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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

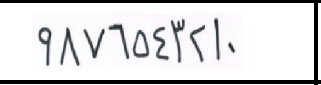
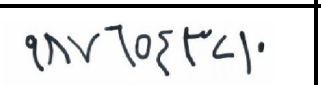
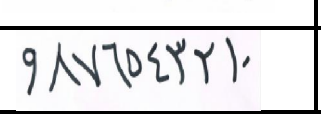
Numbers before thinning	Numbers after thinning
	
	
	

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

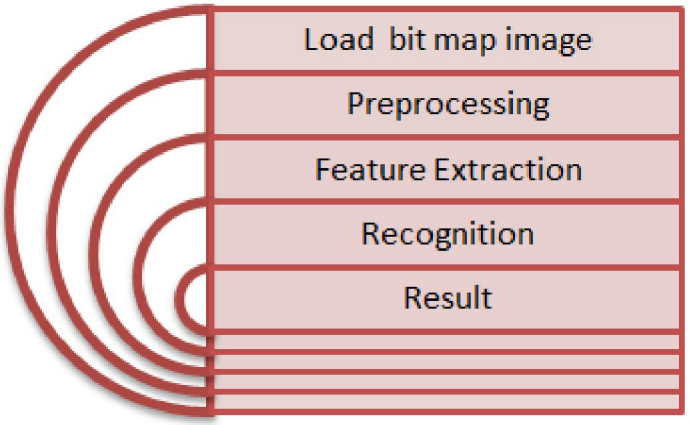


Fig. 1. The main stages of the system

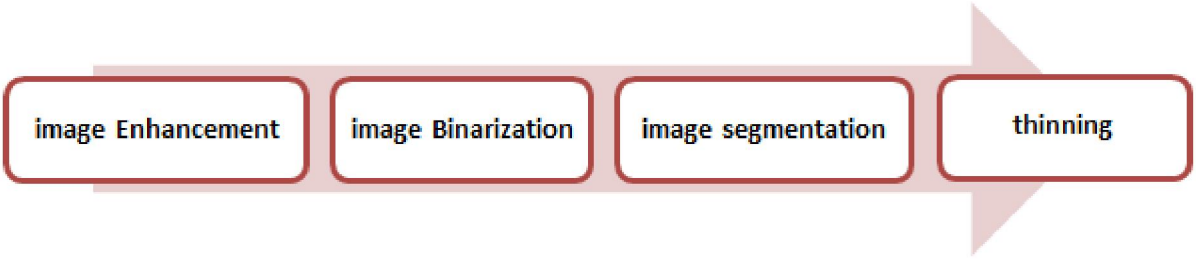


Fig. 2. Preprocessing stage

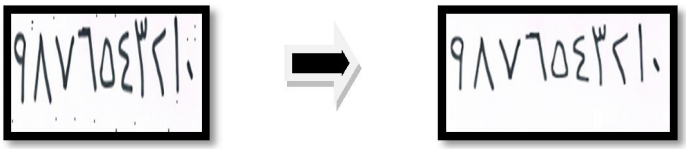


Fig. 3. Image Enhancement Step

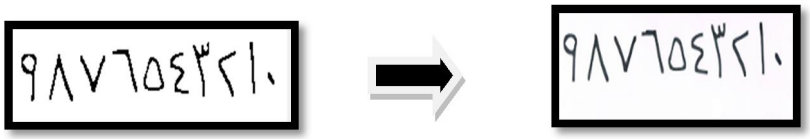


Fig. 4. Binarization Step

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.

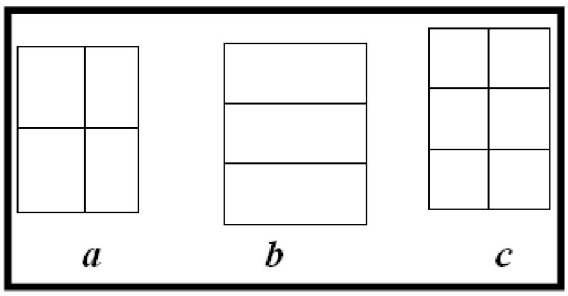


Fig. 7. Image digit division forms

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.

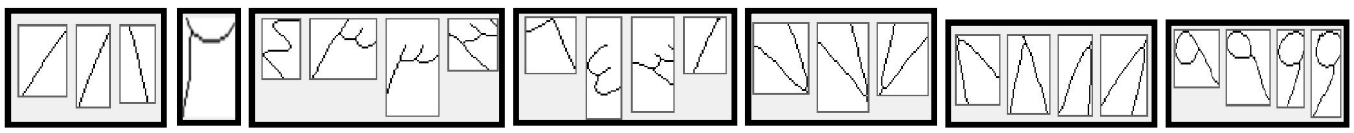


Fig. 8. Recognized handwritten sample with rotation

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.

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