Land Boundary Detection of an Island using improved Morphological Operation

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Abstract

Image analysis is one of the important tasks to obtain the information about earth surface. To detect and mark a particular land area, it is required to have the image from remote place. To recognize the same, the accurate boundary of that area has to be detected. In this paper, the example of remote sensing image has been considered. The accurate detection of the boundary is a complex task. A novel method has been proposed in this paper to detect the boundary of such land. Mathematical morphology is a simple and efficient method for this type of task. The morphological analysis is performed using structure elements (SE). By using mathematical morphology the images can be enhanced and then the boundary can be detected easily. Simultaneously the noise is removed by using the proposed model. The results exhibit the performance of the proposed method.

Keywords: *Remote Sensing images ; Edge detection; Gray- scale Morphological analysis, Structuring Element (SE).*

1. INTRODUCTION

Remote sensing includes the choice of sensors, the reception, and processing of signal data. It is important aspect to study about the image boundary for further processing like detection, classification, and segmentation etc. of the interested images. Mathematical Morphology is the process to analyze image and that derives from set theory. It is based on shape of the image. Morphological analysis is used with the structure element (SE) that has certain structures and features for measuring and processing image. Small-scale structure element is sensitive to edge signals but also prone to noise, whereas large-scale structure element is robust to noise but could filter out fine details. In this paper, a novel mathematical morphology edge detection algorithm is proposed to detect edges in remote sensing images that detects the edges as well as removes the noise better than the traditional methods for edge detection.

The paper is organized as follows. Section-II reviews the previous work; section-III describes some operators for boundary detection. Section-IV follows the proposed method and the result follows it in section-V. In the last section-VI, concludes the work.

2. REVIEW OF LITERATURE

Reconstruction is a very useful operator provided by mathematical morphology. The reconstruction transformation is relatively well-known in the binary case, where it simply extracts the connected components of an image which are “marked" by another image. In [1], the paper has three major goals: the first one is to provide a formal definition of grayscale reconstruction in the discrete case. In fact, they proposed two equivalent definitions:

The first one is based on the threshold superposition principle and the second one relies on grayscale geodesic dilations. The second part of the paper illustrates the use of binary and especially grayscale reconstruction in image analysis applications: examples proving the interest of grayscale reconstruction for such tasks as image filtering, extrema, domes and basins extraction in grayscale images, “top-hat" by reconstruction, binary and grayscale segmentation, etc., is discussed.

Most of the information about the image can be obtained from the boundary. The function of boundary detection is to identify the edges of homogeneous regions in an image based on properties such as intensity and texture. A lot of work has been done in this field. Several algorithms have been developed based on computation of the intensity gradient vector, which, in general, is sensitive to noise in the image. In order to suppress the noise, some spatial averaging may be combined with differentiation such as the Laplacian of Gaussian operator and the detection of zero crossing. Traditional edge detection like gradient operator, Robert operator, the Sobel operator, the Prewitt operator are the evaluation of derivatives of the image intensity. In [2], Raman Maini and J. S. Sobel evaluated the performance of the Prewitt edge detector for noisy image and demonstrated that the Prewitt edge detector works quite well for digital image corrupted with Poisson noise whereas its performance decreases sharply for other kind of noise. Davis, L. S. in [3], has suggested Gaussian pre-convolution for this purpose. However, all the Gaussian and Gaussian-like smoothing filters, while smoothing out the noise, also remove genuine high frequency edge features, degrade localization and degrade the detection of low contrast edges. The classical operators emphasize the high frequency components in the image and therefore act poorly in cases of moderate low SNR and/or low spatial resolution of the imaging device. Shin, M.C et al. in [4] presented an evaluation of edge detector performance using a structure from motion task. They found that the Canny detector had the best test performance and the best robustness in convergence and is one of the faster executing detectors. Rital, S. et al. in [5] proposed a new algorithm of edge detection based on properties of hyper graph theory and showed this algorithm is accurate, robust on both synthetic and real image corrupted by noise. Li Dong Zhang and Du Yan Bi in [6] presented an edge detection algorithm that the gradient image is segmented in two orthogonal orientations and local maxima are derived from the section curves. They showed that their algorithm can improve the edge resolution and insensitivity to noise. Fesharaki, M.N.and Hellestrand, G.R [7] presented a new edge detection algorithm based on a statistical approach using the student t-test. They selected a 5x5 window and partitioned into eight different orientations in order to detect edges. One of the partitioning matched with the direction of the edge in the image shows the highest values for the defined statistic in that algorithm. They show that this method suppresses noise significantly with preserving edges without a prior knowledge about the power of noise in the image. Canny [8] derived analytically optimal step edge operators and showed that the first derivative of Gaussian filter is a good approximation of such operators. An alternative to gradient techniques is based on statistical approaches. The idea is to examine the distribution of intensity values in the neighborhood of a given pixel and determine if the pixel is to be classified as an edge. In comparison with the differential approaches, less attention has been paid to statistical approaches. In [9], the authors have used PERCLOS algorithm in order to detect boundary of the objects in the image. In [10], the method of morphology has been applied for biomedical images. As per the authors it was shown an excellent performance.

3. STANDARD METHODS FOR BOUNDARY DETECTION

An operator for boundary detection is determined as the neighborhood operation that determines the extent to which each pixel's neighborhood can be partitioned by a simple arc passing through the pixel where pixels in the neighborhood on one side of the arc have one predominant value and pixels in the neighborhood on the other side of the arc have a different predominant value. Usually gradient operators, Laplacian operators, zero-crossing operators are used for edge detection. Mathematical morphology is developed from set theory. It was introduced by Matheron [11] as a technique for analyzing geometric structure of metallic and geologic samples. It was extended to image analysis by Serra [12]. As it is based on set theory, its operation is defined by set arithmetic and is to be represented by the set.

Some of the techniques for edge detection are mentioned below and are the traditional operators:
1. Sobel operator
2. Canny edge detection
3. Prewitt operator
4. Laplacian of Gaussian
5. Roberts edge detection

Sobel operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical and is therefore relatively inexpensive in terms of computations. Canny uses a multistage algorithm to detect a wide range of edges in images. Prewitt operator masks are the one of the oldest and best understood methods of detecting edges in images. Multiple masks are used in this method. One for detecting image derivatives in X and another is for detecting image derivative in Y. To find edges, a user convolves an image with both masks, producing two derivative images (dx and dy). The strength of the edge at given location is then the square root of the sum of the squares of these two derivatives. Roberts method is used frequently for hardware implementations for simplicity and speed are dominant factors [13, 14].

4. PROPOSED METHOD

The remote sensing image of island is collected from [15]. In this method, the image is represented using structuring element (SE). SE is characteristic of certain structure and feature, to measure the shape of image and then carry out the processing steps. The aim of this transformation is to search the special set structure of original set. The transformed set includes the information of the special set structure and the transformation is realized by special structuring element. Therefore, the result is correlative to some characteristics of structuring element.

The basic mathematical morphological operators are dilation and erosion and the other morphological operations are the synthesization of the two basic operations.

Let $A(x, y)$ denote a grey-scale two dimensional image, $B(s, t)$ denote structuring element.

Proposed Algorithm:

The following steps are stated for the algorithm of the proposed method:
1. Acquire the image [15].
2. Convert the image into grayscale image.
   The process of conversion to grayscale image is performed as

Grayscale image matrix $A(x, y)$

$$= \text{Red component}*0.3+ \text{Green component}*0.59+ \text{Blue component}*0.11 \quad (1)$$

3. Create the suitable structuring elements (SE). The shape of all structuring elements may be line based flat, linear or both.

Different structuring elements were selected for the erosion and dilation operations. In order to have a basic link between both the operations a difference angle= 90^0 between the dilation angle and the erosion angle is considered. A division angle of *n* has been considered which is used for generating the number of images i.e. $(180^0/n)$ which is to be used for the quantitative analysis.

4. Erode the image. Erosion of image *A* (*x, y*) by a grey-scale structuring element *B* (*s, t*) can be performed by

$$A \ominus B = min_{[i,j]\forall B}\{\mathrm{a[m-j,n-k]+b[j,k]}\} \tag{2}$$

5. Dilate the image. Dilation of a grey-scale image *A (x, y)* by a grey-scale structuring element *B (s, t)* can be performed by

$$A \oplus B = max_{[i,j]\forall B}\{\mathrm{a[m-j,n-k]+b[j,k]}\} \tag{3}$$

6. Find the edges using morphological operator for different structuring elements.

$$Edge(A) = (A \oplus B) - (A \ominus B) \tag{4}$$

7. Then MSE and PSNR were evaluated for different structuring elements as

$$MSE = \sum_{i=1}^{m} \sum_{j=1}^{n} (f1(i,j) - f2(i,j))^2 \tag{5}$$

where *f1* is output image and *f2* is input image.

$$PSNR = 10log(255^2/\mathrm{MSE}) \tag{6}$$

Opening and closing of grey-scale image *A (x, y)* by grey-scale structuring element *B (s, t)* are denoted respectively by

$$A \circ B = (A \ominus B) \oplus B \tag{7}$$

$$A \cdot B = (A \oplus B) \ominus B \tag{8}$$

Erosion is a transformation of shrinking, which decreases the grey-scale value of the image, while dilation is a transformation of expanding, which increases the grey-scale value of the image. But both of them are sensitive to the image edge whose grey-scale value changes obviously. Erosion filters the inner image while dilation filters the outer image. Opening is erosion followed by dilation and closing is dilation followed by erosion. Opening generally smoothes the contour of an image, breaks narrow gaps. As opposed to opening, closing tends to fuse narrow breaks, eliminates small holes, and fills gaps in the contours. Therefore, morphological operation is used to detect image boundary, and at the same time, noise can be eliminated from the image.

5. RESULTS

FIGURE 1: Original Image

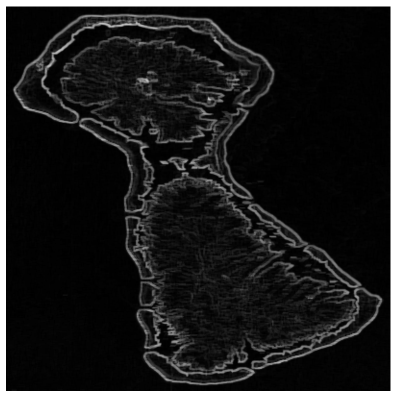

FIGURE.2: Result with 180^0 dilation angle & 90^0 erosion angle based structuring elements

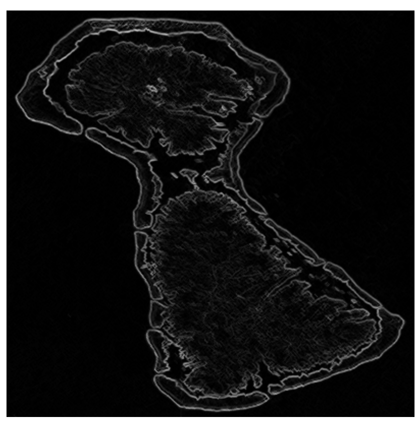

FIGURE3: Result with 135^0 dilation angle & 45^0 erosion angle based structuring elements

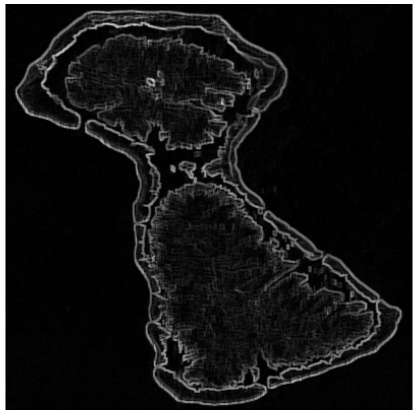

FIGURE 4: Result with 90^0 dilation angle & 0^0 erosion angle based structuring elements

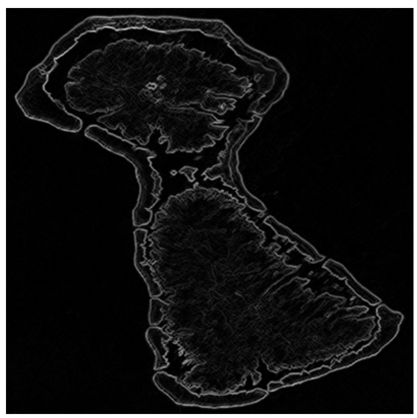

FIGURE 5: Result with 45^0 dilation angle & -45^0 erosion angle based structuring elements

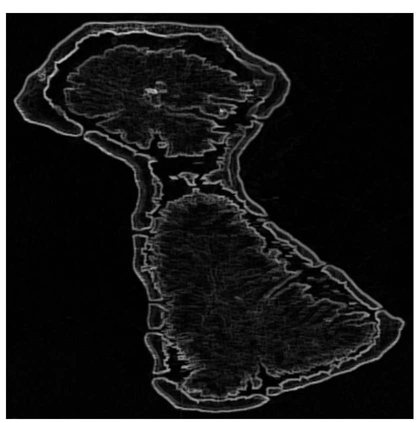

FIGURE 6: Result with 0^0 dilation angle & -90^0 erosion angle based structuring elements

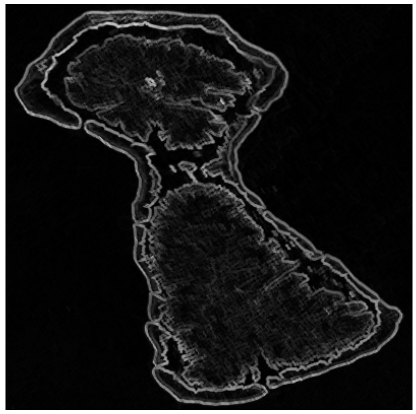

FIGURE 7: Result with 120^0 dilation angle & 30^0 erosion angle based structuring elements

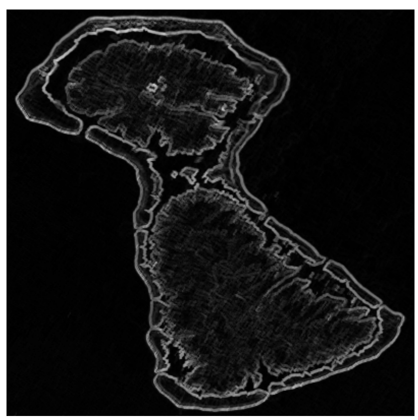

FIGURE 8: Result with 60^0 dilation angle & -30^0 erosion angle based structuring elements

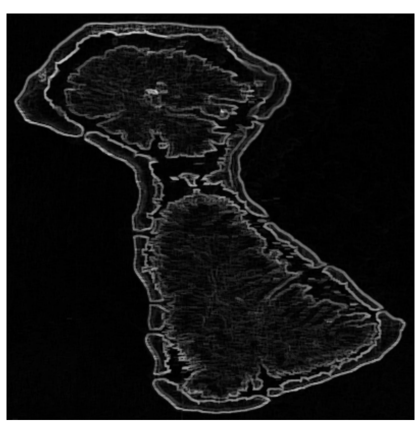

FIGURE 9: Result with 0^0 dilation angle & -90^0 erosion angle based structuring elements

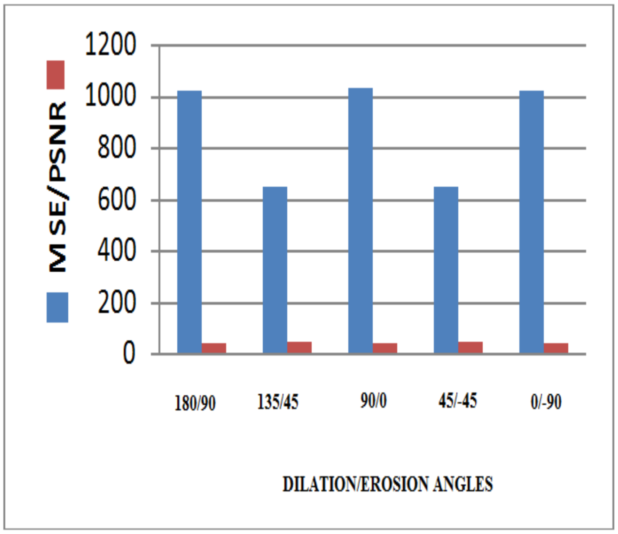

FIGURE 10: PSNR and MSE analysis for 45^0 division angle and 90^0 difference angle.

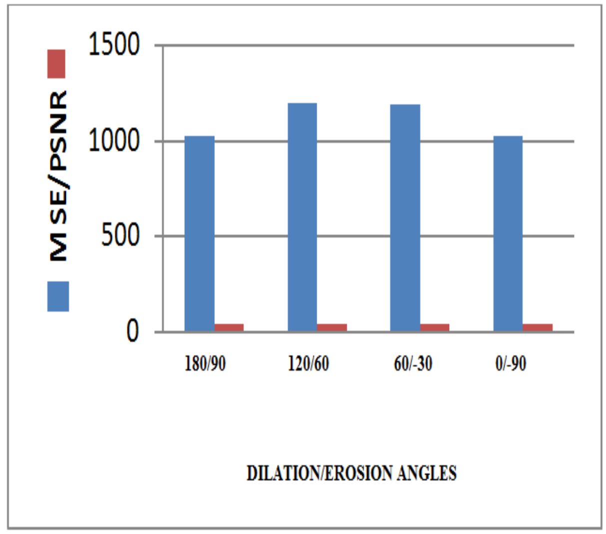

FIGURE 11: PSNR and MSE analysis for 60^0 division angle and 90^0 difference angle.

6. CONCLUSION

The conclusion can be drawn as the boundary detection using mathematical morphology as proposed, is more efficient than the traditional methods. Also the method is simple and easy to implement. Also it can conclude that the method is most important for initial process in boundary detection for noisy images.

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