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A PHP program for the spatial and statistical analysis of lineaments in the Denguélé District (North-West of Côte d'Ivoire)

H. Pinatibi[1], T. J. H. Coulibaly[1], M. Soro[2], and G. J. Ouattara[2]

[1]Department of Fundamental and Applied Sciences, mathematics and computer science Laboratory, Nangui Abrogoua University, 01 PO Box 802 Abidjan 01, Côte d'Ivoire

[2]Department of Environmental Sciences and Management, Geosciences and environment Laboratory, Nangui Abrogoua University, 01 PO Box 802 Abidjan 01, Côte d'Ivoire

ABSTRACT: The aim of this study was the writing of PHP language program to analyze lineaments. To achieve this aim, a TXT file containing the start and end coordinates of 1620 lineaments extracted from four Landsat 8 scenes (with references 198_53, 198_53, 198_54, 199_53 and 199_54) was used. Geomorphological parameters such as minimum, maximum and average lengths, as well as the spatial parameters such as the density of lineaments and density of intersections were determined through the three modules of the program which are calculation of directions modules, calculation of lengths modules and calculation of intersections point's modules. The minimum and maximum lengths of lineaments are respectively 3.95 Km and 15.90 Km and belong respectively to NW-SE and NE-SW directions. 43.9% of the lineaments are in the NE-SW direction, 28.6% are in the NW-SE direction, 11.8% in the E-W direction and 15.7% in the N-S direction. The values of the different proportions of the lineament density classes shows that the medium and high density classes represent 36.78% of the Denguélé District.

KEYWORDS: Lineaments, PHP, Program, Denguélé District.

1 INTRODUCTION

Lineaments can be seen as rectilinear or curvilinear geomorphological entities visible in some places on the earth's surface, they are the external manifestation of folds, fractures or underground faults [1]. Lineament mapping is an approach that has been repeatedly addressed by research in fields as wide as important. Among other things, we have the selection of areas suitable to hydro-agricultural developments; urbanization through the construction of bridges, roads, etc.; risk assessment of natural disasters such as earthquakes and landslides [2]; mining prospecting [3]; stratigraphic and geological studies [4] and spatial geomorphology [5]. The link between the strong presence of lineaments and the existence of groundwater resources is very significant because they (lineaments) can be fractures, which are deep cracks on the earth's surface collecting infiltration water to constitute the groundwater reserve [6]. The geomorphological attributes of lineaments such as length, orientation, density, and intersections have generated research interest in recent years, as they can provide valuable information for delineating areas potentially rich in groundwater. The recent development of remote sensing (multispectral images), geospatial technologies (interpolation and GIS software) and calculation algorithms will make it possible to overcome the difficulties of lineament mapping associated with traditional methods (manual methods). According to [6] a program in FORTRAN language was developed in 2003 by [7] in order to characterize the geomorphological properties (lengths and density) of lineaments, [6] developed a program in Visual Basic for the analysis of properties such as lengths, orientations, parallel and perpendicular spacings of the lineaments. All of these programs explained the details of data processing and visualization. However, the data processed by these programs can only be handled outside computer networks, which limits the dissemination of the data thus produced, internet being today an essential tool, it is necessary to develop tools for an internet environment. It is for this purpose that we have implemented this tool using the PHP programming language which allows to implement web applications. This article describes a PHP program that can be used to calculate the geomorphological properties of lineaments (length, orientation, lineament densities and intersections etc.) in web environment.

2 METHODOLOGY

The program was written in PHP language, which is a language used for web applications. It allows thanks to the web page server named Apache and the database server named MySQL to disseminate information on the internet. PHP uses data in formats (.xls,.txt,.PDF etc.) and images in format (PNG, JPG, etc.). The PHP language also uses numeric variables with all the mathematical operators linked to these variables and allows all scientific calculations to be made. This program allows as input, data containing the geographic coordinates of lineaments to calculate geomorphological (length, number, orientations, intersections) and spatial (lineament densities, intersection density etc.) parameters.

2.1 ORIENTATION OF LINEAMENTS

The direction of the lineaments is generally represented using a rose diagram consisting of a trigonometric circle divided into four portions of 90 ° (in other words 360 °) circles, these four portions of circles represent the directions N-S (North-South), E-W (East-West), NE-SW (North-East South-West) and NW-SE (North-West South-East) which are the four tectonic directions taken by the lineaments. These four directions constitute 18 lineament families, the N-S direction groups together the N80°-90 ° / N260°-270 ° and N90°-100° / N270°-280° families (2 families), the E-W direction groups together the N170°-180° / N350°-360° and N0°-10° / N180°-190° families (2 families), the NE-SW direction includes the N10°-20° / N190°-200°; N20°-30° / N200°-210°; N30°-40° / N210°-220°; N40° -50° / N220°-230°; N50°-60° / N230° -240°; N60 ° -70° / N240°-250° and N70°-80° / N250°-260° families (7 families). Finally, the NW-SE direction consists of the N100°-110° / N280°-290°; 110°-120° / N290°-300 °; N120° -130° / N300°-310°; N130° -140° / N310°-320°; N140°-150° / N320°-330°; N150°-160° / N330°-340 ° and N160° -170° / N340°-350 ° families (7 families). Using Geographic Information System (GIS) software, the start and end coordinates of each lineament are extracted to form a coordinate file. Thus, for any pairs of lineament with start (X1, X2) and end (Y1, Y2) coordinates, the equation below used by [6] makes it possible to calculate the direction denoted by ω:

With X1, X2 respectively the longitude and latitude of the beginning and Y1, Y2 respectively the longitude and latitude of the end of the lineament. The implementation of this equation in PHP script (**Algorithm 1**) makes it possible to obtain the direction of all the lineaments of our coordinate file, these lineaments were extracted from the Denguélé district. These directions were calculated in the range 0°- 360 °, which yielded the 18 lineament families described above.

2.2 LINEAMENT LENGTHS

The lengths which have been calculated are the minimum lengths, maximum lengths and average lengths of each lineament family. The length of the lineament can be defined as positive quantity which represents the level of distance between the starting and ending point [6]. For the calculation of the distances we used an empirical formula which makes it possible to calculate the distance between two points on a spherical surface from the geographical coordinates, this formula was used among others by the following authors ([8]; [6]).

$$D = R.c \quad (1)$$

With R, the earth radius, about 6 371 km,

The direction of each lineament is given by ω, this parameter (ω) is expressed in radians in order to be transmitted as a parameter of a trigonometric function. The constant c can be obtained by using the following equations:

With :

ΔY= (Y2-Y1)

ΔX= (X2-X1)

X1, X2 respectively the longitude and latitude of the beginning and Y1, Y2 respectively the longitude and latitude of the end of the lineament. The PHP script used to calculate the distances is in (**Algorithm 2**).

2.3 INTERSECTION OF LINEAMENTS

The determination of the intersection points with coordinates (X, Y) of two lineaments is done using the equations below used

by (Dinesh et al., 2013):

X= x1 + ua (x2-x1)

Y= y1 + ub (y2-x1)

With

- (x1, y1) and (x3, y3): respectively pair of coordinates (longitude, latitude) for the beginning of two crossing lineaments.
- (x2, y2) and (x4, y4): respectively pair of coordinates (longitude, latitude) for the end of two crossing lineaments.
- X, Y: the point of intersection of the two crossing lineaments

The PHP script in (**Algorithm 3**) gives the intersection of lineaments.

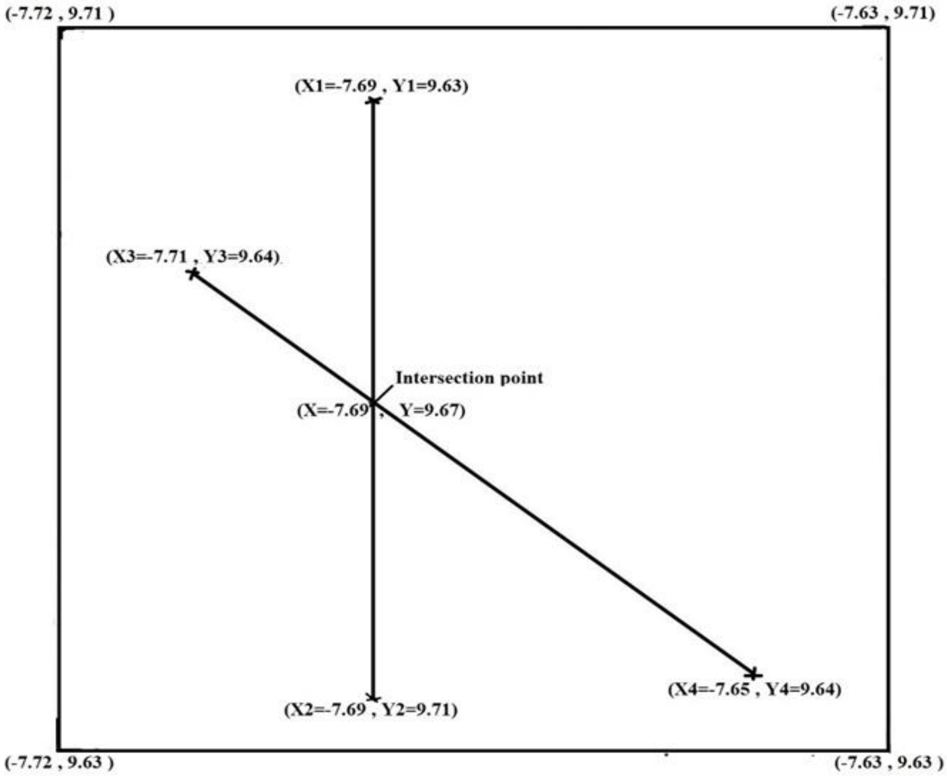


Fig. 1. Example of two crossing lineaments

2.4 SPATIAL MODELING OF LINEAMENTS DENSITY, LINEAMENTS INTERSECTIONS DENSITY AND LINEAMENTS DIRECTIONS

2.4.1 IDW INTERPOLATION METHOD

The special indicators estimated in this study are the lineaments intersections density and lineament density. The intersection points obtained were interpolated by the inverse weighted distance interpolation (IDW) method using the QGIS GIS software 2014, this same method was also used for the production of the lineament density map. The Inverse Weighted Distance Interpolation (IDW) method is one of the most used interpolation method in spatial analysis. This method uses a sample points in the neighborhood of the sought point, this sample is weighted by linear combination in order to obtain the interpolated value ([9]; [10]; [11]).

2.4.2 Rose Diagram

The directional analysis of lineaments is made by a rose diagram, it is one of the most used tools among many others to analyze the different directions taken by a two-dimensional phenomenon ([12], [13], [14]; [15]. These diagrams are circular ones in which the direction of the vector data is presented in an azimuth class defined as 0° to 360°, with a common origin and constant frequency. In the same way as it is for common histograms, there is a relation of proportionality between the area and the frequency of each sector of the rose diagram for a given phenomenon analyzed [16]. Within the framework of our study, the rose diagram used for the representation of the direction of lineaments has a frequency of 10 °.

3 Algorithm And Implementation

Algorithm 1 : Calculation of lineaments direction

Input: $longitude1 , $longitude2, $latitude1, $latitude2

// $longitude1= longitude start ; $longitude2 = longitude end ; $latitude1=latitude start ; $latitude2= latitude end of a lineament.

1. Converting GPS coordinates to radians;

```
$longitude 1=$ Longitude 1*pi () / 180 ;
$latitude 1=$ Longitude 1*pi () / 180 ;
$longitude 2=$ Longitude 2*pi () / 180 ;
$longitude 2=$ Longitude 2*pi () / 180 ;
// NB: teta is the direction of the line in radian
$teta=atan2(sin($longitude2-$longitude1)*cos($latitude2),cos($latitude1)*sin($latitude2)-
sin($latitude1)*cos($latitude2)*cos($longitude2-$longitude1 ) ) ;
```

2. Converting teta to degree

```
$tetaDeg = rad2deg ($teta) ;
if ($tetaDeg < 0)
{
  $tetaDeg = $tetaDeg + 360 ;
 }
```

3. Determination of the 18 lineament families in a function

```
function T_famille ($fid, $longitude1, $latitude1, $longitude2, $latitude2, $tetaDeg)
{
// FAMILLE 1 : 0°-10° / 180°–190°
 if ( ($tetaDeg>0 && $tetaDeg<10) || ($tetaDeg>180 && $tetaDeg<190) ) {
            $f1 = fopen ("familles/f1.txt", 'a+');
fwrite ($f1, $fid.";".$longitude1.";".$latitude1.";".$longitude2.";".$latitude2.";".$tetaDeg."
");
Fclose ($f1);
```

```
// FAMILLE 2 : 10°-20°/190°–200°
 } else if (($tetaDeg>10 && $tetaDeg<20) || ($tetaDeg>190 && $tetaDeg<200)) {
            $f2 = fopen ("familles/f2.txt", 'a+');
fwrite ($f2, $fid.";".$longitude1.";".$latitude1.";".$longitude2.";".$latitude2.";".$tetaDeg."
");
fclose ($f2) ;
// FAMILLE 3 : 20°-30°/200–210°
 } else if (($tetaDeg>20 && $tetaDeg<30) || ($tetaDeg >200 && $tetaDeg < 210)) {
            $f3 = fopen ("familles/f3.txt", 'a+');
fwrite ($f3, $fid.";".$longitude1.";".$latitude1.";".$longitude2.";".$latitude2.";".$tetaDeg."
");
fclose ($f3);
// FAMILLE 4 : 30°-40°/210°–220°
 } else if (($tetaDeg>30 && $tetaDeg<40) || ($tetaDeg>210 && $tetaDeg<220 ) ) {
            $f4 = fopen ("familles/f4.txt", 'a+');
fwrite ($f4, $fid.";".$longitude1.";".$latitude1.";".$longitude2.";".$latitude2.";".$tetaDeg."
");
fclose ($f4);
// FAMILLE 5 : 40°-50°/220°–230°
 } else if (($tetaDeg>40 && $tetaDeg<50) || ($tetaDeg>220 && $tetaDeg<230)) {
            $f5 = fopen ("familles/f5.txt", 'a+');
fwrite ($f5, $fid.";".$longitude1.";".$latitude1.";".$longitude2.";".$latitude2.";".$tetaDeg."
");
fclose($f5);
// FAMILLE 6 : 50°-60°/230°–240°
 } else if (($tetaDeg>50 && $tetaDeg<60) || ($tetaDeg>230 && $tetaDeg<240)) {
            $f6 = fopen ("familles/f6.txt", 'a+');
fwrite ($f6, $fid.";".$longitude1.";".$latitude1.";".$longitude2.";".$latitude2.";".$tetaDeg."
");
fclose ($f6);
 // FAMILLE 7 : 60°-70°/240°–250°
} else if (($tetaDeg>60 && $tetaDeg<70) || ($tetaDeg>240 && $tetaDeg<250)) {
            $f7 = fopen ("familles/f7.txt", 'a+') ;
fwrite ($f7, $fid.";".$longitude1.";".$latitude1.";".$longitude2.";".$latitude2.";".$tetaDeg."
");
fclose ($f7);
```

```
// FAMILLE 8 : 70°-80 / 250°–260°
 } else if (($tetaDeg>70 && $tetaDeg<80) || ($tetaDeg>250 && $tetaDeg<260)) {
            $f8 = fopen ("familles/f8.txt", 'a+');
fwrite ($f8, $fid.";".$longitude1.";".$latitude1.";".$longitude2.";".$latitude2.";".$tetaDeg."
");
fclose ($f8);
// FAMILLE 9 : 80°-90°/260°–270°
 } else if (($tetaDeg>80 && $tetaDeg<90) || ($tetaDeg>260 && $tetaDeg<270 )) {
            $f9 = fopen ("familles/f9.txt", 'a+');
fwrite ($f9, $fid.";".$longitude1.";".$latitude1.";".$longitude2.";".$latitude2.";".$tetaDeg."
");
fclose($f9);
// FAMILLE 10 : 90°-100°/270°–280°
 } else if (($tetaDeg>90 && $tetaDeg<100) || ($tetaDeg>270 && $tetaDeg<280)) {
            $f10= fopen("familles/f10.txt", 'a+');
fwrite ($f10, $fid.";".$longitude1.";".$latitude1.";".$longitude2.";".$latitude2.";".$tetaDeg."
");
fclose ($f10);
// FAMILLE 11 : 100°-110°/280°–290°
 } else if (($tetaDeg>100 && $tetaDeg<110) || ($tetaDeg>280 && $tetaDeg<290)) {
            $f11 = fopen ("familles/f11.txt", 'a+');
fwrite ($f11, $fid.";".$longitude1.";".$latitude1.";".$longitude2.";".$latitude2.";".$tetaDeg."
");
fclose ($f11) ;
// FAMILLE 12 : 110°-120°/290°–300°
 } else if (($tetaDeg>110 && $tetaDeg<120 ) || ($tetaDeg>290 && $tetaDeg<300 ) ) {
            $f12 = fopen("familles/f12.txt", 'a+');
fwrite($f12, $fid.";".$longitude1.";".$latitude1.";".$longitude2.";".$latitude2.";".$tetaDeg."
");
fclose ($f12) ;
// FAMILLE 13 : 120°-130°/300°–310°
 } else if (($tetaDeg>120 && $tetaDeg<130) || ($tetaDeg>300 && $tetaDeg<310)) {
            $f13 = fopen ("familles/f13.txt", 'a+');
fwrite ($f13, $fid.";".$longitude1.";".$latitude1.";".$longitude2.";".$latitude2.";".$tetaDeg."
");
fclose ($f13);
```

```
// FAMILLE 14 : 130°-140°/310°–320°
 } else if (($tetaDeg>130 && $tetaDeg<140) || ($tetaDeg>310 && $tetaDeg<320)) {
            $f14 = fopen ("familles/f14.txt", 'a+');
fwrite ($f14, $fid.";".$longitude1.";".$latitude1.";".$longitude2.";".$latitude2.";".$tetaDeg."
");
fclose ($f14);
// FAMILLE 15 : 140°-150°/320°–330°
 } else if (($tetaDeg>140 && $tetaDeg<150) || ($tetaDeg>320 && $tetaDeg<330)) {
            $f15 = fopen("familles/f15.txt", 'a+');
fwrite($f15, $fid.";".$longitude1.";".$latitude1.";".$longitude2.";".$latitude2.";".$tetaDeg."
");
fclose ($f15) ;
// FAMILLE 16 : 150°-160°/330°–340°
 } else if (($tetaDeg>150 && $tetaDeg<160) || ($tetaDeg>330 && $tetaDeg<340)) {
 $f16 = fopen ("familles/f16.txt", 'a+');
fwrite ($f16, $fid.";".$longitude1.";".$latitude1.";".$longitude2.";".$latitude2.";".$tetaDeg."
");
fclose ($f16);
 // FAMILLE 17 : 160°-170°/340°–350°
} else if (($tetaDeg>160 && $tetaDeg<170) || ($tetaDeg>340 && $tetaDeg<350)) {
 $f17 = fopen ("familles/f17.txt", 'a+');
fwrite ($f17, $fid.";".$longitude1.";".$latitude1.";".$longitude2.";".$latitude2.";".$tetaDeg."
");
fclose ($f17);
// FAMILLE 18 : 170°-180°/350°–360°
 } else if (($tetaDeg>170 && $tetaDeg<180) || ($tetaDeg>350 && $tetaDeg<360)) {
 $f18 = fopen ("familles/f18.txt", 'a+');
fwrite ($f18, $fid.";".$longitude1.";".$latitude1.";".$longitude2.";".$latitude2.";".$tetaDeg."
");
fclose ($f18);
 }
}
Output:  files familles/f1.txt; familles/f2.txt; ….. familles/f18.txt;
```

Algorithm 2 : Intersection of two lineaments

```
// NB: Longitudes and latitudes being already in radians can therefore be used in trigonometric functions
Input:  $longitude1 , $longitude2, $latitude1, $latitude2
```

// $longitude 1= longitude start; $longitude2 = longitude end; $latitude1=latitude start; $latitude2= latitude end of a lineament.

1. Step1

```
$longitude3 = $T_Lineament[$j][0] ;
$latitude3 = $T_Lineament[$j][1] ;
$longitude4 = $T_Lineament[$j][2] ;
$latitude4 = $T_Lineament[$j][3] ;
$denominateur=(($latitude4-$latitude3)*($longitude2-$longitude1)-($longitude4-$longitude3)*($latitude2-$latitude1)) ;
if ($denominateur != 0)
        {
 $ua= (($longitude4-$longitude3)*($latitude1-$latitude3)-($latitude4-$latitude3)*($longitude1 -$longitude3))/(($latitude4-$latitude3)*($longitude2-$longitude1)-($longitude4-$longitude3)*($latitude2-$latitude1)) ;
$ub=(($longitude2 - $longitude1)*($latitude1-$latitude3)-($latitude2-$latitude1)*($longitude1 -$longitude3))/(($latitude4-$latitude3)*($longitude2-$longitude1)-($longitude4-$longitude3)*($latitude2-$latitude1) ) ;
          $InterX= $longitude1 +  $ua*($longitude2-$longitude1) ;
          $InterY= $latitude1 + $ub*($latitude2-$latitude1) ;
          }
       else {
           $InterX = "PARALELLES";
           $InterY = "PARALELLES";
          }
```

Output: $InterX= (longitude) and $InterY=(latitude) of the intersection point.

Algorithm 3 : Calculation of lineament length

Input: $longitude1 , $longitude2, $latitude1, $latitude2

// $longitude 1= longitude start; $longitude2 = longitude end; $latitude1=latitude start ; $latitude2= latitude end of a lineament.

1. Step1

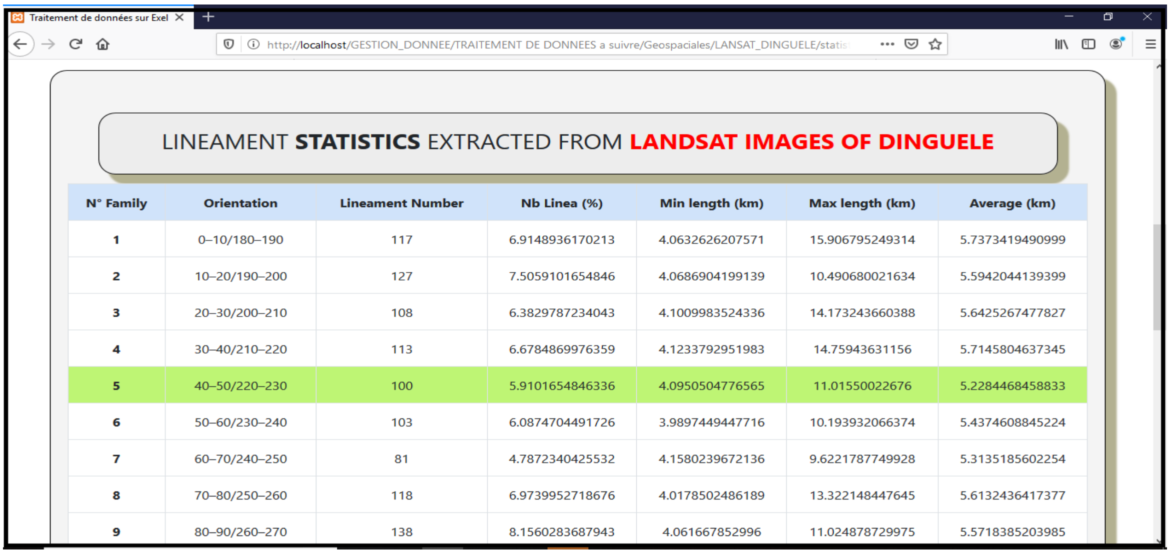
```
$R = 6371; // En Km
// Longitudes and latitudes being already in radians can therefore be used in trigonometric functions
$ΔLatitude = $latitude2 - $latitude1 ;
$ΔLongitude = $longitude2 - $longitude1;
$a = sin (($latitude2 - $latitude1)/2)*sin (($latitude2 - $latitude1)/2) + cos ($longitude1)*cos ($longitude2)*sin (($longitude2 - $longitude1)/2)*sin (($longitude2 - $longitude1)/2);
// $c = 2*atan2 (sqrt ($a), sqrt (1-$a));
$c = 2*atan2 (sqrt ($a), sqrt (1-$a));
$LaDistance = $R*$c ;
```

Output: $LaDistance= the length of a lineament

4 RESULTS

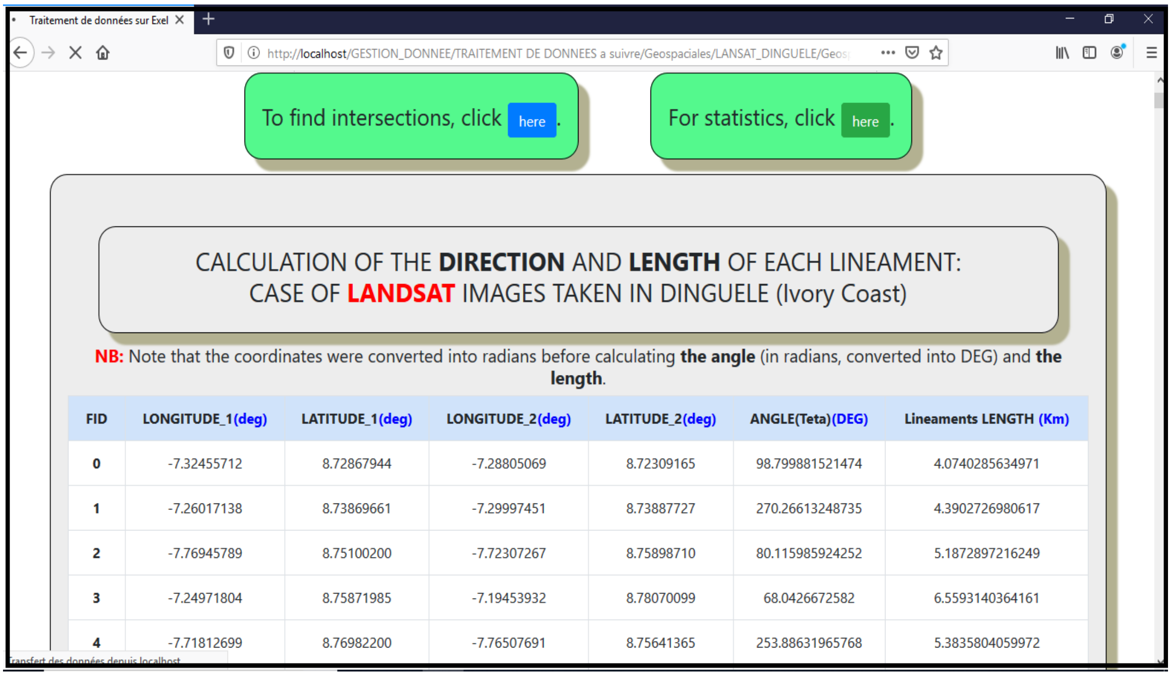
4.1 PROGRAM OVERVIEW

The program has three modules which are: Calculation of directions module, Calculation of lengths module and Calculation of intersection points module. To begin, you have to load the TXT extension file containing the identifier (FID), the latitude and longitude of a given lineament in the data folder (Figure 2). Once the data file has been loaded, you have run one of the modules (Calculation of directions or Calculation of lengths or calculation of intersection points) mentioned above to obtain the desired result. The Calculation of directions module provides as a result a table containing the inclination angles of the different lineaments according to the N-S, E-W, NE-SW and NW-SE directions, the 18 families of lineaments, the number of lineaments per family and the percentage of lineaments represented by each family (Figure 3). The Calculation of lengths module allows you to calculate the minimum and maximum lengths of lineaments in each family and finally the calculation of intersection points module allows you to determine the points of intersection of lineaments contained in the data file.



N° Family	Orientation	Lineament Number	Nb Linea (%)	Min length (km)	Max length (km)	Average (km)
1	0–10/180–190	117	6.9148936170213	4.0632626207571	15.906795249314	5.7373419490999
2	10–20/190–200	127	7.5059101654846	4.0686904199139	10.490680021634	5.5942044139399
3	20–30/200–210	108	6.3829787234043	4.1009983524336	14.173243660388	5.6425267477827
4	30–40/210–220	113	6.6784869976359	4.1233792951983	14.75943631156	5.7145804637345
5	40–50/220–230	100	5.9101654846336	4.0950504776565	11.01550022676	5.2284468458833
6	50–60/230–240	103	6.0874704491726	3.9897449447716	10.193932066374	5.4374608845224
7	60–70/240–250	81	4.7872340425532	4.1580239672136	9.6221787749928	5.3135185602254
8	70–80/250–260	118	6.9739952718676	4.0178502486189	13.322148447645	5.6132436417377
9	80–90/260–270	138	8.1560283687943	4.061667852996	11.024878729975	5.5718385203985

Fig. 2. Interface for calculating lineament directions and lengths



FID	LONGITUDE_1(deg)	LATITUDE_1(deg)	LONGITUDE_2(deg)	LATITUDE_2(deg)	ANGLE(Teta)(DEG)	Lineaments LENGTH (Km)
0	-7.32455712	8.72867944	-7.28805069	8.72309165	98.799881521474	4.0740285634971
1	-7.26017138	8.73869661	-7.29997451	8.73887727	270.26613248735	4.3902726980617
2	-7.76945789	8.75100200	-7.72307267	8.75898710	80.115985924252	5.1872897216249
3	-7.24971804	8.75871985	-7.19453932	8.78070099	68.0426672582	6.5593140364161
4	-7.71812699	8.76982200	-7.76507691	8.75641365	253.88631965768	5.3835804059972

Fig. 3. Statistical analysis interface on lineaments provided by the Calculation of directions and Calculation of lengths modules

4.1.1 APPLICATION OF THE PROGRAM

For the application of our program we used lineament data from the Denguélé District in the north-west of Côte d'Ivoire. These lineaments were extracted from four Landsat 8 scenes with references 198_53, 198_53, 198_54, 199_53, 199_54 dating from 2013. These lineaments were extracted using PCI Geomatica 16 software (Figure 4). The total number of lineaments extracted is 1620. The application of the direction module of our program to our data contained in a text format file made it possible to determine the geomorphological properties of the lineaments. The minimum and maximum lengths are respectively 3.95 Km and 15.90 Km and belong respectively to the lineaments of orientation 120°-130° and 300°-310° representing the NW-SE direction; 10°-20° and 190°-200° orientation representing the NE-SW direction. The orientations of the extracted lineaments are presented as follows: 43.9% in the NE-SW direction, 28.6% in the NW-SE direction, 11.8% in the E-W direction, and finally 15.7% in the N-S direction (Table I).

Table 1. Result of the statistical analysis on lineaments provided by the Calculation of directions and Calculation of lengths modules

Family No.	Orientation (°)	Linear Number	%	Min length (km)	Maxi length (km)	Average Length (km)
1	0°-10°/180°-190°	117	6.91	4.06	15.90	5.73
2	10°-20°/190°-200°	127	7.51	4.06	10.49	5.59
3	20°-30°/200°-210°	108	6.38	4.10	14.17	5.64
4	30°-40°/210°-220°	113	6.68	4.12	14.75	5.71
5	40°-50°/220°-230°	100	5.91	4.09	11.01	5.22
6	50°-60°/230°-240°	103	6.09	3.98	10.19	5.43
7	60°-70°/240°-250°	81	4.79	4.15	9.62	5.31
8	70°-80°/250°-260°	118	6.97	4.01	13.32	5.61
9	80°-90°/260°-270°	138	8.16	4.06	11.02	5.57
10	90°-100°/270°-280°	119	7.03	4.01	14.15	5.51
11	100°-110°/280°-290°	95	5.61	4.15	8.90	5.17
12	110°-120°/290°-300°	74	4.37	3.95	12.10	5.32
13	120°-130°/300°-310°	84	4.96	4.06	9.64	5.44
14	130°-140°/310°-320°	84	4.96	4.14	11.03	5.33
15	140°-150°/320°-330°	44	2.60	4.16	9.26	5.29
16	150°-160°/330°-340°	47	2.77	4.07	10.08	5.23
17	160°-170°/340°-350°	62	3.6	4.12	12.17	5.50
18	170°-180°/350°-360°	78	4.61	4.06	12.85	5.62

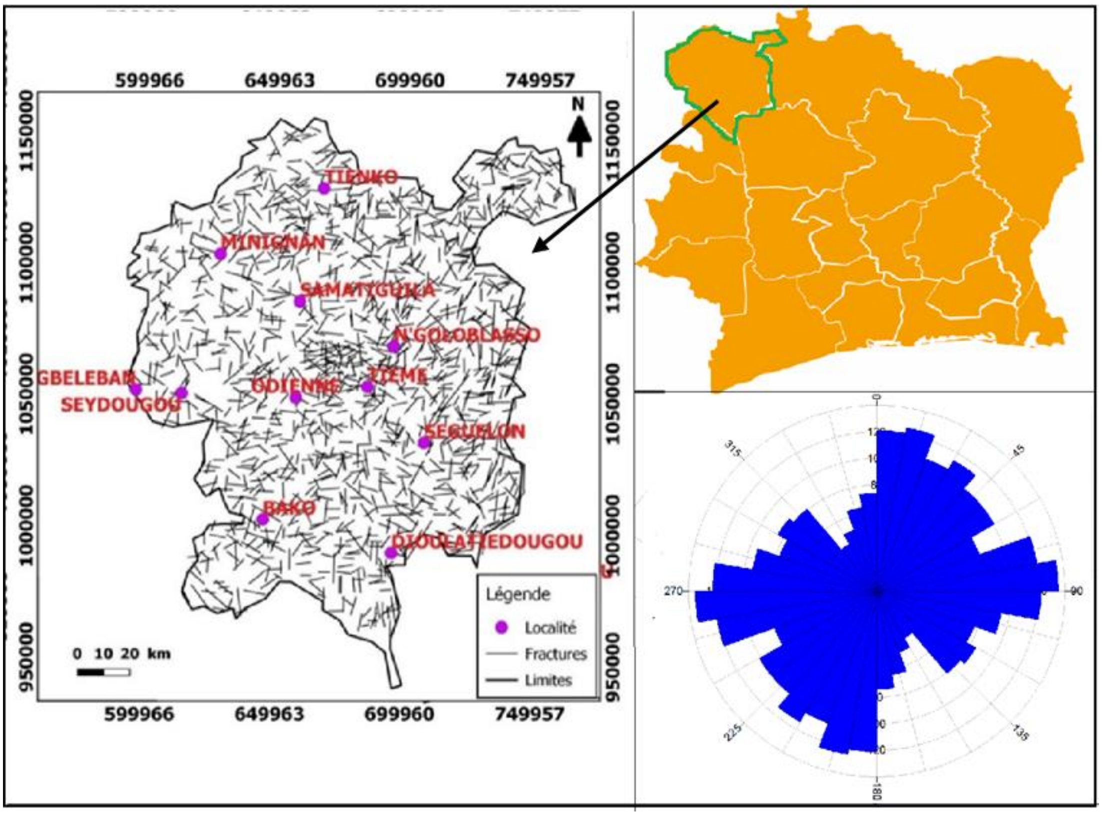
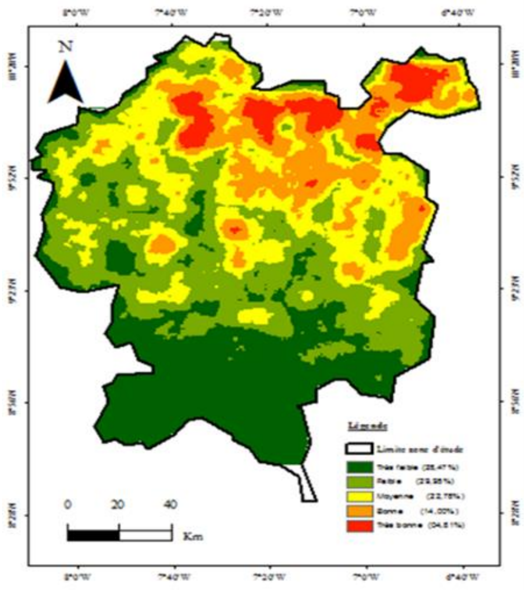


Fig. 4. Lineaments and directions of lineaments extracted on the Denguélé district

4.1.2 DENSITY OF LINEAMENTS AND INTERSECTION

The spatial distribution map of lineaments density (Figure 5), shows a spatial variation of this parameter. The lineaments density map shows a distribution of lineaments over the entire territory of the Denguélé District. Indeed, the view of the different proportions of the density classes shows that the medium and high density classes represent 36.78% of the Denguélé District. It should be noted that these two classes are mainly visible to the northeast of the district, which is characterized by the presence of several geomorphological accidents including the n'goloblasso fault. The low density class represents 28.83% of the area of the study area, this class is found in the north of the district. Finally, the areas of very high lineament densities only constitute traces, 4.81% of the district. The lineament intersection density maps (Figure 6) show a weak lineament intersection over 71% of the territory of the district.



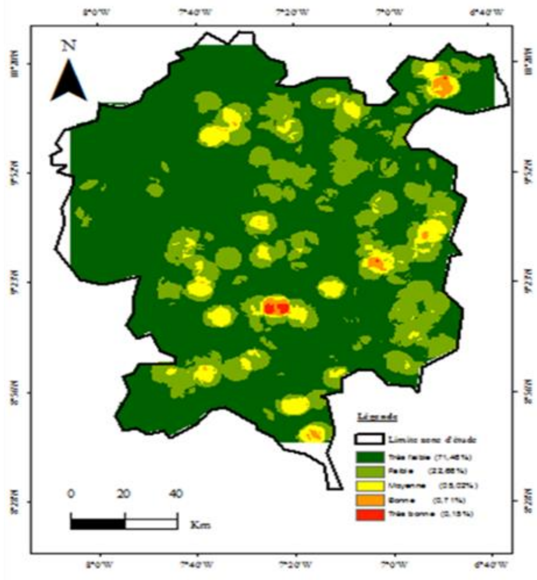


Fig. 5. Lineament density map Figure 6: Lineament intersection density map

5 Conclusions

The contribution to the optimum management of lineaments on a given territory led to the writing of a computer program in PHP language and validated with lineament data from the Denguélé District. This tool makes it possible to efficiently calculate the geomorphological parameters of lineaments, namely orientation, length, density and intersection density, using data files in.txt format. The parameters thus determined (density and intersection density) can be imported into GIS software for the production of thematic spatial analysis maps.

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