channels could be, for instance, plain paper, e-mail, phone, web site.

For the moment, our prototype supports text, speech and gesture as inputs and text and speech as outputs. Once system anticipates user's need through the second layer, "user interface layer" communicates with "context manager layer" in order to check information related to user's situation (e.g., user location, user status, etc.)

In our approach, the influence of the context appears in both second and third layers. The context is used, firstly, to anticipate user's needs and secondly to find the appropriate way of interaction depending on user's situation.

5 ILLUSTRATION AND SCENARIOS

As we see in figure 6, X-CAMPUS matches all axes by integrating one or more values for each capability. We will give more information about this figure in the section below.

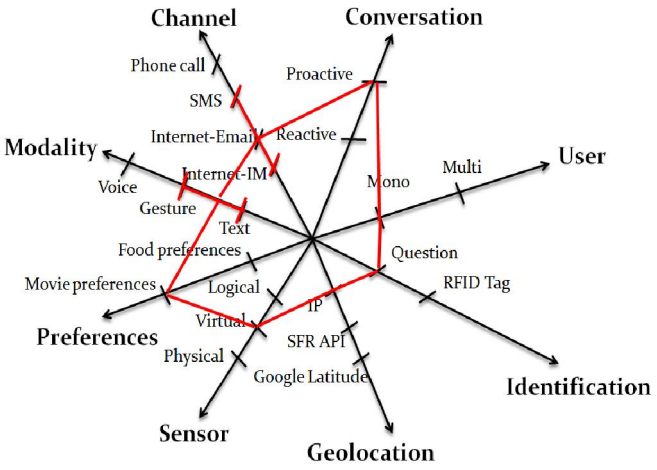

Fig. 6. X-CAMPUS's capabilities used in the favorite show service

The idea, for each scenario, is to illustrate several parts of our X-CAMPUS system, according to different axes (channel, modality, kind of preferences, geolocation, etc.). In the following lines, we will talk about the Internet and the Phone channels.

5.1.1 INTERNET CHANNEL

To demonstrate the identified requirements, a scenario is given in the following. It is about Mr. Marc's favorite TV show. The smart home of Mr. Marc is initially equipped with a standard set of context sensors: in-house location (IP), time, number of persons, movie preferences (see Figure 7). When our system detects that Marc is connected, it salutes him ("Hello, Marc") and starts to dialog and interact with him (see Figure 8).

Fig. 7. User is logged on

Then, the system checks the timing, our TV service and the user's preferences concerning TV shows. If the TV program contains user's favorite shows, our agent calculates the remaining time from the start time of the show and decides to send this information to the "User Interface Layer". Afterward, this last layer sends a request to the "Context layer manager" in order to determine user's situation. For example, at the office, the system will provide this service using a classical text modality by sending a message which contains the title of the show, the broadcasting time, the remaining time and the following question: "Would you like to switch on TV in X minutes. Thank you for answering by 'yes' or 'no' " (see Figure 8).

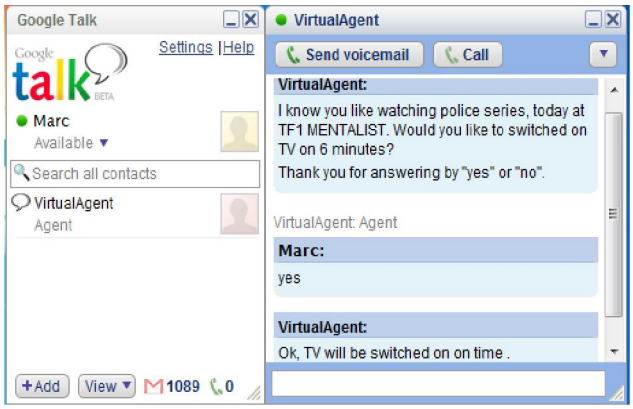

Fig. 8. X-CAMPUS notifies user about her best show

If the user responds “YES” using either a keyboard (see Figure 8), a voice recognition or a gesture through a Kinect sensor (see Figure 9), the agent turns on TV in the appropriate time. In that scenario, by executing this action, the system sends, after six minutes, a new text message to the user, telling that the TV is switched on TF1 channel (see Figure 10), but it can also, in other situations (e.g., user at home), communicate the same service by using a more natural modality such as the vocal one (speech synthesis). As a motion sensing, we have chosen to use the Kinect sensor which can used to interpret specific gestures by using an infrared projector, camera and a special microchip to track the movement of individuals in three dimensions. To implement gesture recognition, we firstly define a set of constraints to describe gesture (the joint, the distance, etc.), and secondly, we associate to this gesture a specific event. In our scenario we have chosen as joint the head, the left and the right hand. If the user raises her left hand, the system interprets this gesture as “NO” and if she raises her right hand, the system interprets it as “YES”. Afterward, our system behaves as for the text modality. For the voice recognition, we also used the Kinect sensor’s capabilities to recognize human voices. So, user can response by saying “YES” or “NO” vocally and system analyses this response according to the grammar defined previously. The goal of using many modalities such as text, voice and gesture is to let the user choose, according to her situation, the most adequately modalities.

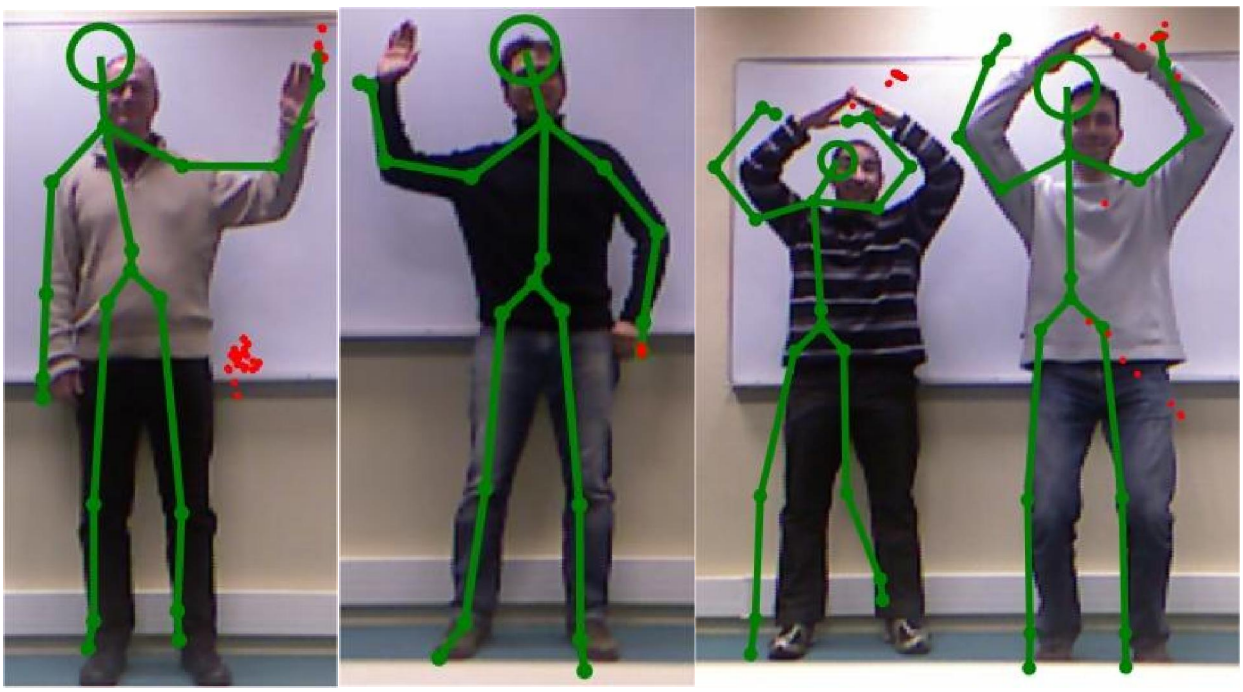

Fig. 9. Some User’s gesture responses (“yes”, “No”, “Home”).

The Figure 10 shows how X-CAMPUS notifies the user that the TV is switched on (left part) and proposes the appropriate show (NCIS, in this scenario, right part).

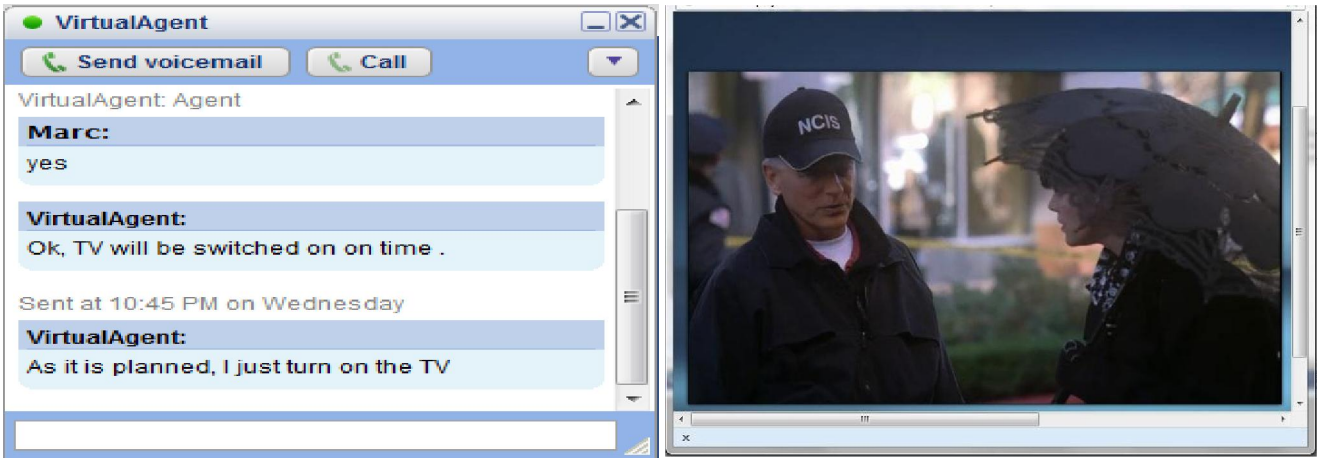

Fig. 10. X-CAMPUS notifies the user that the TV is switched on

If the user responds "NO" (to a question such as "Would you like to watch that show now?", see Figure 8), our agent tries to understand why, and asks the following kind of questions "Are you still interested by this category of show" in order to understand the user motivations. If the user responds also "NO", the agent updates this information in the database (the user is no more interested by this TV show).

5.1.2 PHONE CHANNEL

As we said in previous sections, we tried to provide proactive intelligent interfaces which can associate different types of modalities with different channels. However, when the user is disconnected from the internet network channel, and if the agent has important information to communicate to her, it should find a new way of communication to reach her wherever she is (home, office, outside, etc.). So, as second channel of communication that can be interesting in our work, we have chosen the phone channel, which allows our system to communicate with people when they are disconnected from the internet. This step is very important in our research; it ensures the continuity with the user by sending for example a Short Message Service message (SMS) as illustrated with Figure 11.

Fig. 11. Sending SMS through phone channel to reach disconnected user

5.2 BASIC EVENTS

This other scenario is about Mr. Marc's favorite dishes. The system knows that Mr. Marc likes "potatoes, beef and pizza" and wants to be notified at 11 o'clock AM, thanks to data collected during previous conversations. The context used to satisfy user's favorite dish is: user's food preferences, user's favorite notification period, user's phone number, user's e-mail and restaurant menus. Every day, our system checks user's favorite notification period, menus proposed by restaurants and user's preferences dishes. If X-CAMPUS finds a minimum of one restaurant that contains a minimum of one of user's favorite dishes, it calculates the remaining time from the start period of notification and decides to send this information to the "User Interface Layer". Afterward, this latter layer sends a request to the "Context layer manager" in order to determine user's situation. For example, at the office and when user is connected, the system will provide this service using a classical text modality by sending information which contains the name of the restaurant, its menu, and on upper case user's favorite dishes through the Internet channel (see Figure 12). We can see that X-CAMPUS justifies its decision in order to let users understand easily its behaviors.

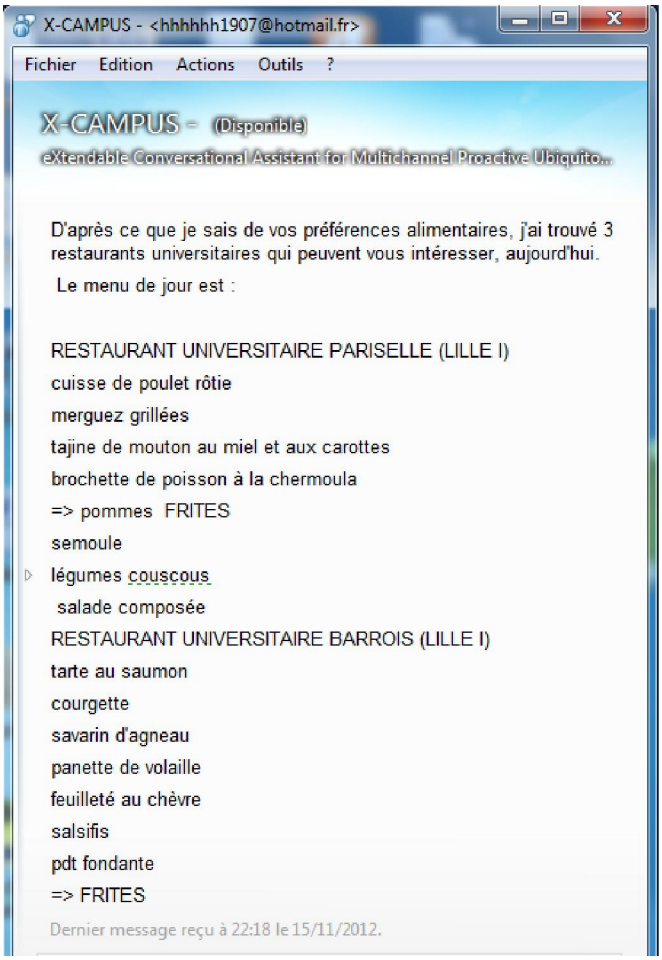

Fig. 12. X-CAMPUS's capabilities used in favorite social dish service

User can be disconnected from the Internet and in this case our system should find another way to communicate at the appropriate period/time. So thanks to a second channel that we use in our approach, messages can be delivered at the right time through the phone channel.

5.3 COMPLEX EVENTS

People frequently organize social events in order to meet, work, or discuss together. This kind of events are complex to managed (time and energy consuming) and to organized correctly. For example, going to the cinema, eating together, etc. can be some very difficult tasks to manage (for a human) as various and multiple criteria can be involved (time, weather, movie category, restaurant style, preferences of each person...).

Obviously, most of the time, the task in more and more complex as the number of invited is increasing. And sometimes, it becomes just impossible to find a convenient solution for everyone. In ordinary case, the organizer should call all participants or invite them through an electronic application such as Google Calendar or Doodle. As a consequence organizer should control by himself guests' responses and find the best solution which satisfies all participants.

In order to help users in these situations, X-CAMPUS has the capability to manage complex situations (multi-user, multi-modality, multi-channel...), according to user's situations, we have decided to integrate a new virtual sensor named "Google Calendar Sensor". Its vocation is to read user's Google Calendar and to send new events to our system. Once the system receives new events, it updates guests' profiles.

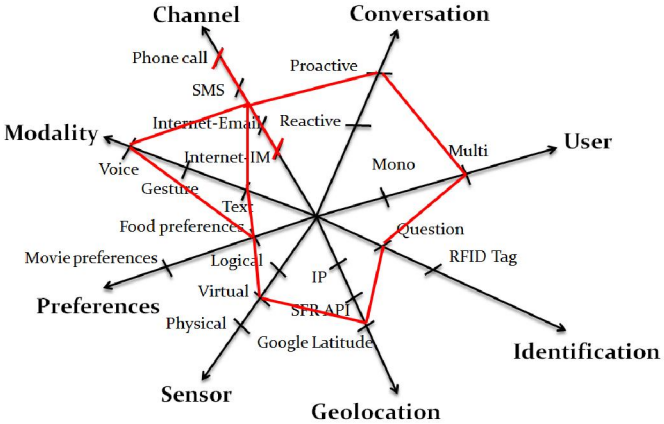

Fig. 13. X-CAMPUS's capabilities used in favorite social dish service

As we can see in figure 13, X-CAMPUS will initiate a proactive conversation by considering as contextual information: user's mode (multi-user), user's location, user's food preferences, user's state (connected or disconnected), and also the possibility to change the used modality (text, voice) and channel (phone or Internet). For example, a user (say Marc) decides to use Google Calendar to invite several colleagues and to organize a meeting in a restaurant (criteria when and where). In this kind of situation, X-CAMPUS is switching from a non-social mode to a social mode. The difference between them is located at the "User Interface Layer".

When the system determines that is time to communicate, it first checks if Marc has a social event named "Eating at university restaurant" recorded in his electronic agenda. Then it decides if it should behave in social or non-social mode. In the first case, it's a complex event management case (multiple users with multiple favorite dishes) whereas in the second case, it's a simple event management case (only one user with multiple favorite dishes). On this basic, X-CAMPUS is able to determine the best available restaurants and more precisely, the name of each restaurant with a menu containing at least one of guest's favorite dishes. When the system knows each guest's available restaurants, it starts its analysis phase in order to find common restaurants. As we can see in Table 1, our system can find the following situations: "no common restaurants", "only one restaurant", or "many restaurants" which satisfy guests' needs.

Table 1. X-CAMPUS's social behavior for two different days

	First day				Second day			
User / Restaurant	User #1	User #2	User #3	User #4	User #1	User #2	User #3	User #4
Restaurant #1	Pasta	Beef	Pizza	chips				
Restaurant #2	Pizza	Potatoes	Beef, pizza	Hamburger	Potatoes	Beef	Pizza	Pasta
Restaurant #3	Pizza, potatoes	Beef	Pizza	Pasta				

Three common restaurants One common restaurant

The ideal situation is the case where only one restaurant satisfies all the users' preferences food (see Table 1). In this case, it communicates by using a classical text modality through Internet channel or phone channel according to user's state. The message sent by the system contains the name of the chosen restaurant, the menu, the names of the guests and the user's favorite dishes (in uppercase).

In a quite simple situation, X-CAMPUS is able to check, each day, for each user, the best suitable (university) restaurant to propose to the users according to various personal criteria stored in the user profile, such as alimentary preferences (Pizza, Beef, Pasta...), status (student, teacher...), etc. X-CAMPUS users are daily notified about the best match between their preferences and the different menus proposed by all the restaurants available in their geographical area. This notification is launched at a moment previously chosen. It can be done across an instant messaging tool (MSN, GTalk...), or by E-mail, or by SMS, according to the context of use.

In a more complex situation, X-CAMPUS is also able to manage situations where people have planned to eat together: it calculates the more relevant restaurant(s) based upon the preferences of all the users involved in a particular meeting. If a unique solution is available, then X-CAMPUS notifies directly all the users by indicating the chosen place. But if there is not only one solution, our system is able to trigger a communication with the organizer in order to choose across a conversation, the best contextual criteria to deal with this complex situation.

Technically, when X-CAMPUS finds multiple solutions to a given situation (restaurants, movies, etc.) a vocal conversation is initiated with the organizer in order to take a decision. We are using Ippi Messenger [11] and Tropo [10] for this purpose. Ippi Messenger is a Voice Over IP (VOIP) tool, compatible with the Session Initiation Protocol (SIP). Tropo is a powerful yet simple API that adds Voice and SMS support to the programming languages that programmers already know (JavaScipt, PHP, Ruby, Python, Groovy...).

In our example, when our system finds more than one restaurants, it decides to place a vocal call to the organizer. During this conversation, some other criteria are proposed to enlarge the contextual information set (geolocation of the participants, for instance).

6 QUANTITATIVE RESULTS

In order to evaluate our work we have realised an evaluation of our system by inviting some users to try, on several days, some services proposed by the X-CAMPUS system. The evaluation consists to subscribe to two different services which are "weather-broadcast service" and "restaurant service". The first one should inform user about the temperature and some other information of her/his city, and the second one should inform user about the best suitable (university) restaurant, according to various parameters. Both of them should interact in appropriate time through the most relevant modality and channel according to the user's situation.

Our evaluation was launched over four weeks from the 4th February to the 1st of March 2013. We have sent an e-mail to approximately 200 users which are principally teacher, researcher and students of our university and 27 users decided to subscribe to our X-CAMPUS agent.

In order to communicate adequately and to ensure continuity with the users, we have decided to use two different channels which are Internet Channel and Phone Channel. So when we use Internet Channel, our agent X-CAMPUS uses the user's state (Online, Busy and Away) as contextual information given by XMPP protocol (logical sensor). However when a user is disconnected from the Internet, our agent tries to find another way (second channel) to reach him/her where ever she/he is. In this evaluation, the second channel that we used is the Phone Channel.

We have contact users by sending an email which illustrates briefly how to use our X-CAMPUS agent. We have just mentioned the e-mail addresses of our agent and how to subscribe to the two mentioned above services. The ultimate goal of our evaluation is to study the effect of the interaction with a conversational proactive agent. So, based on the following four hypotheses we will try to determine the felt of participants.

- Hypothesis H1: We suppose that most of users (more than 80 %) will be disconnected early in the morning (5.00 to 8.00 A.M.).

- Hypothesis H2: We suppose that most of users (more than 80 %) will be disconnected the week-end.

- Hypothesis H3: We suppose that most of users (more than 80 %) will want to be notified about the weather-forecast early in the morning (before 8.00 A.M.). So behind this hypothesis, we are supposing that the users will not be necessarily online when they will receive this weather-forecast notification.

- Hypothesis H4: We suppose that for the restaurant service, more than 50% of the users will be connected (instant messaging) to receive the notification.

- Hypothesis H5: We suppose that for the restaurant service, most of users (more than 80%) will choose to be notified between 10.00 and 12.30 A.M.

We have chosen two different services which should occurred according to our first hypothesis during two different periods. The first one is about the weather forecast and which should occur earlier in the morning however the second one is about restaurant services and which should occur later in the morning.

The two types of services were chosen to be communicated at two different times, in order to be able to study our agent's capability to manage many users simultaneously and to change its behavior according to each user's profile.

As mentioned in figure 14, the results related to the weather forecast service show that **our first hypothesis (H1) is not confirmed**. During 26 days, 217 SMS were sent to disconnected users (68%), 74 instant messages (MI) were sent to connected users with the status "available" or "Away" (23%) and 27 e-mails were sent to users connected with the status "busy" (9%). These results indicate that users are mostly disconnected early in the morning (but not more than 80%, as we supposed with our H1 hypothesis) and those who are connected are mostly connected with status as "available" which justifies the number of e-mails sent during the four weeks of evaluation.

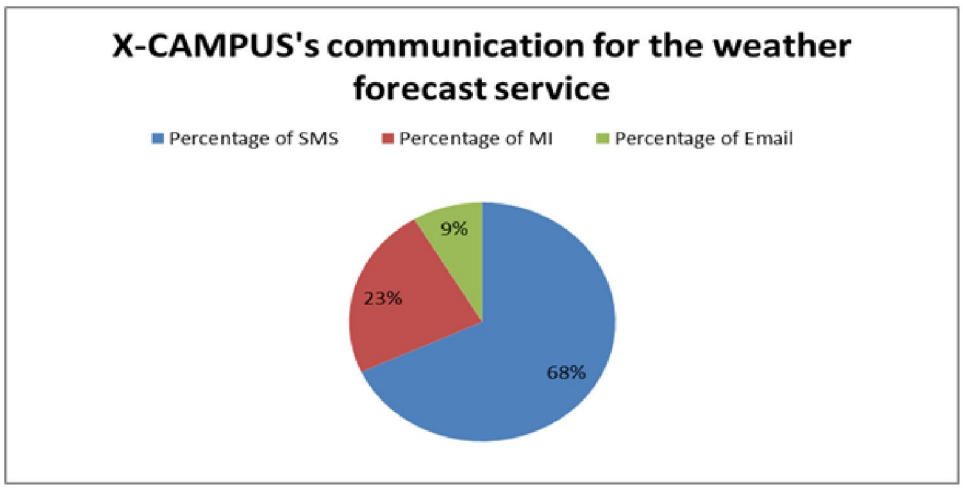

Fig. 14. X-CAMPUS's notifications for the weather forecast service

As we can see in figure 15 the distribution of SMS, MI and Email is different from one day to another, but we remark that usually the number of SMS for each day is greater than the number of MI and the number of Email sent in the same day, with some rare exception, such as the 13rd of February in which the number of SMS is equal to the number of MI sent.

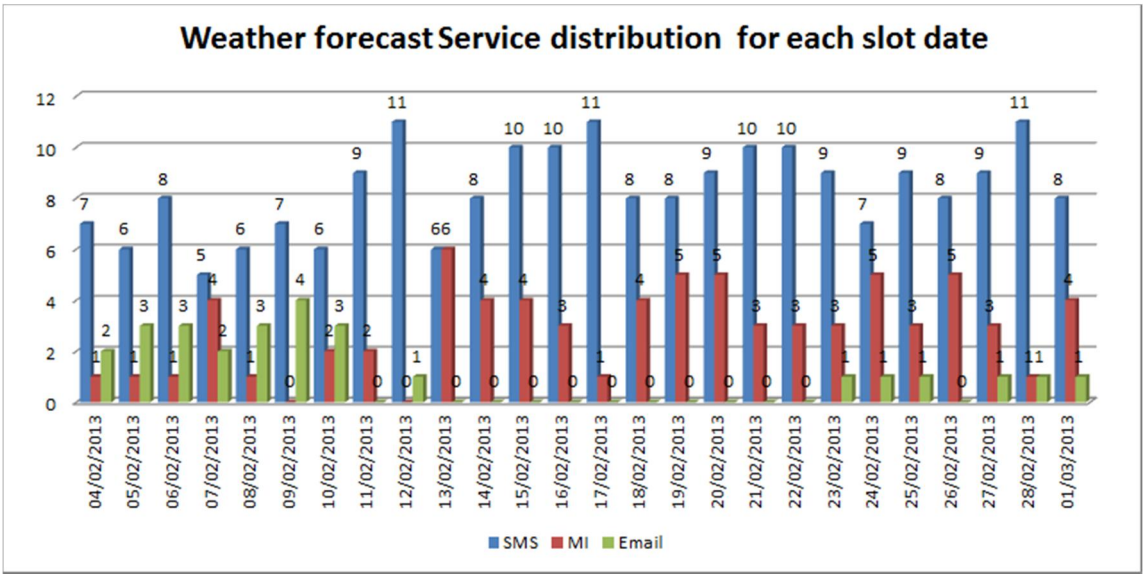

Fig. 15. Weather forecast service distribution for each slot date

We can also see that the use of MI is not negligible during the four weeks of our evaluation. Each day our agent has sent a minimum of one MI except for two days (9th and 12th of February), which let us infer that some users are connected as "available" or "away" early in the morning. However the number of e-mails sent during the period of our evaluation is not very high (negligible); in figure 15 we have 14 days with 0 emails sent, among 26 days (only 9% of the communication in figure 14).

Table 2. Weather forecast service distribution for each week-end

	First weekend			Second weekend			Third weekend		
	Saturday	Sunday		Saturday	Sunday		Sunday	Sunday	
SMS	7	6	59,09%	10	11	84%	9	7	61,53%
MI	0	2	9,09%	3	1	16%	3	5	30,76%
Email	4	3	31,81%	0	0	0%	1	1	7,69%
Number of users	22			25			26		
Result	50/73 = 0.68 (68%)								

We supposed that 80% of the users will be disconnected during the week-ends however results show that this **hypothesis (H2) is not globally confirmed** with only 68,49% of users disconnected during this period (see table 2). However when we detailed week-end by week-end we remark that for the second one our hypothesis is confirmed with 84% of users which are disconnected whereas for the two others week-ends (the first and the third week-end) our hypothesis is infirmed with respectively 59,09% and 61,53%.

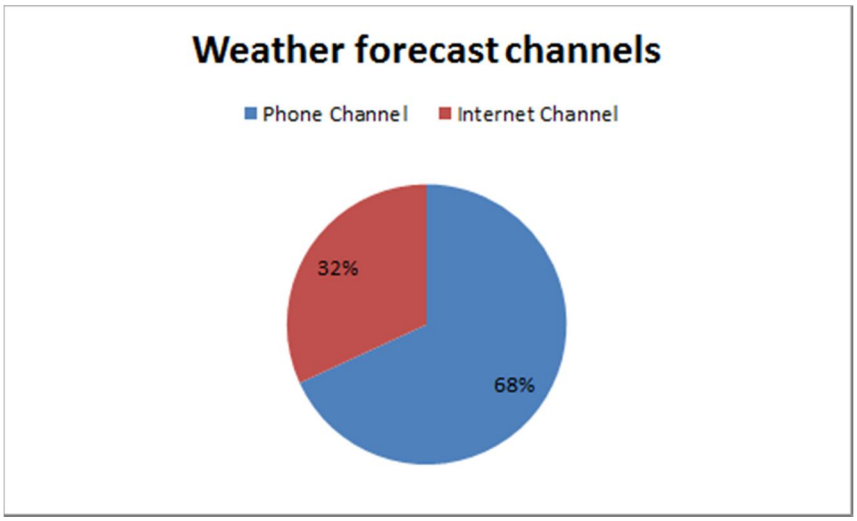

Fig. 16. Weather forecast channels

As we can see in figure 16 the global distribution of the weather forecast channels reveals that globally the use of the Phone Channel is more dominant than the use of the Internet Channel. Despite the fact that thanks to the second channels our agent can send information by MI and/or Email this one is still less used (32%) than the Phone channel, used for distributing SMS (68%), for the four consecutive weeks of the evaluation.

More details on the daily distribution of channels are given in figure 17. We can see that practically the number of SMS sent daily by X-CAMPUS is greater than the number of MI and Email with only the exception of one day which is the 13th of February, in which the number of SMS is equal to the number of MI and email.

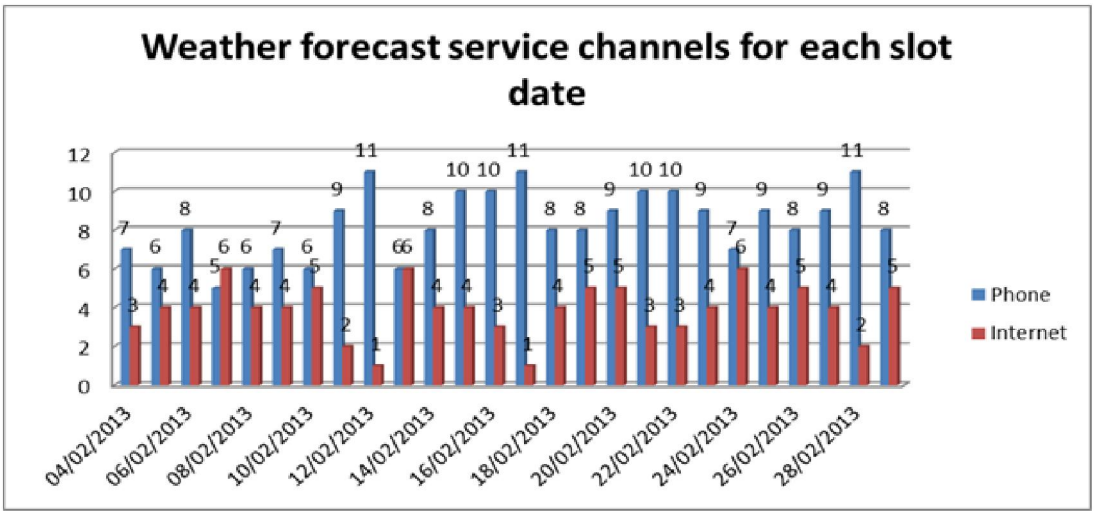

Fig. 17. Weather forecast service channels for each slot date

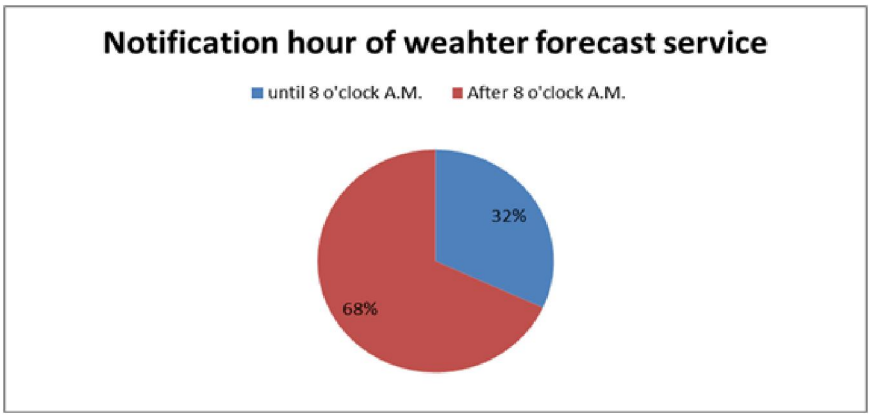

Fig. 18. Notification hour of weather forecast service

During the evaluation, our agent has sent more information about weather forecast after 8 o'clock. **This fact leads to the reject of our third hypothesis (H3)**, because, as we can see on figure 18, 68% of information was sent after 8 o'clock however only 32 % of information was sent before 8.00 A.M. (8 o'clock included), during 26 days.

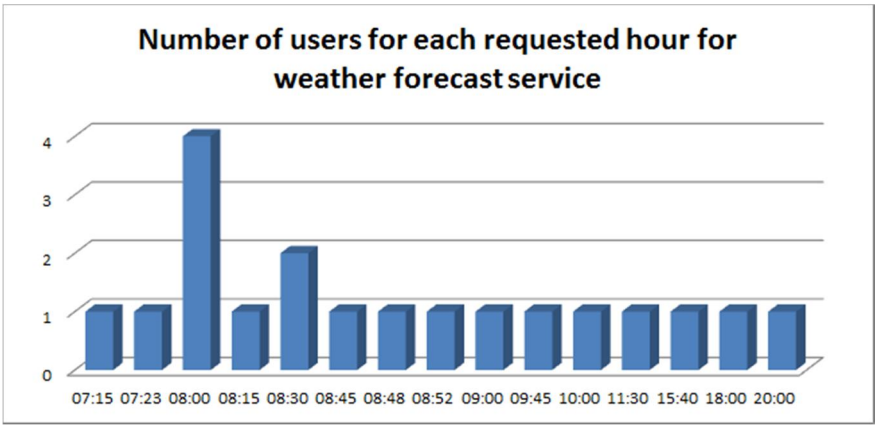

Fig. 19. Number of users for each requested hour for weather forecast service

As we can see in figure 19, the range of slot of times in which users want to be notified for the weather forecast service is from 7.15 A.M. to 8.00 P.M. We supposed that most of users (i.e more than 80 %) will want to be notified about the weather-forecast early in the morning (i.e. 5.00 to 8.00 A.M.) however, only three slots of time are less or equal to 8.00 A.M. (7.15 A.M., 7.23 A.M. and 8.00 A.M. ; this latter is the most requested slot (four users).

Consequently, the hypothesis H3 is effectively rejected with only 31.57 % of users which have choose to be notified before 8.00 A.M. (8 o'clock included), during 26 days.

We have 13 users which are subscribed to the X-CAMPUS's weather forecast service and we have detected 15 requested slots (see figure 19); this means that some users have change their hour of notification during the evaluation period, probably in order to test the X-CAMPUS's adaptation capabilities.

Let now detailed our second scenario and as we see in figure 20 for the X-CAMPUS's restaurant service, the number of MI sent during our evaluation is more important (47%) than the number of SMS (44%) and the number of Email (9%). **This confirms our hypothesis H4** with 56% of users subscribed to X-CAMPUS's restaurant service are connected as "available", "away" or "absent" late on the morning (or early in the afternoon).

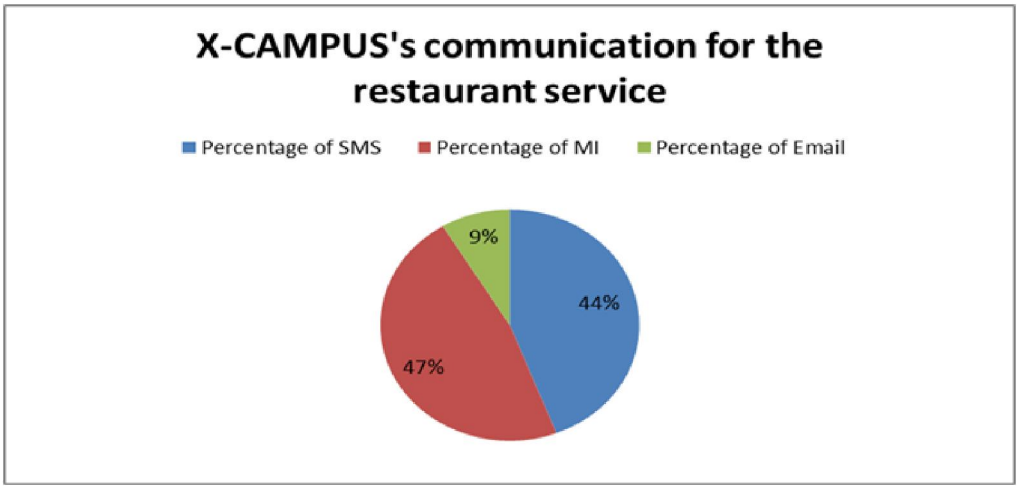

Fig. 20. X-CAMPUS's communication for the restaurant service

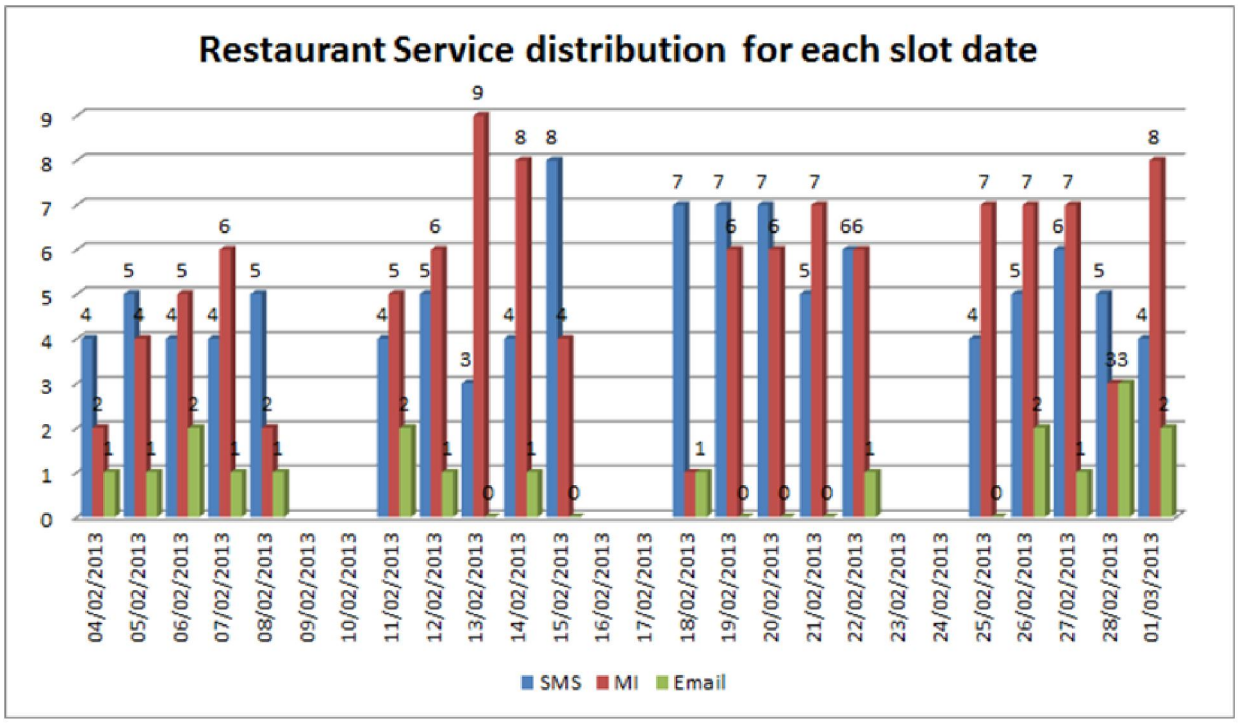

Fig. 21. Restaurant service distribution for each slot date

As we can see in figure 21, the number of SMS, MI and e-mails sent for each slot of date shows more en details the dominance of MI (47%) versus the SMS (44%) and the Email (9%).

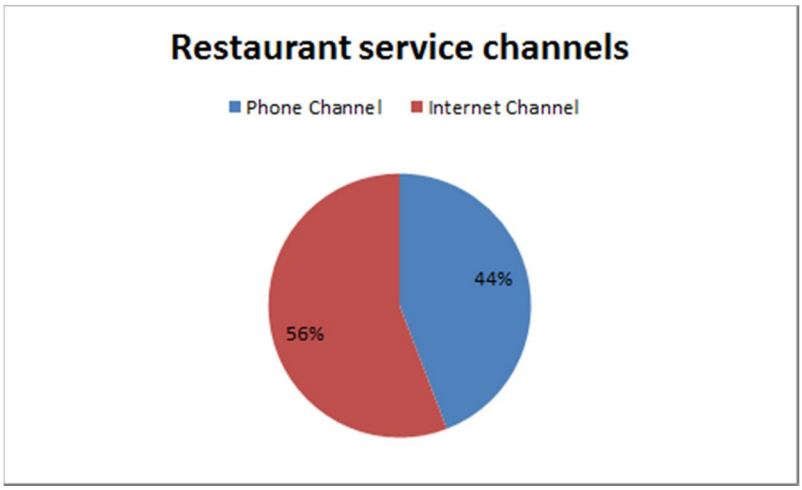

Fig. 22. Restaurant service channels

As we can see in figure 22, the use of Internet channel with the restaurant service appears more important than the Phone channel: our interpretation is that users are probably more connected late in the morning than early (compare to the forecast service, for example). **This confirms again our hypothesis H4**. The use of Internet channel for the restaurant service (56%) is greater than the use of Internet channel for the weather forecast service (32%). So, we observe that services supposed to be used early in the morning, use more the phone channel than the Internet channel, and it's the opposite for the services supposed to be used later in the morning.

We remark that the notion of multi-channel is important in our work because users are not necessary connected according to their requested hour of notification. For instance, during 20 days of evaluation, 44% of communication between the user and the system, for the restaurant service, is made via SMS, that is to say, via the phone channel (see figure 23). Thanks to the capability of our agent to switch from one channel to another, users seem to receive the appropriate information according to the appropriate channel.

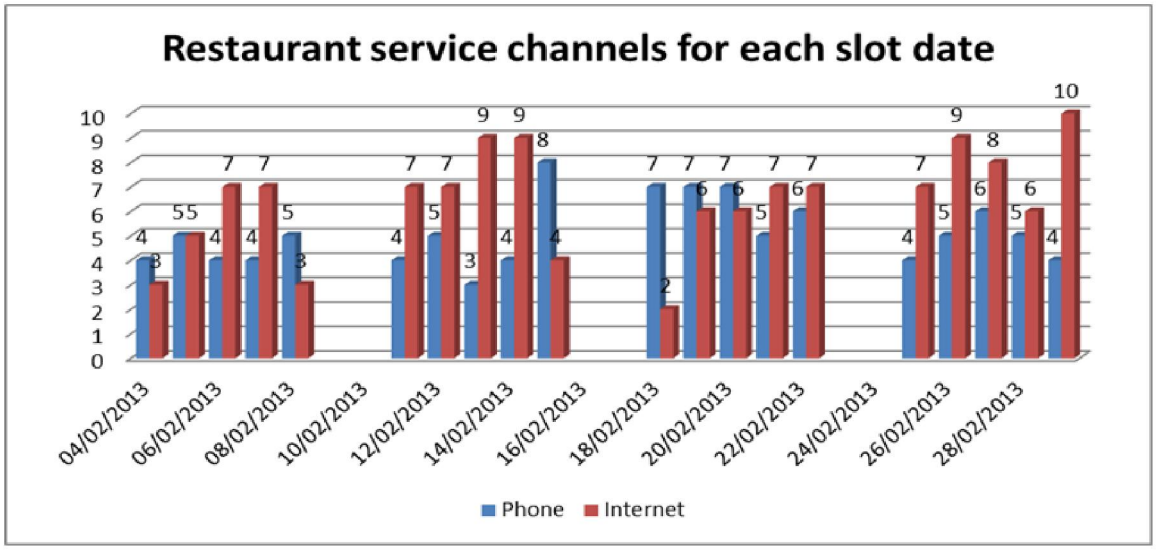

Fig. 23. Restaurant service channels for each slot date

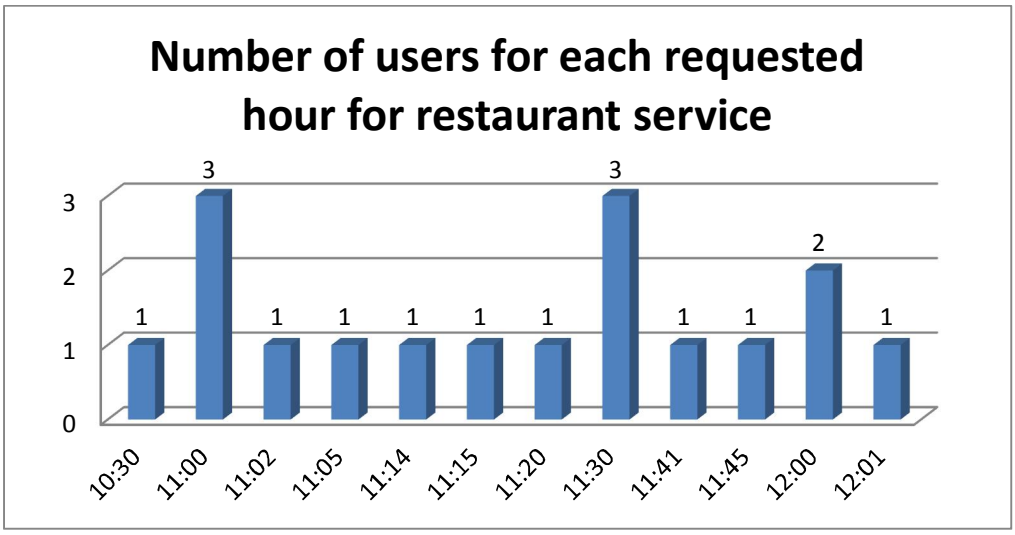

Fig. 24. Number of users for each requested hour for restaurant service

As we can see in figure 24, the range of times notification chosen by users for the restaurant service is from 10.30 A.M. to 12.01 A.M. **The hypothesis H5 is validated by this observation**, because we supposed that most of users (i.e more than 80 %) will choose to be notified about the restaurant service later in the morning (between 10.00 and 12:30 A.M.) As we can see in figure 24, the more requested slots are 11:00 and 11:30, with three users for each. As we know that we have 14 registered users for this service, and we observed 17 notifications, we can conclude that some users have changed their notification time during the experiment.

7 CONCLUSION AND OUTLOOK

In this paper, we have proposed the notion of proactive assistance as a solution to increase the productivity and the welfare of the user situated in intelligent environments. We have presented an approach based on three principal layers: "context manager layer", "anticipate needs layer" and "user interface layer". Each one has a specific functionality: the first one communicates with heterogeneous sensors in order to collect context's information, in real time. The second layer tries to adapt collected information to anticipate user's needs. Afterward and depending on person's situations, "user interface layer" chooses the appropriate way of interaction throw the capabilities of the system to support multimodal and multi-channel interfaces; it can manage text, voice and gesture modalities as inputs, and text and/or speech as outputs.

We have realized a prototype based on the architecture layers described below. This prototype, about TV show preferences, illustrates our approach and implements proactive services which can adapt themselves depending on each user's situation. We have also implemented other services (using Google Agenda, weather forecast, Phydgets sensors, etc.) which are not described in this paper. We have showed, with a quantitative evaluation of our work, that the X-CAMPUS system is really able to choose the appropriate channel in order to deliver relevant information (weather forecast, restaurant menu) to the users, connected or not.

Finally, the results concerning the overall experiments are the following:

- Hypothesis H1: We suppose that most of users (more than 80 %) will be disconnected early in the morning (5.00 to 8.00 A.M.), is rejected.

- Hypothesis H2: We suppose that most of users (more than 80 %) will be disconnected the week-end, is partially rejected.

- Hypothesis H3: We suppose that most of users (more than 80 %) will want to be notified about the weather-forecast early in the morning (before 8.00 A.M.), is rejected.

- Hypothesis H4: We suppose that for the restaurant service, more than 50% of the users will be connected (instant messaging) to receive the notification, is validated.

- Hypothesis H5: We suppose that for the restaurant service, most of users (more than 80%) will choose to be notified between 10.00 and 12.30 A.M., is validated.

In the very close future, we envisage an evaluation with users by proposing a set of proactive services in order to study the users' behavior and the X-CAMPUS capabilities to manage multiple users simultaneously. We will also focus on the way to manage multiple needs at the same time (with possible incompatibility between them), and how to detect that several triggers are semantically related to the same user's need. We have already a theoretical solution for the first problem: we will add a priority ponderation to user's desires. The second problem is being currently studied and we should obtain quickly some relevant solutions in order to respond to users' expectations.

REFERENCES

[1] A. K. Dey, Providing architectural support for building context-aware applications. Thesis, 2000.

[2] A. K. Dey, D. Salber, M. Futakaw and G. D. Abowd, An architecture to support context-aware applications. Submitted to UIST, 99.

[3] A. K. Dey, and G. D. Abowd, Towards a better understanding of context and context awareness. In Proceedings of the Workshop on the What, Who, Where, When and How of Context-Awareness, affiliated with the CHI 2000 Conference on Human Factors in Computer Systems, The Hague, Netherlands. New York, NY: ACM Press, 2000.

[4] A. Dey, G. D. Abowd, and D. Salber, "A conceptual framework and a toolkit for supporting the rapid prototyping of context-aware applications", Human- Computer Interaction, 16:97–166, 2001.

[5] B. Brumitt, B. Meyers, J. Krumm, A. Kern, and S. Shafer, EasyLiving: technologies for intelligent environments. Handheld and Ubiquitous Computing (2000), pp. 97-119.

[6] G. Chen, M. Li, and D. Kotz, Data-centric middleware for context-aware pervasive computing. Journal of Pervasive and Mobile Computing, Volume 4, Issue 2, pp. 216-253, 2008.

[7] J. Hong, The context fabric: an infrastructure for context-aware computing. CHI 2002, April 20-25, 2002, Minneapolis, Minnesota, USA. ACM 1-58113-454-1/02/0004.

[8] J. Pascoe, Adding generic contextual capabilities to wearable computers. In the Proceedings of the 2nd IEEE International Symposium on Wearable Computers (ISWC'98), pp. 92-99, Pittsburgh, PA, IEEE. October 19-20, 1998.

[9] J. Rouillard, J-C Tarby., X. Le Pallec R. Marvie, Facilitating the design of multi-channel interfaces for ambient computing, The Third International Conferences on Advances in Computer-Human Interactions, ACHI 2010, St. Maarten, Netherlands Antilles, pp. 95-100.

[10] https://www.tropo.com

[11] http://www.ippi.fr/index.php?page=home&lang=44&lang=44

[12] M. C. Mozer, The neural network house: an environment that adapts to its inhabitants. Proceedings of the American Association for Artificial Intelligence Spring Symposium on Intelligent Environments, AAAI Press (1998), Menlo Park , CA, pp. 110-114.

[13] M. H. Coen, Design principles for intelligent environments, Proceedings of the fifteenth national/tenth conference on Artificial intelligence/Innovative applications of artificial intelligence (1998), American Association for Artificial Intelligence, Madison, Wisconsin, United States, pp. 547-554.

[14] M. Lamming, and M. Flynn, Forget-me-not: intimate computing in support of human memory. In the Proceedings of the FRIEND 21: International Symposium on Next Generation Human Interfaces, pp. 125-128, Meguro Gajoen, Japan. 1994.

[15] M. Weiser, Some computer science issues in ubiquitous computing, Communications of the ACM (1993), Vol 36(7).

[16] M. Weiser, "The computer for the 21st century", Scientific American, 265(3):94–104, September 1991.

[17] P. Fahy, S. Clarke, "CASS – a middleware for mobile context-aware applications", Workshop on Context-Awareness,MobiSys 2004.

[18] R. Want, A. Hopper, V. Falcao, and J. Gibbons, The active badge location system. ACM Transactions on Information Systems 10(1): pp. 91-102. January 1992.

[19] R. J. Orr and G. D Abowd, The Smart Floor: a mechanism for natural user identification and tracking. In the Proceedings of the Conference on Human Factors in Computing Systems (CHI 2000), pp. 275-276, The Hague, Netherlands, ACM. April 1-6, 2000.

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Handwritten Hindi Numerals Recognition

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ABSTRACT: The proposed method is efficient where it is new, simple, fast, accurate so it is used in this research for recognizing Hindi numerals (0,1,2,3,4,5,6,7,8,9), that are usually used by Arabic population. The method is effective with handwritten numerals. This method is simply depends on determining number of terminal points and its positions for each digit in its different shapes, that represent the main feature for recognition. Only five features are added when there are similarity between digits (have the same number of terminals and position), the additional features was: less pixels number to recognize digit zero, intersection point position to recognize digit (2,3,6,7) that have three terminal points, image width to recognize digit one, curve number to recognize digit (2,4) that have two terminal points finally closed shape feature is added to recognize special cases of digit five and nine that have irregular shapes. Hence the proposed method is based on structural primitives such as curve, line, point type and etc. in a manner similar to that in which human beings describe characters geometrically. This work deals with noisy object by removed them from the original image to ensure that the noise pixels not merge with the original digit pixels. Encouraged recognition results are obtained for handwritten numerals samples written by different persons, different ages, different pens type, also different size, digits with rotation state are tested that gave an excellent recognition results. Some of problems with digit 9,5 are solved.

KEYWORDS: Hindi numerals, Terminal points, Feature Extraction, Pixels description, Recognition.

1 INTRODUCTION

There are two fundamental approaches to implement a pattern recognition system: statistical and structural. Each approach employs different techniques to implement the description and classification tasks. Hybrid approaches, sometimes referred to as a unified approach to pattern recognition, combine both statistical and structural techniques within a pattern recognition system [1]. A structural approach is selected in this research to implement recognition.

One of the most frequent tasks in computer vision and image processing is the recognition of an image or an object in the image. Among these tasks, Optical Character Recognition (OCR).Numeral recognition still one of the most important challenge in OCR, it is used in reading of bank checks, postal sorting, car plates recognition and automatic data entry. Several researchers have researched the recognition of Arabic (Indian) printed and handwritten digits; most of these researches are based on neural network, mathematical method, template matching, and feature extraction methods. For example: Seong-W. [2] proposed a method depends on using a simple multilayer cluster neural network trained with the back propagation algorithm, and show that the use of genetic algorithms avoids the problem of finding local minima in training the multilayer cluster neural network with gradient descent technique, and improves the recognition rates, the recognition rate reached 97-99%. Herminch S. [3] proposed a method, where a feature extraction technique is presented and applied to printed Hindi numerals. Classification is performed using neural networks, the results show that some fonts perform much better than

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others, also there are some fonts where, achieve classification rate up to 100%. Hussein Al-Zoubi, et al. [4], presents a new method of using motion estimation for the purpose of offline recognition of machine-print Hindi digits. Yun L. [5] proposed an algorithm employs template matching, the recognition rate of this algorithm is 99, 25. Huda M. [6] proposed a method, where different forms of printed Arabic characters written in three different style was recognized using back-propagation neural network, the result of recognition rate is 97%. Li Y., et al. [7] they present a novel method of character stroke feature extraction based on the histogram of gradient angles, the recognition accuracy is up to 99%.

2 IMAGE ACQUISITION

The first stage for our recognition method that proposed in this research is begin by acquiring image, in this stage the image of a list of digit is scanned using scanner device, and saved as bitmap image. Then three stages where used to recognize a numerals these stages are preprocessing, feature extraction and recognition. As shown in figure (1). The result is recognized digit. In the next sections, the details of the stages are demonstrated.

3 PREPROCESSING STAGES

The details of the preprocessing steps (image enhancement, image binarization, segmentation and thinning) as shown in figure (2). Are illustrated in the next sections.

3.1 IMAGE ENHANCEMENT

In this research the enhancement is done by removing the noise using median filter. Median filtering is a nonlinear signal processing technique that is useful for noise elimination in images. The median filter consists of a sliding window encompassing an odd number of pixels. The center pixel in the window is replaced by the median of the pixels in the window [8]. A median filter is able to preserve sharp signal changes and is very effective in removing noise (or salt and pepper noise). It's very widely used in digital signal and image/video processing applications [9]. The result is shown in figure (3).

3.2 BINARIZATION

Images in this stage are considered to be binary. The pixels in binary image can assume only two values, 0 or 1; [10]. The goal of binarization is to separate the character from the background in the gray image and make the image color into Black and White [11]. The digit image is converted to gray scale using equation (1).

$$GRY_{xy} = \frac{R_{xy} + G_{xy} + B_{xy}}{3} \quad (1)$$

At the next step, the gray image is converted to binary image using global thresholding method [12]. The result is shown in figure (4).

3.3 SEGMENTATION

Image segmentation involves the division or separation of the image into regions of similar attribute. Segmentation does not involve classifying each segment. There is no theory of image segmentation. As a consequence, no single standard method of image segmentation has emerged. Rather, there are a collection of ad hoc methods that have received some degree of popularity [8]. The result of segmentation is shown in figure (5).

3.4 THINNING

Thinning is very important preprocessing step for many image analysis operations, such as optical character recognition and finger print recognition [13]. Thinning algorithm is a morphological operation that is used to remove selected foreground pixels from binary images. It preserves the topology (extent and connectivity) of the original region while throwing away most of the original foreground pixels. Thinning algorithms can be divided into two types [14]:

1. Sequential thinning algorithms: result of n^{th} iteration depends on result of $(n-1)^{th}$ iteration as well as pixels already processed in the n^{th} iteration.

2. Parallel thinning algorithms: (that used in this work) deletion of pixels in n^{th} iteration depends only on the result that remains after $(n-1)^{th}$ iteration. In this work Zhang- Suen Thinning Algorithm is used.

Table (1) show, the result of thinning algorithm for some of tested numbers samples, note that the digits have got different shapes for different samples, and have different terminal point number and positions, table (1) shows examples for handwritten numerals before and after thinning.

4 FEATURE EXTRACTION

Feature extraction is the process of generating features to be used in the classification task. Feature selection reduces the number of features provided to the classification task. Those features which are likely to assist in discrimination are picked out and allowed to be used in the classification task. Features which are not selected are discarded [1]. In this stage (3*3 pixel) window moves over the digit image in order to analysis the relation between adjacent pixels, and then the following two steps are implemented:

1. Image pixels description: in this step the type of each digit image pixel is determined like (terminal pixel, connection pixel, split pixel and cross pixel) see figure (6), also pixels location are determined and their accounts (number of terminal pixels, number of connection pixels and number of cross pixels).

Important information is obtained from this step that is the number of terminal pixels for all digits from different samples see table (2).

2. Feature extraction: in this step each (3*3 pixels windows) are tested starting from terminal pixel to determine their features that are used to recognized the similar digit, which the information gotten from description step was not enough to make them recognized, there was need to determine some features Table (3) main and additional features. like curves number, intersection point position and closed shape that demonstrated in the next section briefly.

5 RECOGNITION

From the information of image pixels description step and the features that are extracted, the results that shown in table (3) are obtained.

This table illustrate the features that are used to recognize each digit with different samples Note that the main feature is number of terminal points, see table (2), where this table shows, that there are many digit have the same feature (number of terminal point), so the position of each terminal point is used to solve this problem for the most digit and makes it recognized simply see table (3), to recognize the digits depending on the positions of terminal points there was need to divide the digit image into regions see figure (7) that shows the division forms using in this work for recognizing some digits. But in certain case (for different samples) that have not only the same terminal points number but also the same positions ,for these cases the need for additional feature is appeared, so only five feature are added, that are illustrated below:

1. Numbers of pixels to recognize the digit zero, where digits zero have fewer number of pixels than other digits.
2. Image width to recognize digit one, where digit 1 have the same number and position of terminal point with other digit but digit one have less image width than the others, so it's used for recognizing digit 1.
3. Intersection point position to recognize digit 2,3,6,7 that have 3 terminal, where these four digits have the same number and position of terminal point (two terminal point top and one bottom, so the feature intersection point position is used to recognize the four digits, but digit 3, that have three terminal did not recognized because of its similarity with digit 2, so there was a need to add fourth additional feature.
4. Number of curves in top side to recognize digit 3 that have 3 terminal point, where digit 3 have 2 curve in top side while digit 2 have only one curve, by adding this feature the recognition of digit 2 ,3 is done. The same feature that determine the number of curves is used to determine the number of curves in left side of digit image to recognize the handwritten digit (2,4) that have two terminal points one top and the other bottom which is the main features that is used to recognize digit (2,4), so the addition of this feature is used to recognize the digit (2) from digit (4).
5. The feature (closed shape) help in solving the problem with digit (5,9) that have different terminals point number in addition to determine the position of these terminal.

Note that the determination of these features is implementing using some special algorithms.

6 RESULTS

Finally depending on these features the result of recognition rate is excellent for different samples that are written by different persons, also digit with rotation state are tested and gave high recognition rate, that emphasize the method successful, figure (8) shows samples of recognized hand written digit.

The proposed method also deals with the problem of digits (5,9) that have irregular shapes, figure (9) show some of the recognized digit samples after solved their problems.

7 TABLES AND FIGURE

7.1 TABLES

Table 1. Different hand written example before and after thinning

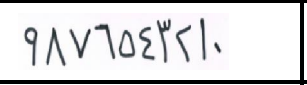
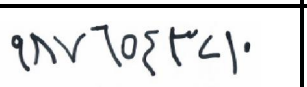
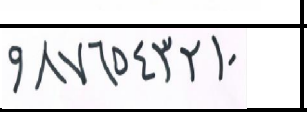
Numbers before thinning	Numbers after thinning
	
	
	

Table 2. Number of terminals in each digit

Number of terminal point	Digits	Examples
0	5	
1	5,9	
2	0,1,2,4,6,7,8,5,9	
3	2,3,4,6,7,8	
4	3	

Table 3. Main and additional features

digit	Number of terminal points	Terminals position	Additional features				
			Less pixels number	Image width	Intersection position	Curve number	Closed shape
0	2	No restriction	√				
1	2	Top, bottom		√			
2	2	Top right, bottom left or center				√	
	3	Top right, top left, bottom			√	√	
3	3	Top right, top left, bottom			√	√	
	4	No restriction					
4	2	Top, bottom				√	
	3	Top, bottom, middle center					
5	0						√
	1	Top					√
	2	Top					√
6	2	Top left, bottom right					
	3	Top right, top left, bottom			√		
7	2	Top, top					
	3	Top, top, bottom			√		
8	2	Bottom, bottom					
	3	Bottom, bottom, top					
9	1	Bottom					√
	2	Bottom, Top, right or center					√

7.2 FIGURES

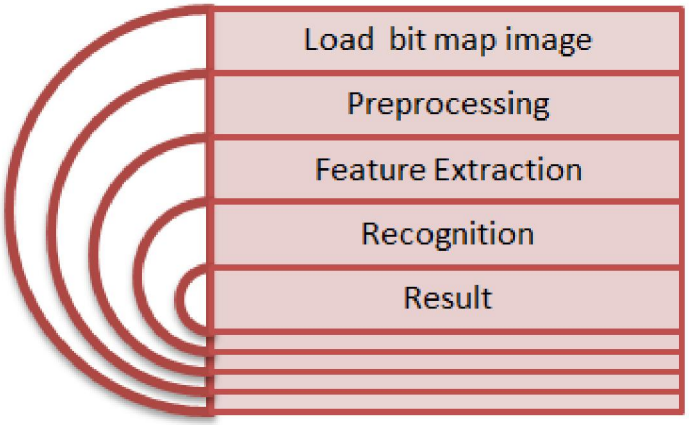


Fig. 1. The main stages of the system

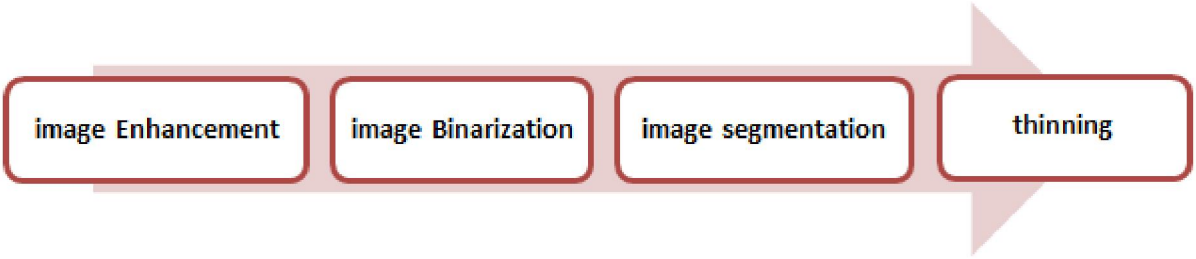


Fig. 2. Preprocessing stage

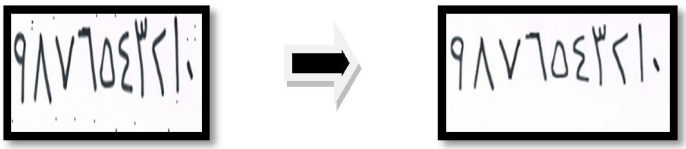


Fig. 3. Image Enhancement Step

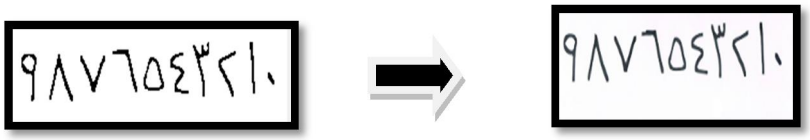


Fig. 4. Binarization Step

Fig. 5. Segmentation step

0	1	0	0	1	0	0	1
0	1	0	0	1	0	0	1
0	1	0	0	1	0	0	1
0	1	1	1	0	1	1	0
0	1	0	0	0	0	0	0
0	1	0	0	0	0	0	0
0	1	0	0	0	0	0	0
0	1	0	0	0	0	0	0
0	1	0	0	0	0	0	0
0	1	0	0	0	0	0	0
0	1	0	0	0	0	0	0

Fig. 6. Digit image pixels type

Where:

Represent terminals pixels.

Represent connection pixels.

Represent cross pixels.

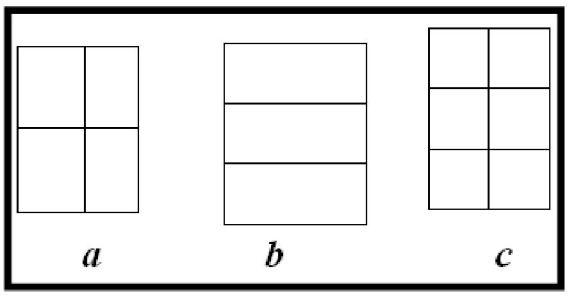


Fig. 7. Image digit division forms

Where:

(a) Is used with 1 terminal point state.

(b) Is used with 2 terminal point state.

(c) Is used with 3 terminal point state.

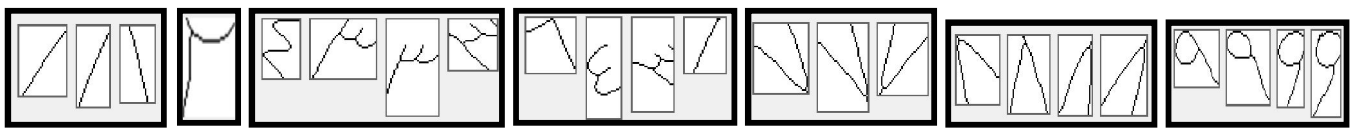


Fig. 8. Recognized handwritten sample with rotation

Fig. 9. Some of recognized digits

8 CONCLUSION

The proposed method is simple, fast and gives accurate results using minimum features comparing with former similar studies. Its only depends on number of terminal points and its position for each digit plus only five additional features in certain cases. The system applied perfectly on Hindi numbers, it gives an excellent recognition rate with handwritten numerals that are tested; the state of rotation digit is recognized. In the face of some problem that is appeared during the work time, the results were very acceptable.

REFERENCES

[1] Robert T. Olszewski, "Generalized Feature Extraction for Structural Pattern Recognition in Time Series Data", Ph.D. Thesis, School of Computer Science, Carnegie Mellon University, 2001.

[2] Seong-Whan Lee, ”Off-Line Recognition of Totally Unconstrained Handwritten Numerals Using Multilayer Cluster Neural Network”, IEEE Trancactions on pattern analysis and machine intelligence,vol. 18, no. 6, June , 1996.

[3] Hermineh Sanossian ,"Feature Extraction technique for Hindi Numerals", Mu’tah University, P.O. Box 7 Mu’tah-Jordan,1998.

[4] Hussein Al-Zoubi, Mahmood Al-Khassaweneh, " Offline Machine- Print Hindi Digit Recognition Using Translational Motion Estimation", Computer Engineering Department, Hijjawi Faculty for Engineering Technology, Yarmouk University, Irbid 21163, Jordan,2008.

[5] Yun Li Mei Xie, "An Effective Method for Number and Letter Character Recognition", School of Electronic Engineering, University of Electronic Science and Technology of China Chengdu China,11th. IEEE International conference on communication technology proceedings,2008.

[6] Huda Mahdi Abbas, " Printed Arabic Character Recognition Using Neural Network", M.SC. thesis, Al-Nahrain University, 2011.

[7] Li Yuchen, Tian Zhen, You Jia, " Character feature extraction method and its effectiveness evaluation", North China University of Technology, Beijing, 100144, China,2012.

[8] William K. Pratt, "Digital Image Processing", the Wiley biennials- knowledge for generation, fourth edition pixel soft, INC, California, 2007.

[9] Daggu Venkateshwar Rao, shutiPatil, Navveen Anne Babu and Vmuthukumar "implementation and evaluation of image processing algorithm on reconfigurable architecture using C-base hardware descriptive language", BS publishers and distributors (India) Volume I Number 1, pp. 9-34, 2006.

[10] Raghad Khrebit Rashid Al-Khalidy "Arabic Character Recognition Based on Moment Method", M. Sc. Thesis, Al-Nahrain University, 2008.

[11] B. Snakur, M. Sezgin, Thresholding techniques and quantitative Performance". evaluation, Journal Electron. Imaging, Vol. 13, No.1, pp.146-165, 2004.

[12] John C. Russ “The Image Processing handbook”, CRC, Fifth Edition, 2007.

[13] Gonzales, R, C. and woods R.E. "Digital Image Processing”, addition- Wesley, New York, 1992.

[14] Jun-Sik Kwon., Jun-Woong Gi' and Eung-Kwan Kang, “An enhanced thinning algorithm using parallel processing”, International Conference, Volume: 3, Pages: 752-755, 7-10 Oct. 2001.

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Selection of Lightning Arrester in the Niger Delta Environment

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ABSTRACT: Hundred percent reliability is the utmost desire of every electricity operator, therefore a good designer will always aim at giving the optimum reliable conditions. This requires choosing the best and suitable materials according to the required regulations. The Niger Delta environment, due to its peculiar terrain and harsh climatic conditions requires special attention in terms of choosing the materials in construction. Therefore, a good protective device is necessary not only for equipment but also for personnel. The climate of Niger Delta is known to have heavy rainfall, high humidity and high Isokeraunic level, therefore proper selection of Surge Absorber (diverter) is necessary for a reliable protection from travelling waves and switching surges in lines and substations. The aim of the paper is to study the performance of surge diverters and identify the diverter that is best suited for both performance and construction in this harsh environment. From the records ZnO (linear) arrester has better performance but the type and place of usage determines the reliability (life span) of the diverter. Due to dust and rainfall, the external material is also a major factor in determining erosion of material and watt losses. It is therefore necessary to suggest some maintenance procedure that may help extend the life span of the diverter.

KEYWORDS: Protective Ratio, gapless metal Oxide, Surge diverter, Basic Impulse level, hydrophobicity, Polymer housing.

1 INTRODUCTION

An overhead earth wire provides considerable protection against direct stroke. They also reduce induce over voltages. However, they do not provide protection against surges that may still reach the terminal equipment. Such protection may either be done by diverting the major part of the energy of the surge to earth using surge diverter [1].

A surge diverter is a device that is connected between lines and earth, that is, it is connected in parallel with the equipment to be protected.

When a travelling wave reaches the diverter, it sparks over at certain prefixed voltage (point A) and provides a conducting part of relatively low impedance between the line and ground. The surge impedance of the line restricts the amplitude of current flowing to ground, that is maintaining the residual voltage of the arrester [2, 3]. This is shown in fig.1.

Arresters are of three important types and are classified according to their internal structures. These are:

- Gap type arrester without current-limiting functions
- Gap type arrester with current limiting capabilities
- Gapless metal oxide variators

An ideal arrester should (1) conduct electric current at a certain voltage above the rate voltage (2) hold the voltage with little change for the duration of overvoltage (3) substantially cease conduction at very nearly the same voltage at which conduction started.

The cheapest and the simplest among the first group is the Rod Gap Arrester. They are usually connected across the bushings of various equipments. It has two end rods facing each other, one connected to line and the other connected to

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earth. The selected gap spacing should not only be capable of withstanding the highest normal power frequency voltage but should flashover when over voltage occur protecting the equipment. Once a gap flashes over under a surge voltage, the ionized gap allows a power frequency follow through current, even at low voltage, sometimes may lead to system outage. Another disadvantage is that the rod gaps are liable to be damaged due to high temperature of the arc [4, 5].

The performance of the rod-gap is easily affected by climate variation and the surge polarity.

2 GAP TYPE SiC ARRESTERS

The non current – limiting and the current limiting types, use sintered silicon carbide material which is made for a particular voltage rating. As many disc as are necessary for the arrester rated voltage are stacked in series and provide with voltage grading circuits [6, 7]. These may consist of high voltage resistors, capacitors or a combination of both.

They function in two stages. When over voltage occur the gap sparks over providing a low impedance path to ground. The series resistor reduces power frequency follow current so that the arc across gap is able to reseal. The block diagram of valve arrangement of silicone carbide and metal oxide is shown in fig.2.

In modern surge diverters, the Zinc Oxide Zn0 arresters are used due to its superior volt-ampere characteristics. The Zn0 arrester is often used as gapless as its normal follow current is negligibly small. The volt ampere characteristics of S_ic and Zn0 non-linear elements are shown in fig. 3.

Their characteristics can be mathematically expressed as

$V = K_1 i$ for a linear resister

$V = K_2 i^{0.2}$ for silicon carbide resistance

$V = K_3 i^{0.03}$ for a Z_{inc} Oxide resister

If the current were to increase a 100 times, the corresponding increase in voltage would be 100 times for linear resistor.

For S_1C resistor it would increase 2.5 times but for Z_n0 resistor the increase would be 1.15 times. This means that for the same residual voltage and the same discharge current, the follow current would be in kilo amps for linear resistor (in absence of series gap) and for S_1C, it will be in Amps but for Z_n0 arrester it would be in milliampere (mA).

For various improvement of the metal oxide varistor (MOV), the compact and sintered granules of Zinc Oxide with a small amount of other carefully selected metal oxide additives to improve the V – I non linearity [2, 8]. The Zinc Oxide grains have a low resistivity, while the additives (oxides $B1_2\ 0_3$, M_n0, $Cr_2\ 0_3$ $Sb_2\ 0_3$) which form the boundaries between the grains provide high resistance. The two are strongly bonded when sintered at high temperature.

With such a high degree of non linearity it is entirely feasible to use these elements without series gaps in an arrester with a current of only tens of μA at operating voltage. The volt-amp. Characteristics of zinc oxide and silicon carbide valve element is shown in fig.4

For SiC valve I = KV^a, where a = 4 – 6

For ZnO valve I = KV^b, where b = 25 – 30 and K is a constant.

3 ARRESTER HOUSING

In earlier construction the valve elements were mounted within a ceramic housing. The metal oxide element was surrounded by a gaseous medium and the end was generally sealed with rubber O-rings. With time in service, especially in hostile environment the seals tend to deterioration, allowing the ingress of moisture. In the 1980s polymeric housed surge arresters were developed.

It extends from distribution to heavy duty station arresters for voltage up to 400KV. In their design, the surface of the metal oxide element column is bonded homogeneously with glass fibre reinforced resin. The construction is void free, gives the unit a high mechanical strength and provides a uniform dielectric at the surface of the metal oxide column. The housing material is a polymer (EPDM) – Ethylene propylene diene monomers) which is a hydrocarbon rubber, resistant to tracking and particularly suitable for application in regions where pollution causes a problem [2, 7, 9].

Another polymer material that may claim more superiority is the silicon rubber which is very ideal for harsh conditions.

A complete polymer housing MOV is shown in fig 5.

The advantages of the polymeric – housed arresters over their porcelain housed equivalents are:

- No risk to personal or adjacent equipment during fault current operation
- Simple light modular assembly – no need for lifting equipment
- Simple installation
- High strength construction, eliminate accident damage during transport
- Reduces pollution flashover.

4 SELECTION OF ARRESTERS

The most important property of a surge absorber is the protective ratio (C_p) which is defined as

$$C_p = \frac{Peak\ Impulse\ Insulation\ level\ of\ Protected\ Equipment}{Rated\ Arrester\ Power\ Frequency\ Voltage\ (RMS\ Value)}$$

The selection of lighting arrester with a specific voltage rating is governed by the value of earthing co-efficient or earthing factor (EC). These are defined and are based on a single line to ground fault condition.

$$\text{E.C} = \frac{RMS\ Value\ of\ healthy\ phase\ voltage\ at\ arrester\ location}{Line\ to\ Line\ voltage\ at\ arrester\ location}$$

The earth fault factor, $Eff = \sqrt{3}\ E\ C$

The second important quantity of arrester selection is the discharge current. This is the current having a designated crest value and wave shape which is used to classify a surge diverter with respect to durability and protective characteristics. The standard wave form for the discharge current is taken as $8/20\mu s$.

The norminal value of discharge current is selected from the standard values depending on the application as follows:

10KA – Station Arrester type

5KA – Intermediate line type

2.5KA – Distribution – type

1.5KA – Secondary type

The highest ratings are used for the protection of major power stations, while the lowest ratings are used in rural distribution system.

The third important characteristic of an arrester is the protective level offered by it to the connected equipment. The arrester rating is selected based on the system earthing co-efficient with a specified V.I characteristic of the resistance materials. This is generally selected corresponding to 80 percent of the system phase to phase voltage for effectively earthed system and 100 percent for non-effectively earthed systems.

The protective level offered by a lightning arrester is the higher of the following two voltage value.

- Sparkover voltage of the series gap under standard $1.2/50\mu s$ impulse
- Residual voltage (discharge voltage), when discharging the specified test impulse current of $8/20\mu s$ wave shape.

The discharge voltage of the selected arrester should be below the BIL of the protected equipment between 15 – 25 percent.

In any good design, the aim is to keep

- The peak discharge residual voltage (the IR drop)
- The maximum impulse sparkover voltage
- The maximum wave front impulse sparkover voltage reasonably close to each other.

A comparism is seen in table 1

5 AVERAGE CLIMATIC EFFECT AND ARRESTER SPECIFICATIONS

A typical coastal area in the Niger Delta region was selected (BAYELSA STATE). In table 2 some climatic figures are shown.

The pollution level depends on the closeness to the pollutant. In the coastal areas the sea breeze with the salt spray becomes heavy pollutant. The gas flaring environment which is common in Bayelsa State is a source of acid pollution. In this environment the fungi growth is a major problem for outdoor operations of electrical equipments.

In table 3 some climatic specification for satisfactory operations are given by some designers.

6 DISCUSSION

The keraunic level and the rainfall in the area are high, much higher than the climate specification given in table 3. It showed that special consideration is needed for arrester application.

From the analysis of various arrester performances, it was shown that the Zinc oxide varistors are best suited for this environment. A change in current of 0.1A to 10^4A results in a voltage change of 54 percent. That is, under normal operating condition the current conducted may not exceed 1mA. When a surge reaches the arrester, it conducts only current necessary to restrict the voltages (the residual voltage).

The absence of spark gap also eliminates the need for voltage grading system which in turn eliminates the voltage / time lag property in other arresters.

The MOV arresters has excellent performance in terms of energy absorption capability, surge protection and substantial increasing watt loss with normal system conditions due to penetration of moisture into the metal oxide blocks, thereby promoting oxidation [1]. This form of aging no longer takes place in more recent manufactured metal oxide arresters but external watt loss (housing) is possible due to wet surface contaminations.

As some housing materials are known to age more rapidly than others, watt-loss can be expected to increase with normal service aging on some polymer housed surge arrester. Silicon rubber (SR) housing exhibit significant higher leakage current under wet contamination.

Silicon Rubber is highly hydrophobic and exhibit good retention of hydrophobicity, preventing watt loss on the polymer housing, while many polymeric materials with similar initial hydrophobic properties lose their hydrophobicity after a relatively short period. Such materials are (EPDD) and mixture of EPDM with silicone.

Silicon Carbide Arrester (Non Linear Gap)

Environmental factors, ingress of moisture and dust particles into the lightning arrester are the most common causes of failure in SiC lightning arresters. The failure is as a result of inadequate sealing of arrester and as such causes internal degradation.

From investigation of defective SiC arrester, it was identified that the airgap was damaged in most of them [7].

Damaging of airgap usually causes the decrease in the discharge current level, exposing the lightning arrester to high thermal pressure and the total discharge level of the arrester is reduced.

Researches have shown that after 13 years the S_iC lightning arrester decreases significantly.

It is likely that such environment is a more ideal one but in an environment like the Niger Delta the life of silicon carbide arrester may not last for more than 5 to 8 years.

There are two main contaminants in the Niger Delta. These are:

- The salt spray from the ocean to the coastal areas
- The flaring of gases

The Niger Delta is quote to have about one hundred and three flaring sites. In states like Bayelsa State some are not more than 50km from each other.

Under moderate rainfall the salt and acid solutions from these contaminants reduce breakdown voltage and increase watt-loss on the surfaces of these surge arresters. Also due to the salt and acid concentration rust may form on the metal surfaces of the arrester.

Another problem in the area is the algae growth. In humid climate algae growth is rapid. These algae die and form black patch on the surface of insulator when conditions are not favorable.

7 FIGURES AND TABLES

7.1 FIGURES

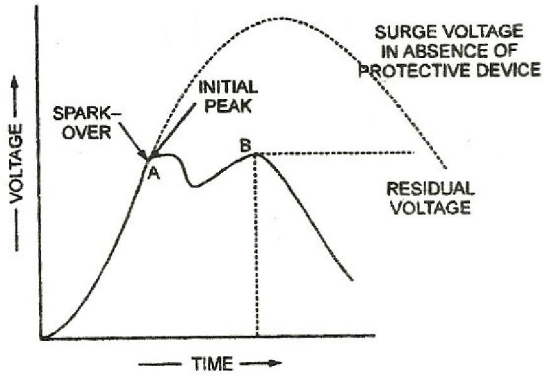

Fig. 1. Voltage Characteristics and Residual Voltage

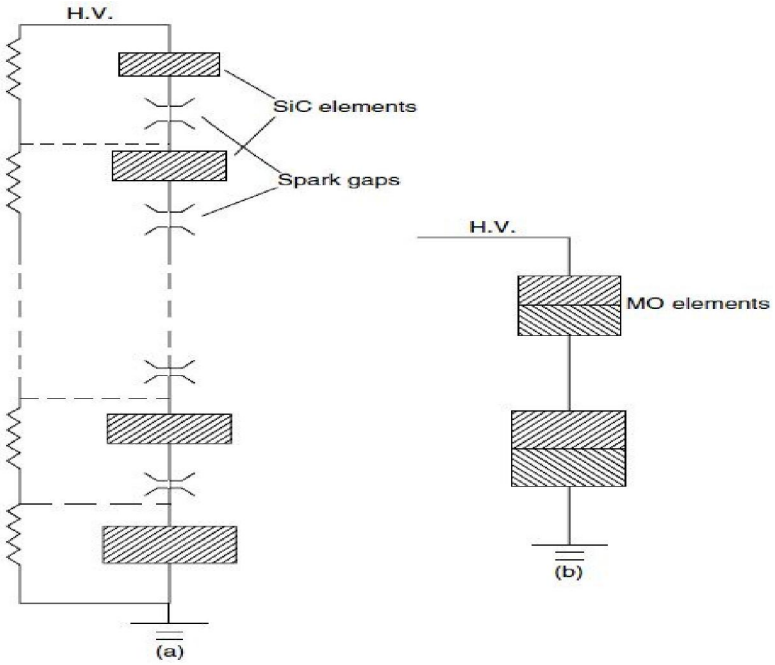

Fig. 2. Block diagram of Silicon Carbide (SiC) and metal oxide arrester (MOA)

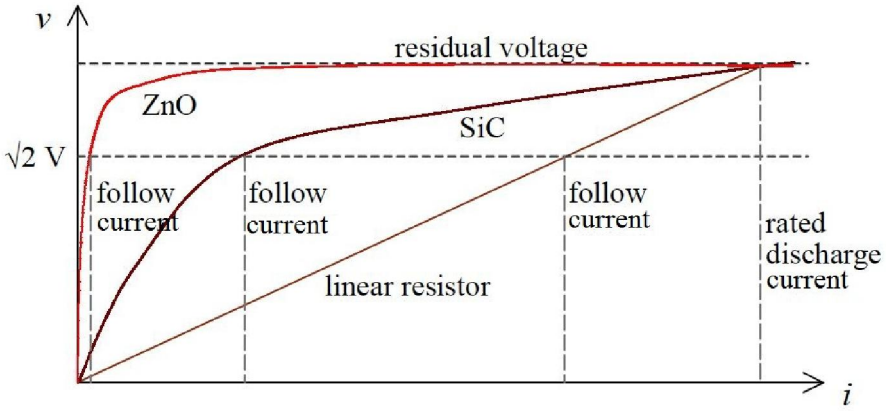

Fig. 3. Volt-Ampere characteristics of non-linear elements

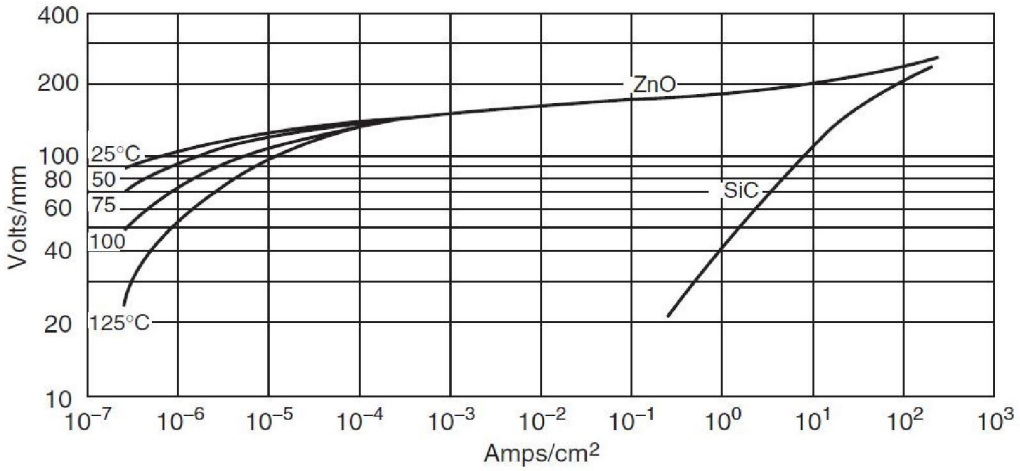

Fig. 4. Volt-Amp characteristics of ZnO and SiC valve element

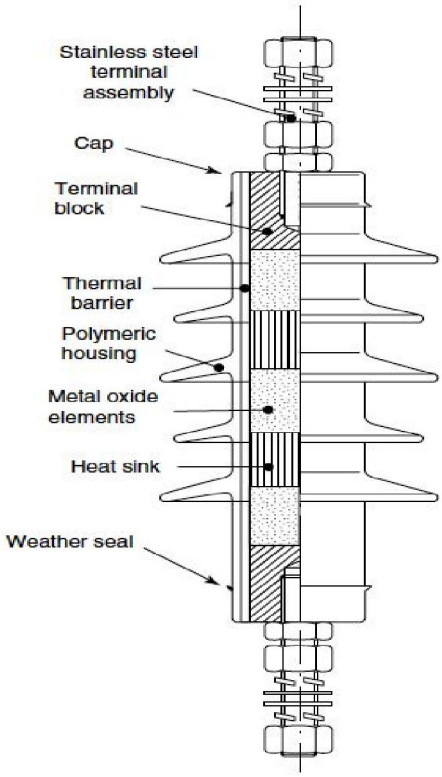

Fig. 5. Polymer-housed arrester

7.2 TABLES

Table 1. Comparative results of residual voltage, max sparkover voltage and sparkover voltage

Arrester Rating KV MM	Minimum Power Freq with stad	Max Imp spark over voltage (1.2/50μs) KV crest	Max. Residual voltage KV crest	Max wave from spark over voltage KV crest
36	1.5 times rated voltage	130	133	150
50		180	184	207
60		216	221	250
75		270	276	310

Table 2. Approximate climatic data of Niger Delta

Rainfall mm	Humidity percent	Lightning days	Pollution	Sun Intensity W/m^2	Pressure mm Hg	Ambient Temp ^{0}C	Soil Resistivity
2100 – 2940	55 – 90	60 – 90	Depend on location	3.5 – 5.1	748	27 – 35	40-80 Ωm

Table 3. Recommended climatic data for safe operation

i.	Maximum Ambient air temperature (^{0}C)	50
ii.	Humidity (%)	10 – 100
iii.	Maximum attitude above sea level (meters)	1000
iv.	Maximum Annual Rainfall 9mm)	1450
v.	Maximum wind pressure (Kg/Sq meter)	150
vi.	Isokeraunic level	50

8 CONCLUSION

The rod-gap arrester is not recommended either for main protection or backup protection in the coastal areas of Bayelsa State. Apart from the burning of the rod terminals, the climatic variation will badly affect performances of the gap. With the high humidity in the area the spark over initiation voltage will reduce. Once a gap flashover under surge voltage, the ionized gap allows a power frequency follow through current leading to system outage.

With the high keraunic level and high humidity there will be much of system disturbances due to irregular flashover and the system outages.

Silicon Rubber for arrester housing retains the hydrophobicity for several years and therefore reduces external watt loss. Some metal oxide arresters are designed with the following advantages.

- High resistance to tracking erosion
- Excellent resistance to flashover
- Self extinguishing flame retardancy
- High degree of non linearity.

With these advantages the metal oxide arresters outweigh other arresters in performance and reliability. These qualities coupled with low soil resistivity in Bayelsa State and in most part of the Niger Delta, may provide a better protection for substation equipments and lines.

For every arrester selection, both arrester survival and equipment protection must be considered. Many lightning and switching surges are of a magnitude that is much higher than the design rating.

It is of vital importance to properly select, locate and apply surge arresters in order to avoid damaging equipment. For better reliability of the metal oxide arrester the following points are important:

- It is necessary to regularly check and service the lightning arrester of the network and replace defective ones.
- Equipments in an indoor substations be connected through cables
- Surge absorbers, and surge capacitors and reactors may be needed in some areas of the installation.

REFERENCES

[1] D.R. Miller, J.J. Woodworth, C.M. Daley, "Watt loss of polymer Housed Arrester in a simulated Florida coastal climate", *IEEE Transactions on Power Delivery*, vol. 14, n° 2, pp. 940 – 947, 1999.

[2] E. Kuffel, W.S. Zaengi and J. Kuffel, *High Voltage Engineering Fundamentals*. Butter Worth – Heinemann, 2nd Ed., Oxford, pp. 500 – 523, 2000.

[3] R.P. Singh, T.V.P. Singh, "Influence of Pollution on the Performance of Metal Oxide Surge Arresters", *IEEE Conference on ELectaxcom.eng*. vol. 1, pp. 224 – 229, 2000.

[4] S.A. Hosseini, F. Razavi, M. Karami, A.A. Ghadimi, S.S. Karimi Madahi, "A New Method of recognize the status of S_eC Surge arrester in substation", *Indian Journal of Science and Technology*, vol. 5 n° 5, pp. 2692 – 2700, 2012.

[5] H. Kanashior, M. Tatizawa, P. Zanotti, F. Obase, W.R. Bacega, "Diagnostic of Silicon carbide surge arrester", *WSEAS Transactions on systems*, vol. 8, n° 12, pp. 1284 – 1293, 2009.

[6] R.D. Begamudre, *Extra High Voltage AC Transmission Engineering*, New Age International Publishers, New Delhi, 2008.

[7] M. Darveniza, O.R. Mercer, R.M. Watson, "An Assessment of the reliability of service gapped silicon carbide distribution surge arrester", *IEEE Transactions on Power Delivery*, vol. 11, n° 4, pp. 1789 – 1797, 1996.

[8] J.B. Gupta, *A course in Power Systems*, S.K. Kataria & Sons, Delhi, 2008.

[9] A. Bargigia, M. de Nigris, A. Pigini, A. Sivoni, "Definition of testing procedures to check the performance of Zn0 surge Arresters in Different Environmental conditions". *CIGRE*, pp. 33 – 206, 1992.

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Chimpanzee conservation status in the World Heritage Site Taï National Park, Côte d'Ivoire

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ABSTRACT: Effective conservation of African ape populations that have dramatically declined over the last decades requires updated information on the population status and habitat. However, at many sites, the densities and the spatial distribution of chimpanzees as well as the threats faced by the species are poorly described and not updated. To contribute towards filling these gaps, we conducted a survey along a total of 701.5km line transects to collect signs of chimpanzee and human activities over two years in the Taï National Park, Côte d'Ivoire. Encounter rates for signs of chimpanzee presence were low in most locations with less than two signs observed per kilometer walked. This was notably true within and around areas subject to the permanent existence of illegal human activities, such as the presence of plantations in the peripheral eastern regions. Using distance sampling methods, we estimated that the overall density of chimpanzees in 2008 was 0.087 individuals/km2 and 464 weaned individuals in the park. Taï National Park is a world heritage site but its biodiversity is threatened by human pressures. We further suggested work on the spatio-temporal modeling of the factors influencing the distribution and abundance of species to improve management and to optimize conservation decision-making.

KEYWORDS: Abundance estimates, encounter rates, Pan troglodytes, spatial distribution, transect counts.

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1 INTRODUCTION

There is a general consensus among conservationists concerning the evidence of the dramatic decline of wild populations of chimpanzee (*Pan troglodytes*) and other African great apes throughout the last decades across their range countries, caused mainly by habitat loss, commercial hunting and disease [1], [2], [3], [4]. All four species of African apes are recognized as being threatened by extinction, with the chimpanzee, the bonobo (*Pan paniscus*) and the eastern gorilla (*Gorilla beringei)* listed by the IUCN-International Union for Conservation of Nature as endangered species, and the western gorilla *(Gorilla gorilla*) listed as critically endangered [5]. The importance of each of these species and their survival is, however, many-faceted. Such aspects of importance include their role in the functioning of tropical ecosystems [1], [6], their vital role for the understanding of human evolution and human disease [7], [8] and their importance in the development of ecotourism [9].

Even though chimpanzees are the most abundant and widespread of the apes, with the larger populations found within protected areas, the declines that have occurred and that are expected to continue, justify the criteria for ranking them as endangered [10].

In Côte d'Ivoire, from 1995 to 2007, the population of chimpanzee rapidly declined by an alarming 90%, in the country thought to be one of the final strongholds for this subspecies [2]. Although, the Taï National Park (TNP) which harbors long-term research and tourism sites is believed to represent one of the main refuges for chimpanzees within Côte d'Ivoire [2], [11], information about the species' spatial distribution and the threats to its population has remained scarce and poorly known. However, the risk of deforestation of the rainforest in the southwest of Côte d'Ivoire, which includes the Taï region, and the unavoidable loss of biodiversity become increasingly high with human population growth associated with the poaching pressure for the bushmeat trade [12], and the unsustainable use of land for agricultural activities such as cocoa, rubber and coffee plantations [13].

Locating the remaining populations of chimpanzee in individual sites and gaining a better understanding of how humans interact with them in nature is crucial for guiding management and conservation strategies [8], [14], [15]. TNP is part of the Upper Guinean forest and represents one of the world's 25 biodiversity hotspots with a high level of endemism [16]. Improvement of knowledge of illegal activities occurring in the park and other factors affecting species distribution is therefore vital to contribute to meeting global conservation targets [17].

Despite the indisputable importance of the above-mentioned information for conservation, collecting data for accurately estimating chimpanzee distribution and density is a notoriously challenging task in large tropical rainforests. In addition to the large areas of thousands of square kilometers, other factors such as low visibility, the cryptic behavior of the species, the difficulties of accessing most locations and the necessity of training several surveyors are all aspects which add to the initial complexity of collecting sufficient data for the aforementioned estimates [15]. Inaccessible locations and non-sampled areas have rarely been described in terms of their animal densities and distributions. Such aspects can be further affected by political instability for example, which may temporarily block international funding, as has been experienced in Côte d'Ivoire due to the civil unrest since 2002, as well as in other range countries of *P. troglodytes verus* in the past (e.g, Liberia, Sierra Leone). As a result, research and management activities in protected areas may be hindered during such periods of crisis. In the TNP, however, funding since 2005 has provided an opportunity to train local assistants from various towns surrounding the park to implement an efficient monitoring program across the park. This program was designed by the Wild Chimpanzee Foundation and the Office Ivoirien des Parcs et Réserves [18] to inform park managers about the status of the TNP's large mammal populations [19].

2 OBJECTIVES

This study aims to provide information on the conservation status of one key population of the western chimpanzee and contribute to a better understanding of the current threats to the distribution of its population in the TNP, which is a prerequisite for the design of an efficient conservation strategy. More specifically, the objectives of our work were to:

1) Determine the population size and spatial distribution of the western chimpanzee in the Taï National Park;
2) Determine the spatial distribution of human illegal activities in the TNP.

3 METHODS

3.1 STUDY SITE

Our work was carried out in the Taï National Park (TNP) during two main data collection phases which included the periods from September 2006 to April 2007 (2006-2007) and from August 2007 to March 2008 (2007-2008). The TNP is located in the south-west of Côte d'Ivoire (Fig. 1a.) between 5°15'-6°7'N and 7°25'-7°54'W. TNP, including the adjacent N'Zo Fauna Reserve, covers 5,360 km² and remains the largest protected rainforest in West Africa. The relative humidity in the TNP is high, ranging between 85% and 90% while the annual rainfall and temperature are 1800mm and 24°C, respectively [20]. TNP is managed by the OIPR and is a recognized UNESCO World Heritage Site with extraordinary species diversity and a high level of endemism making it one of the world's 25 biodiversity hotspots [16]. Details of the location, climate, flora and fauna can be found elsewhere [7], [21], [22].

3.2 SURVEY DESIGN AND SAMPLING METHODS

Our survey design covered the entire park, and consisted of forty-six systematically spaced clusters of line transects with a random start in the TNP. The distance between the centroids of consecutive clusters of transects was 11 km (Fig. 1b.). This systematic design provided equal coverage probability over the entire park, i.e. each location in the study area has the same probability of being sampled, which one assumes during a standard line transect analysis [23], [24]. More precisely, clusters of transects consisted of four sampling units or transects with the length of each unit measuring 2 km subdivided into four segments of 0.5 km each (Figure 1c.). Others details about the survey design are given by [19].

Transects were located in the field using a map and a GPS (Global Positioning System) and each transect was visited once in each data collection phase by five experienced survey teams to record all signs of chimpanzee activities (hereafter chimpanzee signs) as well as signs of human activities. Signs of chimpanzees included sleeping nests, feeding signs, vocalization and direct observations that can be used to identify the presence of the species at any location in the park. We used the same definition for human activities which included illegal activities such as flora aggression, fauna aggression and other threats to wildlife. For each sign detected, the GPS coordinates were recorded to allow determination of the spatial distribution of the species. In order to estimate the density of the chimpanzee population, for each sleeping nest detected, we measured perpendicular distances from the nest to the transect line. Further details about transect data collection including chimpanzee nest counts along line transects can be found elsewhere [25], [26].

3.3 DATA ANALYSIS

3.3.1 ESTIMATION OF CHIMPANZEE POPULATION SIZE FROM TRANSECTS NEST COUNTS

We calculated nest encounter rates by dividing the number of nests encountered by the total length of transects. We used conversion factors (nest production rate and nest mean lifetime) with their associated errors estimated by [25] for chimpanzee densities and abundance estimates using the package DISTANCE 6.0 with the equation:

$$\widehat{Dc} = \frac{\widehat{Dn}}{r.t} = \frac{n}{2wL.r.t.\hat{P}_a}$$

where $\widehat{Dc}$ is the estimated chimpanzee density, n is the number of nests detected in the surveyed area a with $a = 2wL$; $\widehat{Dn}$ is the estimated nest density, r is the nest production rate; t nest mean lifetime; L is the total length of transects or survey effort, w is the distance from transect line beyond which no nests were detected; $\hat{P}_a$ is the probability that a randomly chosen nest within the surveyed area is detected [23].

To allow robust estimations of densities and animal abundance, we pooled nest count data from the first and second visits on transect. Each visit was defined as a stratum in the DISTANCE 6.0 software, and calculations were made following [23].

3.3.2 MAPPING THE SPATIAL DISTRIBUTION OF HUMAN SIGNS AND CHIMPANZEE PRESENCE

To indicate the spatial distribution visually, we used the encounter rates of chimpanzee signs as well as for human signs calculated for each sampling unit. We performed mapping analysis using the deterministic interpolation method of Inverse

Distance Weighted [27]. This method assumes that the influence of a known data point is inversely related to the distance from the unknown location that is being estimated. We carried out all mapping analysis using the Geographic Information System software ArcGIS 9.2 (Environmental Systems Research Institute, Redlands, USA).

3.3.3 STATISTICAL ANALYSIS

To compare the signs of chimpanzee presence and human activities in the two related sampling phases namely from 2006-2007 and 2007-2008, we used the non-parametric *Wilcoxon* signed-rank test of the Statistical Package for Social Sciences (SPSS 13.0). Since the recorded chimpanzee signs were not normally distributed, we used the Poisson regression function in a Generalized Linear Model (GLM) to test the effects of human activities on chimpanzee density and distribution, using the R for Windows software (R 2.12.0). In this test, the response variable was the encounter rates of chimpanzee signs and the independent variables were the encounter rates of fauna aggression signs and flora aggression signs by considering each data collection phase.

4 RESULTS

4.1 CHIMPANZEES DENSITY AND ABUNDANCE IN THE TAÏ NATIONAL PARK (TNP)

We walked 701.5km during the visits of transects with the survey effort being 362 km and 339.5km for the first and second visits, respectively. Overall, during the two visits, we detected 270 sleeping nests of chimpanzees implying the encounter rates of 3.85 nests for ten kilometers walked in the TNP. Among various models, the half normal detection function model in combination with the cosine adjustment term of order two produced the best fit for pooled nest data for the two visits (AIC= 842.35). The density of chimpanzee nests in the TNP over the entire study period was 9.02 nests per km^2 and conversion to individual densities was made with nest decay time t= 91.22 days and nest production rate r=1.14 nests per day. This resulted in a density estimate of 0.087 weaned chimpanzee individuals per km^2, CV= 14.04 % and the confidence limits (CL) ranging from 0.057 to 0.132 individuals per km^2. We estimated 464 weaned chimpanzee individuals (CV= 14.04%) with the CL ranging from 305 to 707 individuals during the entire study period.

However, the CV of the point estimates per stratum (i.e for each visit) was relatively higher than the one from the pooled data mentioned above. Indeed, during the first visit (year 2006-2007) the mean estimates of chimpanzee population size was 504 weaned individuals with CV= 24.79% and CL varying from 312 to 815 individuals. During the second visit, we found that the population size of chimpanzee was 422 weaned individuals with CV= 26.32% and CL ranging from 253 to 702 individuals.

4.2 ENCOUNTER RATE AND SPATIAL DISTRIBUTION OF CHIMPANZEE SIGNS OF PRESENCE IN THE TNP

The presence of chimpanzees in the TNP was confirmed during transect surveys by sleeping nests of individuals, nut cracking sites, direct observations, vocalizations and footprints with the encounter rates being 0.39 nests per km, 0.24 nut cracking sites per km, 0.09 individuals per km, 0.07 vocalizations per km and 0.003 footprints per km walked (Table 1).

While comparing the data of the two visits, we did not find any significant decrease of chimpanzee nests from 2006-2007 to 2007-2008 (Wilcoxon test, Z = -1.15, P-value = 0.25). Moreover, the relative increase of all chimpanzee signs was not statistically significant (Wilcoxon test, Z = -1.33, P-value = 0.18).

We found that the encounter rate of chimpanzee signs along transects was generally higher in the western and the northern parts of the park than in other locations. Areas of lower encounter rates (0.30 signs observed per km walked) were located in the peripheral areas, and more specifically in the eastern region around the plantation areas (Fig. 2). Furthermore, higher encounter rates of chimpanzee sings in the park generally ranged from 1.5 to 10.5 signs per kilometers walked.

4.3 HUMAN AGGRESSION SIGNS IN THE PNT

We observed various signs of human activities distributed throughout the park (Table 1). They were mostly observed in the peripheral areas of the park with encounter rates globally ranging from 1.5 to 8 signs per km (Fig. 3). But, in a few locations from the north, encounter rates reached 8 signs to 24.2 signs per km. Signs of human activities are less likely to be detected in the central and western areas of the park where they tended to be absent with encounter rates ranging from 0 to 1.5 signs per km walked. Human signs observed during transect surveys were classified into three categories: signs of flora aggression, signs of fauna aggression by humans and other human signs (Table 1).

Signs of flora aggression by humans included signs such as forest clearing for farming, plantations, abandoned fields and cutting of plant stems or branches for teeth brushing. The encounter rates of all signs of flora aggression were 0.48 signs per km walked during the entire study period; flora aggression signs did not significantly decrease from the phase 2006-2007 to the phase 2007-2008 (Wilcoxon test, Z = -1.87, P-value = 0.06). The signs of fauna aggression by humans included observations of poaching camps, gun shells, gunshots and traps with a total encounter rate of 2.37 signs per km. As obtained for the flora aggression signs, fauna aggression signs remained statistically stable (Wilcoxon test, Z = -0.17, P-value = 0.87). Other signs of humans included humans being heard, objects left, good panning locations, patrols and research trails with the last mainly observed in the western area of the park around the research station and Djouroutou. We also noticed that all human signs significantly decreased from the phase 2006-2007 to the phase 2007-2008 (Wilcoxon test, Z = -3.84, P-value < 0.001).

When comparing the spatial distribution of chimpanzee presence signs (Fig.2) to the spatial distribution of human signs (Fig. 3), we found that areas of higher chimpanzee densities - the central and the western areas - showed low signs of illegal human activities. However, in the northern areas, we found higher densities of anthropogenic disturbance although chimpanzees were relatively abundant.

This impact of human activities on chimpanzee density is negatively significant during the phase 2006-2007 through the fauna aggression signs (coefficient = -0.423, Standard Error = 0.117, Z value = -3.624, P-value < 0.001) but not negative for the flora aggression signs (coefficient = 0.236, Standard Error = 0.050, Z value = 4.724, P-value < 0.001). The effects seemed to be reduced in 2007-2008: the negative effects were significant for the fauna aggression signs (coefficient = -0.214, Standard Error = 0.089, Z value = -2.392, P-value =0.017) but not for the flora aggression signs (coefficient = -0.158, Standard Error = 0.109, Z value = -1.446, P-value =0.148).

5 DISCUSSION

The findings of the present study provide updated information on the estimates of chimpanzee population size and distribution in the Taï National Park (TNP), the largest protected rainforest in West Africa. In addition, we contributed to the discussion about the extent of human influence on biodiversity in protected areas [28].

Firstly, our results strongly suggest that there are low densities of chimpanzees observed in the TNP (0.087 weaned individuals per km^2), and these densities were 20 times lower than the estimates from [29] at the same site. This observed negative trend of densities is consistent with the general catastrophic decline of the Ivorian population of chimpanzees [2]. The relatively higher densities of chimpanzee in the central areas of the park could be explained by the difficulty or the higher risk for hunters to access these locations. The mean estimates of the population size of the species can be extended to 464 weaned individuals. However, following [26] who found that 17.5% of chimpanzees in the population do not build nests, the total size of the population including infants can be estimated at 562 individuals. Despite the negative trend observed, the size of the current chimpanzee population can be considered as viable.

Secondly, we found that the species is facing many threats compromising its survival in the park. Indeed, the decline in chimpanzee density is most likely due to intense human pressure on the park with a human population increasing at a high rate and an uncontrolled influx of migrants from the northern regions of the country and from the Sahel belt [13]. The resulting increase in demand for protein may drive bushmeat hunting in the park and has already led to the 'empty forest syndrome' in the eastern parts of the park [19]. Hunting is not only motivated by food/protein needs of local populations, but unfortunately also by the illegal trade in bushmeat supply for the urban centers as a source of income. The relatively higher encounter rates of signs of fauna aggression in comparison with the other human signs and signs of flora aggression support the idea that poaching activities are the major threat in the park [30]. Though hunting for bushmeat is illegal in Côte d'Ivoire and even more so in national parks, in reality, bushmeat is a common part of the local communities' diet. Nowadays, hunting has reached an unsustainable level in the Taï region and is causing the depletion of local wildlife (see also [31]). The persistence of farming activities or plantations in part of the protected area, even in the peripheral areas, remains hardly understandable as it can substantially affect biodiversity as partly illustrated by the distribution of chimpanzees in Fig. 2. Indeed, previous studies demonstrated that the presence of humans in protected areas represent important threats to biodiversity as they may leave potentially infectious fluids that can infect wild chimpanzees and other wild primates [31]. For instance, human feces are a particular problem because fecal micro and macro-parasites are typically more resistant to environmental degradation than are other parasites (e.g. respiratory viruses).

Due to the prominence of human activities in the park, more specifically on the eastern areas, there is a need for urgent research investigation and conservation actions in order to guarantee the conservation of this threatened ape. For instance, spatio-temporal modeling may be required to determine the locations and the key periods of interaction between poachers

and the primates in the park. The spatial distribution of the social groups of chimpanzees at the scale of the entire TNP is not yet well-known and requires additional research, in particular in the other areas of the park excluding the territories of the four habituated groups studied by the Taï Chimpanzee Project [32].

In line with our research, we suggest that the conservation researchers and park managers should improve communication or work closely to efficiently pursue the common aim of biodiversity conservation. There is an urgent need for more active patrolling in the park to try to keep under control the pressure resulting from poaching. This has to be implemented as quickly as possible, and through our data the areas of priority are clearly indicated (see fig. 2). Indeed, patrols of rangers employed by the park managers need to continue using such results to orientate their activities as shown by [19]; this may lead to higher significant decrease in the impact of human aggression signs, and on the other hands favors the increase of wildlife populations. Furthermore, the activities should include rigorous assessments of wildlife population status in a cost-effectiveness manner with special emphasis on a long- term monitoring program.

6 TABLES AND FIGURES

Table 1. Numbers and encounter rates of signs of chimpanzee presence and human signs recorded during the study period at Taï National Park

Type of observation		Number of signs			Encounter rates (n/km)		
		2006-2007	2007-2008	Total	2006-2007	2007-2008	Total
Signs of chimpanzee presence	Nuts cracking sites	19	147	166	0.052	0.433	0.236
	Vocalizations	22	27	49	0.061	0.080	0.070
	Direct observations	46	14	60	0.127	0.041	0.085
	Footprints	0	2	2	0.000	0.006	0.003
	Nests	151	119	270	0.417	0.351	0.385
Total of chimpanzee signs		238	309	547	0.657	0.910	0.779
Indices of flora aggression	plantations	27	54	81	0.074	0.159	0.115
	Abandoned plantations	5	35	40	0.014	0.103	0.057
	Cleared land	3	0	3	0.008	0.000	0.004
	Cutting of plants as teeth brush	166	49	215	0.458	0.144	0.306
Total of flora aggression		201	138	339	0.554	0.406	0.483
Indices of fauna aggression	Empty cartridge cases	115	144	259	0.317	0.424	0.369
	Gunshots	39	34	73	0.108	0.100	0.104
	Poacher camps	22	7	29	0.061	0.021	0.041
	Traps	207	186	393	0.571	0.548	0.560
	Hunting trails	564	343	907	1.556	1.010	1.292
Indices of fauna aggression		947	714	1 661	2.612	2.103	2.366
Other signs of human presence	Human heard	1	0	1	0.003	0.000	0.001
	Items or objets left	0	4	4	0.000	0.012	0.006
	Gold panning locations	13	6	19	0.036	0.018	0.027
	Other human trails (for patrols, etc.)	11	48	59	0.030	0.141	0.084
	Research trails	29	19	48	0.080	0.056	0.068
Total of other signs of human presence		54	77	131	0.149	0.227	0.187
Total of human signs		1 202	929	2 131	3.316	2.736	3.036

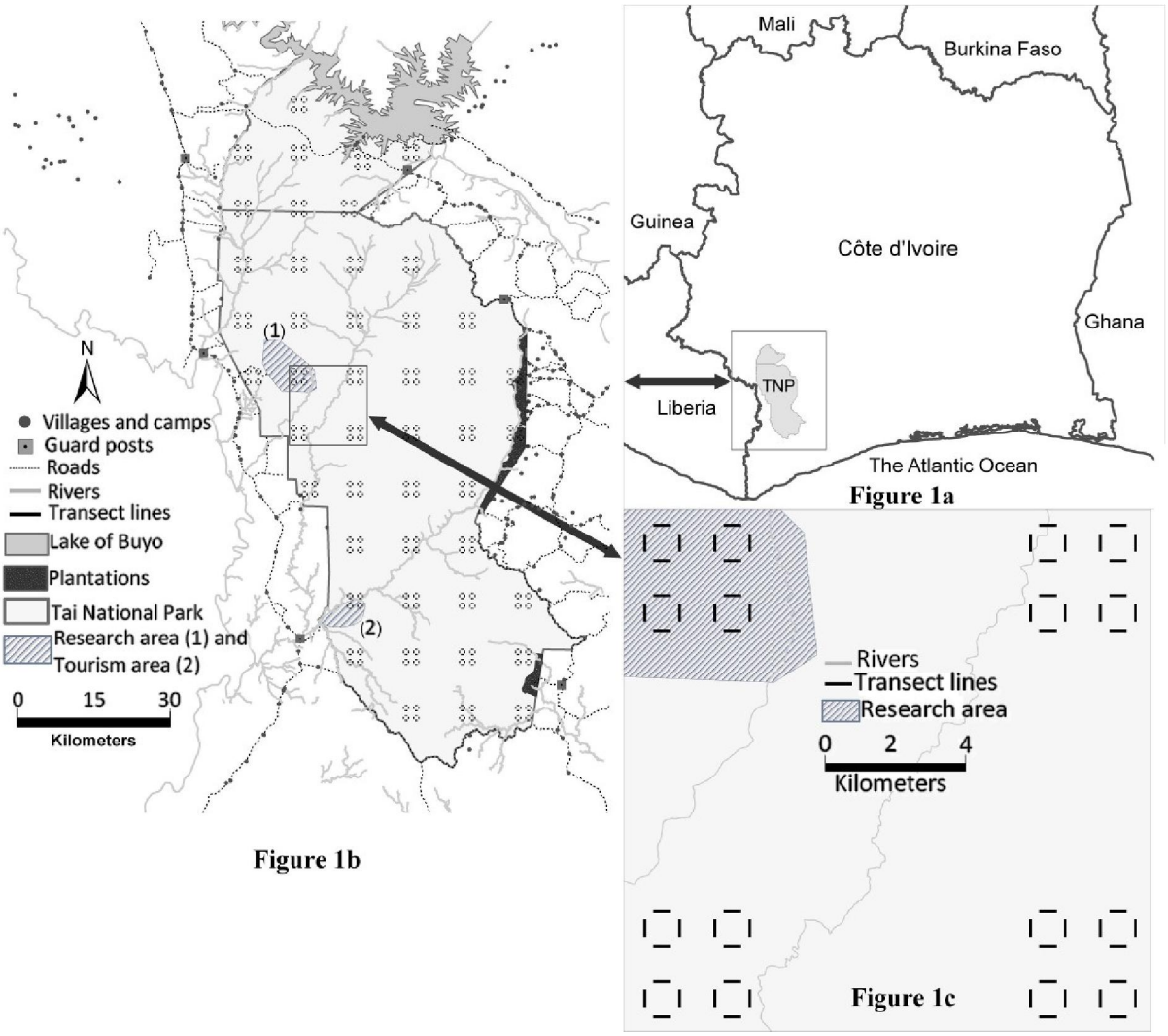

Fig. 1. Location of Taï National Park (1a) in southwestern Côte d'Ivoire, survey design (1b) within the park, and a detail viewing of one group of transects (1c).

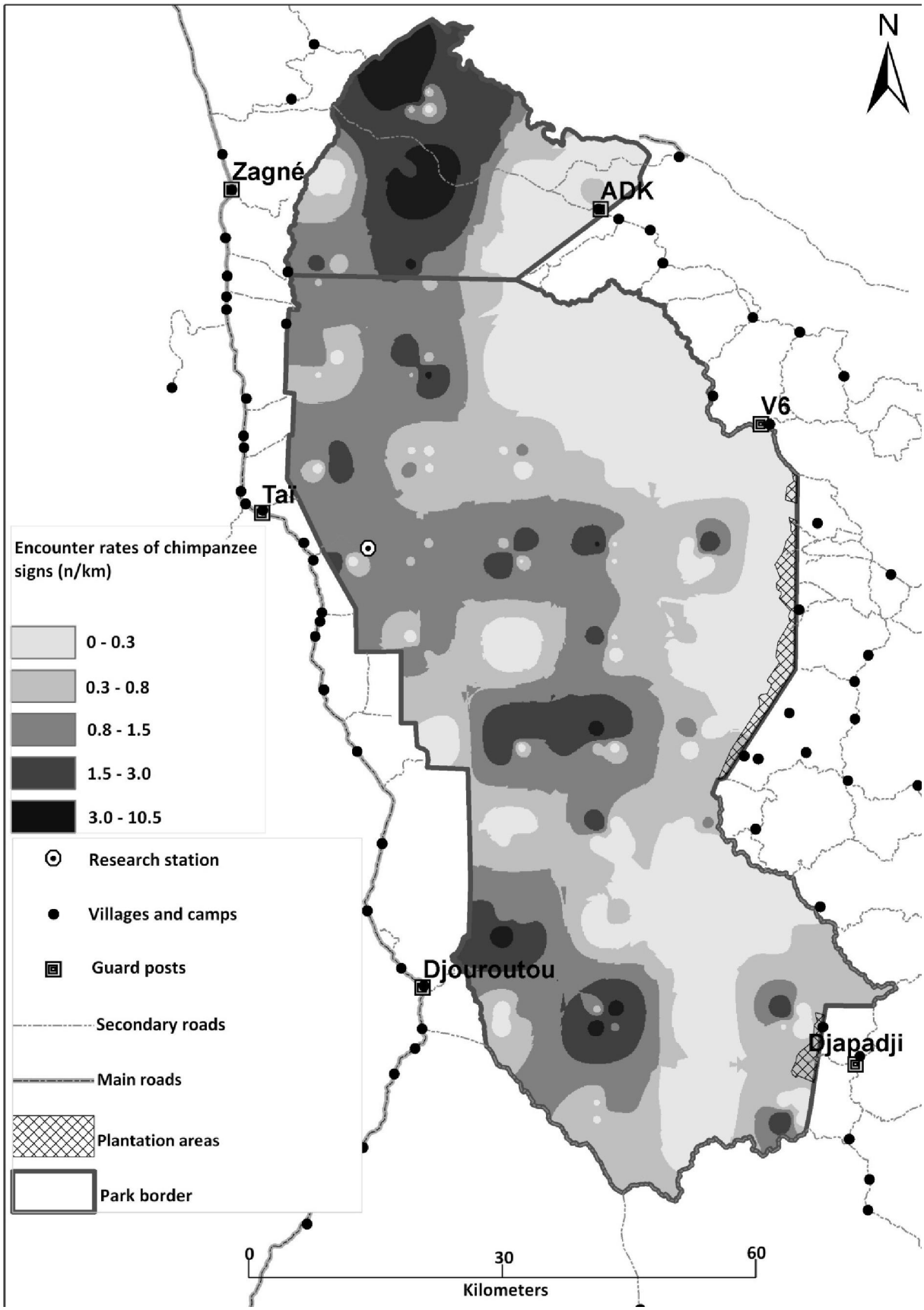

Fig. 2. Spatial distribution of chimpanzee presence signs in the Taï National Park

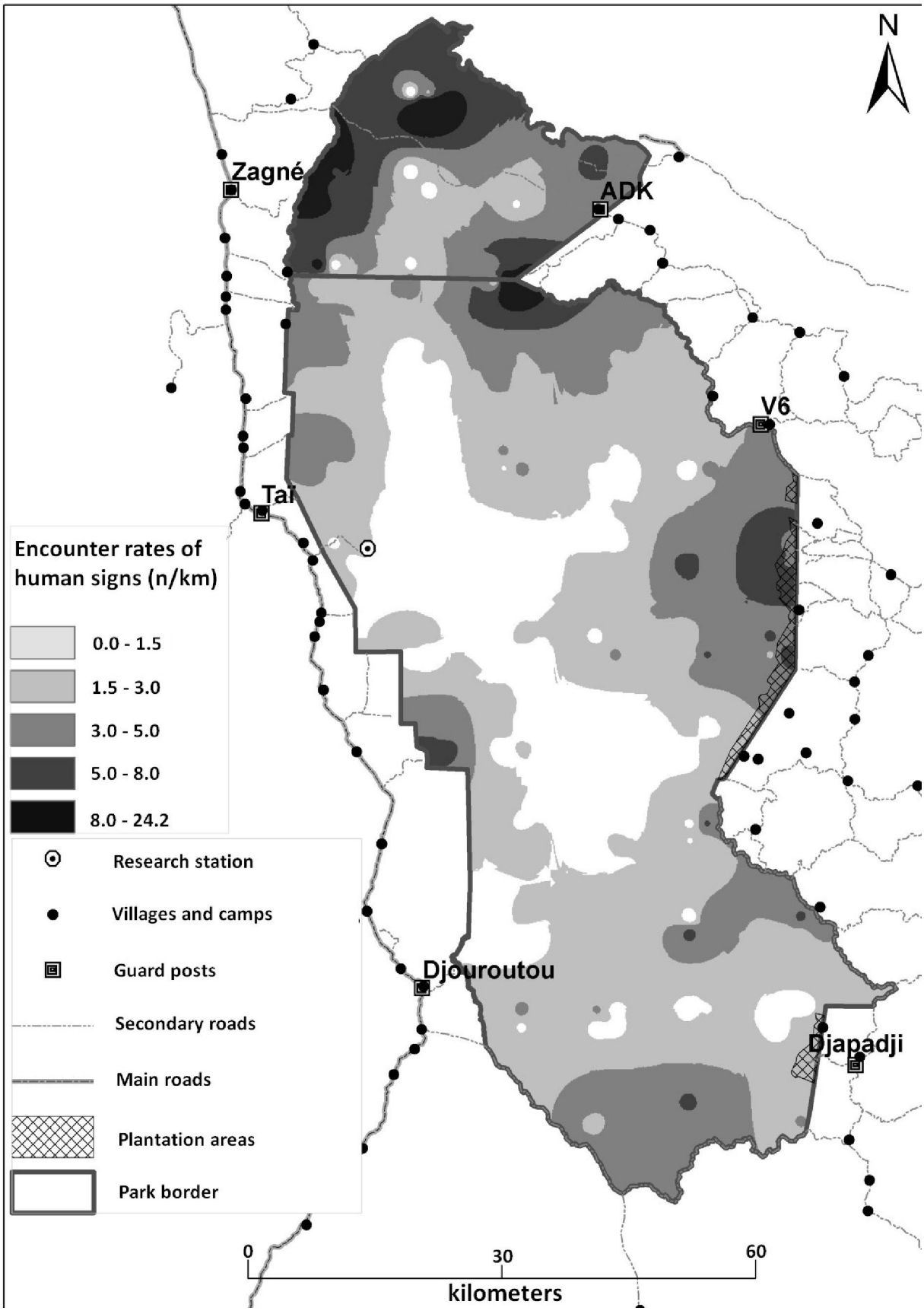

Fig. 3. Spatial distribution of human signs in the Taï National Park

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REFERENCES

[1] T. M. Butynski, Great Apes and Humans: The Ethics of Coexistence, in Great Apes and Humans: The Ethics of Coexistence, Beck, et al., Editors. 2001, *Smithsonian Institution Press,*: Washington, D.C., USA. pp. 3-56, 2001

[2] G. Campbell, H. Kuehl, P. K. N'groan and C. Boesch, ''Alarming decline of West African chimpanzees in Côte d'Ivoire'', *Current Biology*, vol. 18, pp. R903-R904, 2008.

[3] J. Junker, S. Blake, C. Boesch, G. Campbell, L. du Toit, C. Duvall, A. EKobo, G. Etoga, A. Galat-Luong, J. Gamys, J. Ganas-Swaray, S. Gatty, A. Ghiurghi, N. Granier, J. Hart, J. Head, I. Herbinger, T. C. Hicks, B. Huijbregts, I. S. Imong, N. Kuempel, S. Lahm, J. Lindsell, F. Maisels, M. McLennan, L. Martinez, B. Morgan, D. Morgan, F. Mulindahabi, R. Mundry, K. P. N'goran, E. Normand, A. Ntongho, D. T. Okon, C-A. Petre, A. Plumptre, H. Rainey, S. Regnault, C. Sanz, E. Stokes, A. Tondossama, S. Tranquilli, J. Sunderland-Groves, P. Walsh, Y. Warren, E. A. Williamson and H. S. Kuehl, ''Recent decline in suitable environmental conditions for African great apes'' *Diversity and Distributions*, vol. 18, n°11, pp. 1-15, 2012.

[4] P.D. Walsh, K. A., Abernethy, M. Bermejo, R. Beyersk, R, P. De Wachter, M. E. Akou, B. Huljbregis, D. I. Mambounga, A. K. Toham, A. M. Kilbourn, S. A. Lahm, S. Latour, F. Maisels, C. Mbina, Y. Mihindou, S. N. Obiang, E. N. Effa, M. P. Starkey, P. Telfer, M. Thibault, C. E. G. Tutin, L. J. T. White and D. S. Wilkie, ''Catastrophic ape decline in western equatorial Africa''*, Nature*, vol. 422**,** pp. 611-614, 2003.

[5] J.F. Oates, C.E.G.Tutin, T. Humle, M.L. Wilson, J.E.M. Baillie, Z. Balmforth, A. Blom, C. Boesch, D. Cox, T. Davenport, A. Dunn, J. Dupain, C. Duvall, C. M. Ellis, K. H. Farmer, S. Gatti, E. Greengrass, J. Hart, I. Herbinger, C. Hicks,,K. D. Hunt,, S. Kamenya, F. Maisels, J. C. Mitani, J. Moore, B. J. Morgan, D.B. Morgan, M. Nakamura, S. Nixon, A. J. Plumptre, V. Reynolds, E. J. Stokes and P.D. Walsh ''*Pan troglodytes*''. In: IUCN Red List of Threatened Species. Version 2012.2. [online], Available: http://www.iucnredlist.org/details/15933/0 (March 15, 2013).

[6] F. Bourlière, ''Primate Communities: Their Structure and Role in Tropical Ecosystems''*, International Journal of Primatology*, vol. 6, n°1, pp. 1-26, 1985.

[7] C. Boesch and H. Boesch-Achermann. *The chimpanzees of the Taï Forest: behavioural ecology and evolution*. New York: Oxford University Press, 2000.

[8] S. Köndgen, H.Kuhl, K. P.N'Goran, D. P. Walsh, S. Schenk, , N. Ernst, , R. Biek, P. Formenty, K. Maetz-Rensing, B. Schweiger, S. Junglen, H. Ellerbrok, A. Nitsche, T.Briese, I. W. Lipkin, G. Pauli, C. Boesch and H. F. Leendertz ''Pandemic human viruses cause decline of endangered great apes'', *Current Biology,* vol. 18, pp 260-264, 2008.

[9] J. E. Macfie and A. E. Williamson, *Best practice guideline for great ape tourism*, Gland Switzerland: IUCN/SSC Primate Specialist Group, 78pp, 2010.

[10] J. F. Oates, ''Is the chimpanzee, *Pan troglodytes*, an endangered species? It depends on what ''endangered means''. *Primates*, vol. 47, n°1, pp. 102-112, 2006.

[11] G. Campbell, H. Kuehl, A. Diarrassouba, P. K. N'goran and C. Boesch, ''Long-term research sites as refugia for threatened and over-harvested species''*, Biology Letters*, vol. 7**,** n° 5, p. 723-726, 2011.

[12] J. Refisch and I. Koné, ''Impact of commercial hunting on monkey populations in the Tai region, Cote d'Ivoire''*, Biotropica*, vol. 37**,** n° 1, pp.136-144, 2005.

[13] T. Brou Yao, J. Oszwald, S. Bigot and E. Servat, ''Risques de déforestation dans le domaine permanent de l'état en Côte d'ivoire : quel avenir pour ces derniers massifs forestiers ?'', *Télédétection*, vol. 5, n°1-2-3, pp. 105–121, 2005.

[14] L. Boitani, L. Maiorano, D. Baisero, A. Falcucci, P. Visconti and C . Rondinini, ''What spatial data do we need to develop global mammal conservation strategies?'', *Philosophical Transactions of the Royal Society*, vol. 366, n°1578, pp. 2623-2632, 2011.

[15] H. Kühl, F. Maisels, M. Ancrenaz and Williamson, A. E., *Best Practice Guidelines for Surveys and Monitoring of Great Ape Populations*. Gland, Switzerland: IUCN SSC Primate Specialist Group, 32pp, 2008.

[16] N. Myers, A. R. Mittermeier, C. G. Mittermeier, G. A. B. da Fonceca and J. Kent, ''*Biodiversity hotspots for conservation priorities'', Nature*,. vol. 403, pp. 853-858, 2000.

[17] M. S. H. Butchart, W. J. P. Scharlemann, I. M. Evans, S. Quader, S. Arico, J. Arinaitwe, M. Balman, A. L. Bennun, B. Bertzky, C. Besancon, , M. T. Boucher, M. T. Brooks, I. J. Burfield, D. N. Burgess, S. Chan, P. R. Clay, J. M. Crosby, , N.C. Davidson, D. N. Silva, C. Devenish, L. G. C. Dutson, F. D. F. Dıaz, C. L. D. Fishpoo, C. Fitzgerald, M. Foster, F. M. Heath, M. Hockings, M. Hoffmann, D. Knox, , W. F. Larsen, , W. F. Lamoreux, C. Loucks, I. May, J. Millett, D. Molloy, P. Morling, M. Parr, H. T. Ricketts, N. Seddon, B. Skolnik, N. S. Stuart, A. Upgren and S. Woodley, ''Protecting Important Sites for Biodiversity Contributes to Meeting Global Conservation Targets'', *PLoS One*, vol. 7, n°3, pp. e32529, 2012.

[18] OIPR, Plan d'aménagement et de gestion du Parc National de Taï, Office Ivoirien des Parcs et Réserves, pp. 110, 2006, [online], Available: http://www.giz.de/Themen/de/dokumente/fr-ci-Plan-amenagement-gestion-PN-Tai-2006-2015.pdf, (March 10, 2012).

[19] K. P. N'goran, C. Boesch, R. Mundry, E. K. N'goran, I. Herbinger, A. F. Yapi and S. Kuehl, ''Hunting, Law Enforcement, and African Primate Conservation*'', Conservation Biology*, vol. 26, n° 3, pp. 565-571, 2012.

[20] P. D. Anderson, V. E. Nordheim, C. T. Moermond, B. Z. Gone Bi, and C. Boesch, ''Factors influencing tree phenology in Taï National Park, Côte d'Ivoire*'', Biotropica*, vol. 37, n° 4, pp. 631-640, 2005.

[21] W. S. McGraw, K. Zuberbühler and R. Noë, *Monkeys of the Tai forest: an african primate community*, Cambridge University Press, 2007.

[22] P. E. Riezebos, P. A. Vooren and J. L. Guillaumet, *Le Parc National de Taï, Côte d'Ivoire. I: Synthèse des connaissances. II: Bibliographie*. Ed. Tropenbos Wageningen, 1994.

[23] T. S. Buckland, R. D. Anderson, P. K. Burnham, L. J. Laake, L. D. Borchers and L. Thomas, *Introduction to distance sampling: estimating abundance of biological populations*. Oxford University Press, 2001.

[24] L. Thomas, T. S. Buckland, A. E. Rexstad, L. J. Laake, S. Strindberg, L. S. Hedley, R.B. J. Bishop, A. T. Marques and P. K. Burnham, ''Distance software: design and analysis of distance sampling surveys for estimating population size*'',Journal of Applied Ecology*, vol. 47, n°1, pp. 5-14, 2009.

[25] Y. C. Kouakou, C. Boesch and H. Kuehl, ``Estimating Chimpanzee Population Size with Nest Counts: Validating Methods in Taï National Park*'', American Journal of Primatology*, vol. 71, n°6, pp. 447–457, 2009.

[26] A. J. Plumptre and V. Reynolds, ``Censusing chimpanzees in the Budongo Forest, Uganda'', *International Journal of Primatology*, vol. 17, n°1, pp. 85-99, 1996.

[27] H. Akima, A. Gebhardt, T. Petzoldt and M. Maechler, Interpolation of irregularly spaced data. 2006, R package. [online], Available: ftp://ftp.auckland.ac.nz/pub/software/CRAN/doc/packages/akima.pdf, (February 1, 2006).

[28] A. Blom, R. van Zalinge, E. Mbea, I. M. A. Heitkonig, H. H. T. Prins, ``Human impact on wildlife populations within a protected Central African forest'', *African Journal of Ecology*, vol. 42, n° 1: pp. 23-31, 2004.

[29] P. Marchesi, N. Marchesi, B. Fruth and C. Boesch, ``Census and Distribution of Chimpanzees in Cote d'Ivoire'', *Primates*, vol. 36, n° 4, pp. 591-607, 1995.

[30] J. Refisch and I. Koné, ``Market hunting in the Tai Region, Cote d'Ivoire and implications for monkey populations'', *International Journal of Primatology*, vol. 26, n°3, pp. 621-629, 2005.

[31] S. J. Ryan and P. D. Walsh, ``*Consequences of Non-Intervention for Infectious Disease in African Great Apes'', PLoS One*, vol. 6, n°12, pp. e29030, 2011.

[32] Y. C. Kouakou, C. Boesch and H. Kuehl, ``Identifying hotspots of chimpanzee group activity from transect surveys in Taï National Park, Côte d'Ivoire*'', Journal of Tropical Ecology*, vol. 27, pp. 621–630, 2011.