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EXTRACTION OF INFORMATION FROM RASTER IMAGE: A MATHEMATICAL MORPHOLOGICAL APPROACH

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ABSTRACT

The extraction of specific information from raster image and creating a vector database are primary inputs in GIS modeling. One of the methods of extraction of this information from a raster map is accomplished by digitizing the required theme manually using digitizer, but the accuracy of such a data depends on the digitizing person and precision with which the above technique is executed. The parallax error is one of the inevitable problems in digitization, as the eye position of the person changes from time to time. The aim of this paper is to overcome the above problem by converting the entire map as a Binary Image by scanning and extracting only the required information using Mathematical Morphological methods.

Key Words: Dilation, Erosion, Open, Close, Mathematical Morphology, Binary Image.

INTRODCTION

In image enhancement, the main function of a filter is to eliminate noise in order to preserve the geometric features of our interest. The requirement in developing an algorithm to preserve the geometric features of interest, while filtering or suppressing the noise without blurring the resultant image can be achieved by suitably choosing a prior geometric information (structuring element) and transforming the information through the mathematical morphological operators.

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The mathematical morphological operators are based upon set theoretic concepts [7] and an image is defined as a subset of the two dimensional Euclidean Space RxR. The two fundamental operations in mathematical morphology are Minkowski Addition (A $\oplus$ B) and Minkowski Subtraction (A Θ B) and they are defined set theoretically as,

$$A \oplus B = \bigcup_{b \in B} A + b \qquad \ldots(1)$$

$$A \,\Theta\, B = \bigcap_{b \in B} A + b \qquad \ldots(2)$$

where A and B are two sets and A + b is the translate of A by b. These were discussed by Serra, Doughetry and Giardina, Harallic, Sternberg and Zhuang, Jianning Xu, Ronse et.al, Jisheng Song and Edward J. Delp.

In order to use the morphological operators more effectively, combination of fundamental morphological operations with multi structuring elements has been attempted in this paper. For this exercise a binary image of 512x512 was selected by scanning the topographic map. Such an image is called a raster image. A raster data is a grid data comprising of pixels and scan lines (column and row) without any attributes in case of binary. But in the case of satellite imagery showing the points of different radiance in terms of gray level qualify further for separating the needed information using mathematical morphological operators. To create a spatial database as an input to the Geographical Information System (GIS), an experiment has been attempted by taking an image of size 140(L)x215(P) and extracting only desired features of interest by running morphological operators. This will enable further processing in a short time to set various attributes like relative position of the needed feature, their width and length in case of lines (linear features), and the area if it is a polygon. Using the above technique, it is possible to create a database on the spatial data with more parameters like density, brightness (gray levels) etc. in the form of vector database.

MORPHOLOGICAL OPERATORS

Given an image $A \subset$ ZxZ (where Z is set of all integers) and a point x $\in$ ZxZ, the translation of A by x is defined as

$$A + x = \{ a + x : a \in A \} \qquad \ldots(3)$$

Given two images A and B in RxR , the Minkowski addition A $\oplus$ B is defined set theoretically as in equation (1). A $\oplus$ B is constructed by translating A by each element of B and then taking the union of resultant translates.

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Digitally Minkowski Addition is defined as

$$A \oplus B = \bigcup_{(i,j) \in D_B} TRAN(A;i,j) \qquad \ldots(4)$$

where D_B denotes the domain of B, TRAN(A;i,j) is the translate of A by (i,j).

The morphological operation Dilation of A by B is defined as

$$DILATE(A,B) = A \oplus B \qquad \ldots(5)$$

Dilation has the effect of expanding an image.

Given two images A and B in RxR, Minkowski subtraction is defined set theoretically as in equation (2). In this operation A is translated by every element of B and then intersection of the resultants is taken. Digitally, this operation is defined as

$$A \, \Theta \, B = \bigcap_{(i,j) \in D_B} TRAN(A;i,j) \qquad \ldots(6)$$

where D_B denotes the domain of B, TRAN(A;i,j) is the translate of A by (i,j).

The morphological operation Erosion of A by B is defined as

$$ERODE(A,B) = A \, \Theta \, (-B) \qquad \ldots(7)$$

where -B is 180^{o} rotation of B with respect to origin in anti-clock wise direction. If B = -B, the erosion is simply Minkowski subtraction. Eroding an image by a structuring element B has the effect of shrinking the image in a manner determined by B.

Eroding an image A with the structuring element B will give the locus of centers of B_x (translate of B to x) included in the set A. Since erosion shrinks the object, this necessarily enlarges the background A^C [Serra, 1982]. This operation is dilation. i.e. eroding the object is dilating the background. These two operations are said to be dual to each other.
The two other macro operations used in the morphological processing are

$$OPEN(A,B) = DIALTE(ERODE(A,B)) \qquad \ldots(8)$$

$$CLOSE(A,B) = ERODE(DILATE(A,B)) \qquad \ldots(9)$$

METHODOLOGY AND RESULTS

To achieve the desired result, a binary image with only two features was selected for simplicity. As for the discussion the two features chosen are continuous curvilinear and

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dissected curvilinear features. The algorithm applied to separate the continuous line from the master image [fig.1] is by opening the master image with the chosen structuring element. It is evident that the continuous lines of different directional orientation and necessary directional filtering is applied iteratively in all directions and then their union is taken. The first step gives the result as in fig.2. It can be noticed that some of the undesired noise is not effectively removed. The small structuring element cannot remove all the noise[6]. The problem has been overcome by choosing second structuring element and repeating the above said operations. The figures 3 and 4 are the results of intermediate directional filtering. The union of figures 3 and 4 is shown in fig 5. A recursive operation of choosing the structuring element from the fig. 5 has provided the fig. 6, which is devoid of all other features except the continuous curvilinear feature, intended with a positional accuracy of 100% ad transformational accuracy of 90%. The resultant image [fig. 6] of the former operation was subtracted from the master image [fig. 1]. This retained discontinuous lines in the fig. 7. Similar operations can be applied to any number of features of distinct characteristics. The above process will enable us to separate any geometric feature from a binary image.

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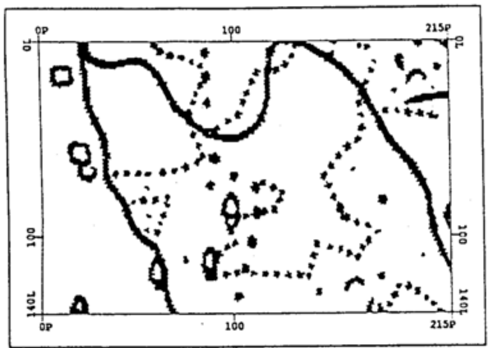
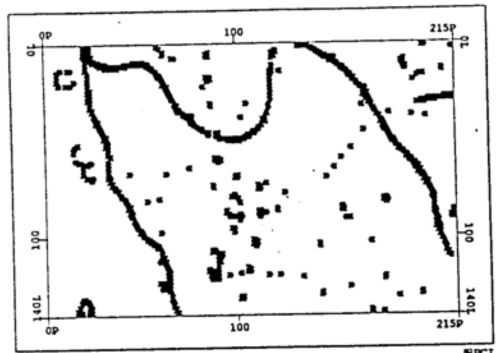


FIGURE 1



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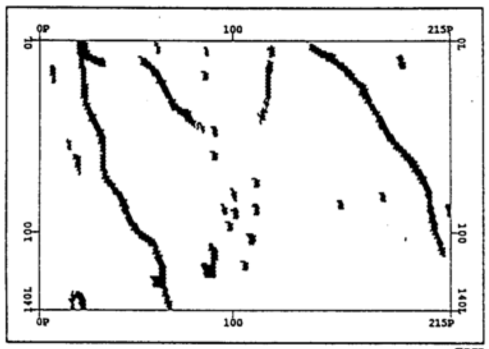

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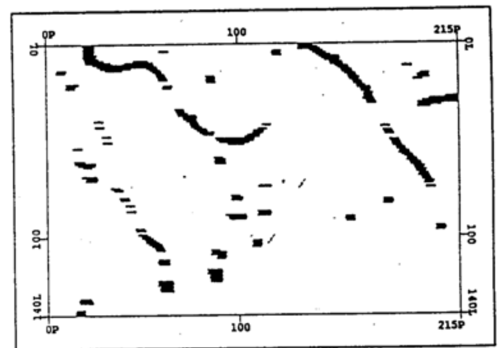

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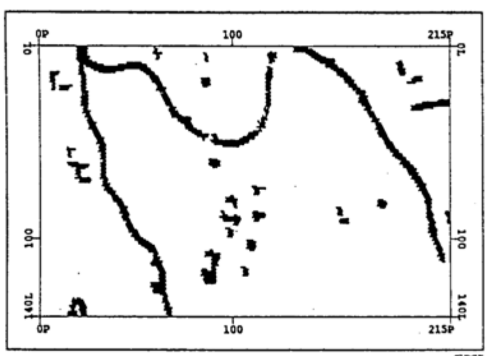

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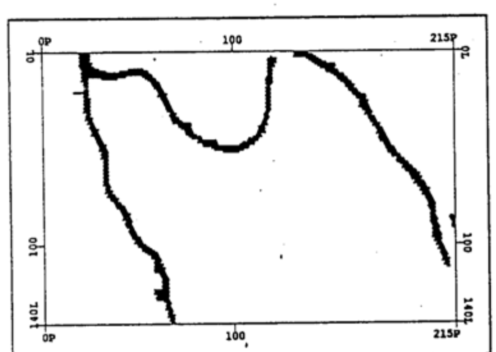

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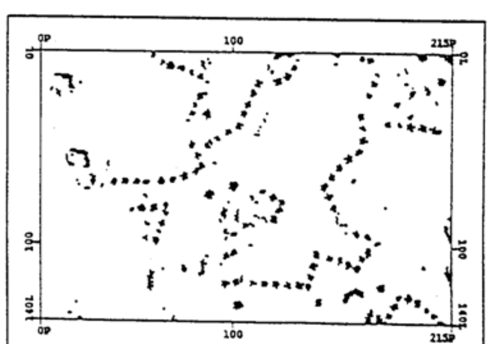
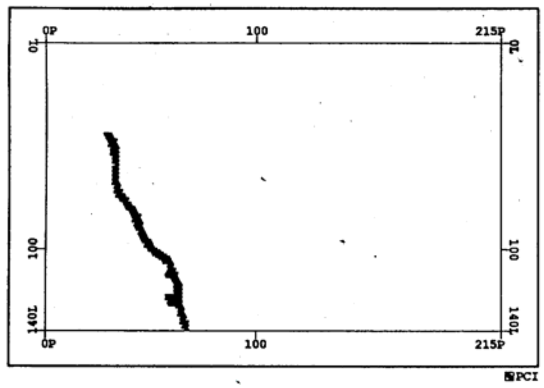


FIGURE 7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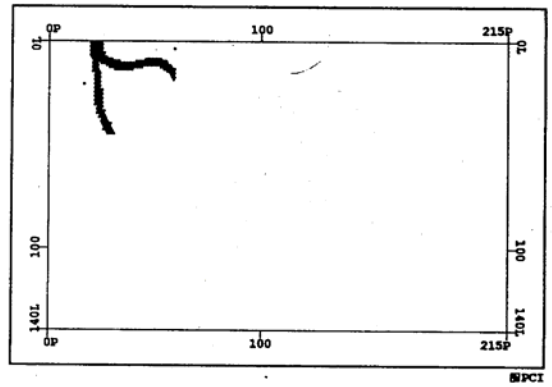
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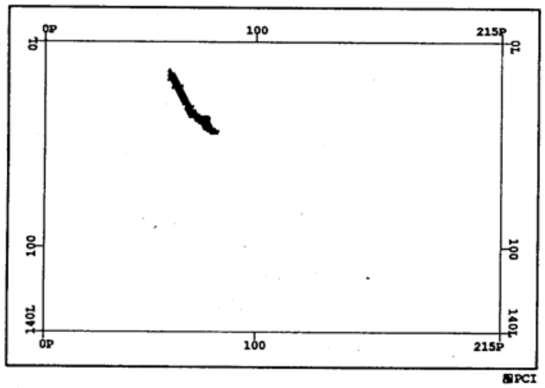
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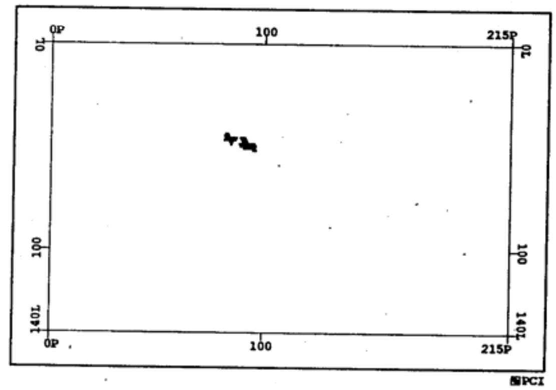
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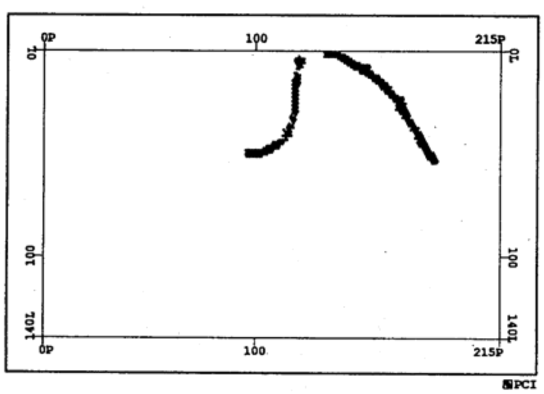
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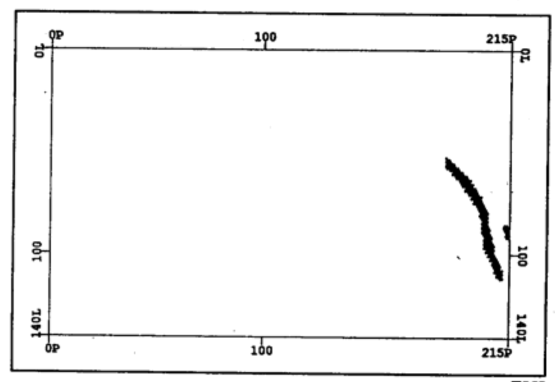
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