Mathematical Morphological Edge Detection For Remote Sensing Images

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Abstract
Edge detection is a terminology in image processing and computer vision particularly in the areas of feature detection and extraction to refer to the algorithms which aims at identifying points in a digital image at which the image brightness changes sharply or more formally has discontinuities. The need of edge detection is to find the discontinuities in depth, discontinuities in surface orientation, changes in material properties and variations in scene illumination. Remote sensing images are generally corrupted from noise. Mathematical morphology is a new technique for edge detection .It is a theory and technique for analysis and processing of geometrical structures, based on set theory. Mathematical morphology was originally developed for binary images, and later extends to grey scale functions and images .Basically the noise can be easily suppressed by mathematical morphology. So by using mathematical morphology the image can be enhanced and the edges can be detected. The result of edge detection using mathematical morphology will be compared with sobel edge detector, Prewitt edge detector, laplician of gaussian edge detector and Canny edge detector.

Keywords
Mathematical morphology, edge detection, remote sensing images , canny edge detection ,erosion , dilation .

I. Introduction

Remote sensing is the collection of information about earth surfaces and phenomenon using sensors not in physical contact with surfaces and phenomenon of interest. remote sensing includes the mission plan and choice of sensors, the reception ,recording and processing of signal data and finally the analysis of resultant data .The types of remote sensing is aerial photography,multispectral, active and passive microwave.
Mathematical morphology is a tool for extracting image components that are useful in representation and description of region shape, such as boundaries, skeletons and convex hull. The technique was originally developed by Matheron and Serra at Ecole des mines in Paris .The language of mathematical morphology is set theory and sets in mathematical morphology represent objects in an image. It is also useful for pre and post processing techniques.
Mathematical morphology is a theory of image transformations and image functional .Morphological operations are based on simple expanding and shrinking operations. Mathematical morphology examines the geometrical structure of an image by probing it with small patterns ,called 'structuring element', of varying sizes and shapes .This procedure results in non-linear image operators which are well suited to exploring geometrical and topological structures.
Edges are very important to any vision system. They do provide the strong visual clues that can help the recognition process. Edges are effected by noise present in an image though .An edge may be regarded as boundary between two dissimilar regions in an image .edge detection is a terminology in image processing and computer vision , particularly in areas of feature detection and feature extraction.
Remote sensing images are generally corrupted by noise.

II. Traditional methods of edge detection

There are many techniques for edge detection as under:
1. Sobel operator
2. Canny edge detection
3. Prewitt operator
4. Laplician of Gaussian
5. Roberts edge detection

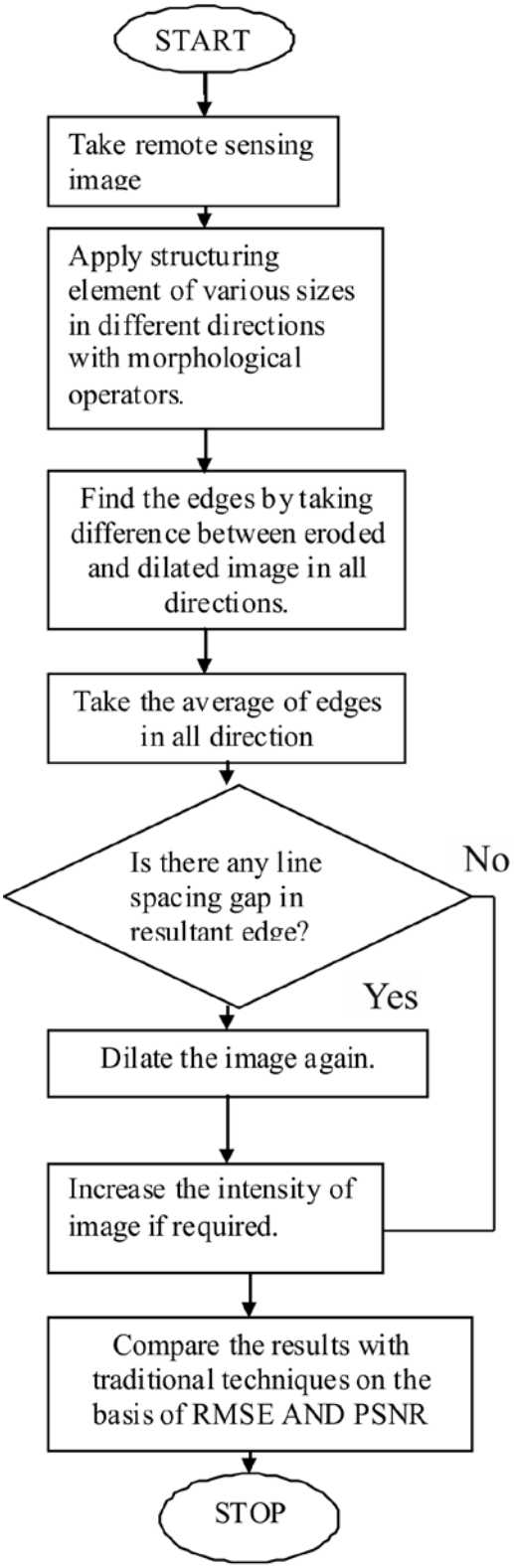
Sobel operator is used in image processing techniques particularly in edge detection. The sobel operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical and is therefore relatively inexpensive in terms of computations.
Canny edge detection operator was developed by John F. Canny in 1986 and uses a multistage algorithm to detect a wide range of edges in images.
Prewitt operator edge detection masks are the one of the oldest and best understood methods of detecting edges in images. Basically, there are two masks, one for detecting image derivatives in X and one 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 rot of the sum of the squares of these two derivatives.
Roberts edge detection method is one of the oldest method and is used frequently in hardware implementations where simplicity and speed are dominant factors.

III. Morphological operators

1. Dilation
2. Erosion
3. Opening
4. Closing

Above all are the basic mathematical morphological operators.
Dilation is defined as the maximum value in the window. Hence the image after dilation will be brighter or increased in intensity. It also expand the image and mainly used to fill the spaces.
Erosion is just opposite to dilation. It is defined as the minimum value in the window .The image after dilation will be darker than the original image .It shrinks or thins the image.
Opening and closing both parameters are formed by using dilation and erosion. In opening, firstly image will be eroded and then it will be followed by dilation.
In closing, first step will be dilation and then result of this is followed by erosion.
All above operators perform their tasks by using structuring elements, which is a matrix of 0's and 1's.structuring elements have various sizes and shapes.

IV. Proposed Algorithm



V. Implementation of method

First step is to take the north pole of the moon as the remote sensing image .Then apply the different structuring elements which are as follows:

1st method:

Se1=1 1 1 1 1
1 1 1 1 1
0 0 0 0 0
1 1 1 1 1
1 1 1 1 1

This structuring element is used as in 180 degree direction.

Se2= 1 1 0 1 1
1 1 0 1 1
1 1 0 1 1
1 1 0 1 1
1 1 0 1 1

This structuring element element is used as used as in 90 degree direction.

Se3 = 0 1 1 1 1
1 0 1 1 1
1 1 0 1 1
1 1 1 0 1
1 1 1 1 0

This structuring element is used as in 135 degree direction.

Se4 = 1 1 1 1 0
1 1 1 0 1
1 1 0 1 1
1 0 1 1 1
0 1 1 1 1

This structuring element is used as in 45 degee direction.

The following steps is applied for the implementation of the method:

1) Above four structuring elements are used with morphological operators like erosion and dilation.
2) Edges can be detected by taking the difference between the dilated and eroded image of all these four structuring elements.
3) Take average of these four.i.e. (Se1+Se2+Se3+Se4)/4
4) Dilate the image if any line spacing is there in the resultant edge.
5) Increase the intensity if required.
6) Compared the result with the traditional techniques on the basis of Root mean square error(RMSE) and Peak signal to noise ratio(PSNR).

$$MSE=1/MN \sum_{i=1}^{M} \sum_{j=1}^{N} (f_1(i,j)-f_2(i,j))2$$

where f_1 is output image and f_2 is input image.

$RMSE=\sqrt{MSE}$

$PSNR=10 \log(255^2/MSE)$

Apply the same above method by using different structuring elements(5*5) as follows:

2nd method:

180 degree structuring element=
0 0 0 0 0
0 0 0 0 0
1 1 1 1 1
0 0 0 0 0
0 0 0 0 0

90 degree structuring element=
0 0 1 0 0
0 0 1 0 0
0 0 1 0 0
0 0 1 0 0
0 0 1 0 0

135 degree structuring element=
1 0 0 0 0
0 1 0 0 0
0 0 1 0 0
0 0 0 1 0
0 0 0 0 1

45 degree structuring element=
0 0 0 0 1
0 0 0 1 0
0 0 1 0 0
0 1 0 0 0
1 0 0 0 0

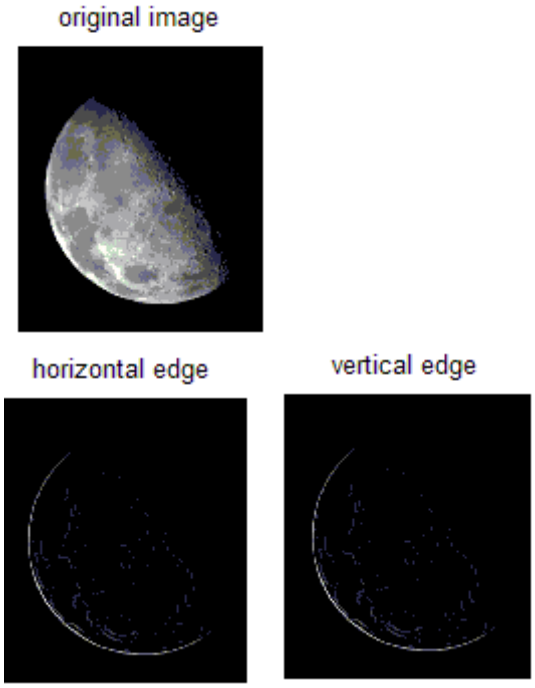
tAbove all structuring elements are opposite to the earlier one, but method of implementation is same.
Another structuring element is of 3*3 matrix form which is as follows:

3rd method:
90 degree direction= 1 0 1
1 0 1
1 0 1
180 degree direction=1 1 1
0 0 0
1 1 1

45 degree direction= 1 1 0
1 0 1
0 1 1

135 degree direction= 0 1 1
1 0 1
1 1 0

VI. Results



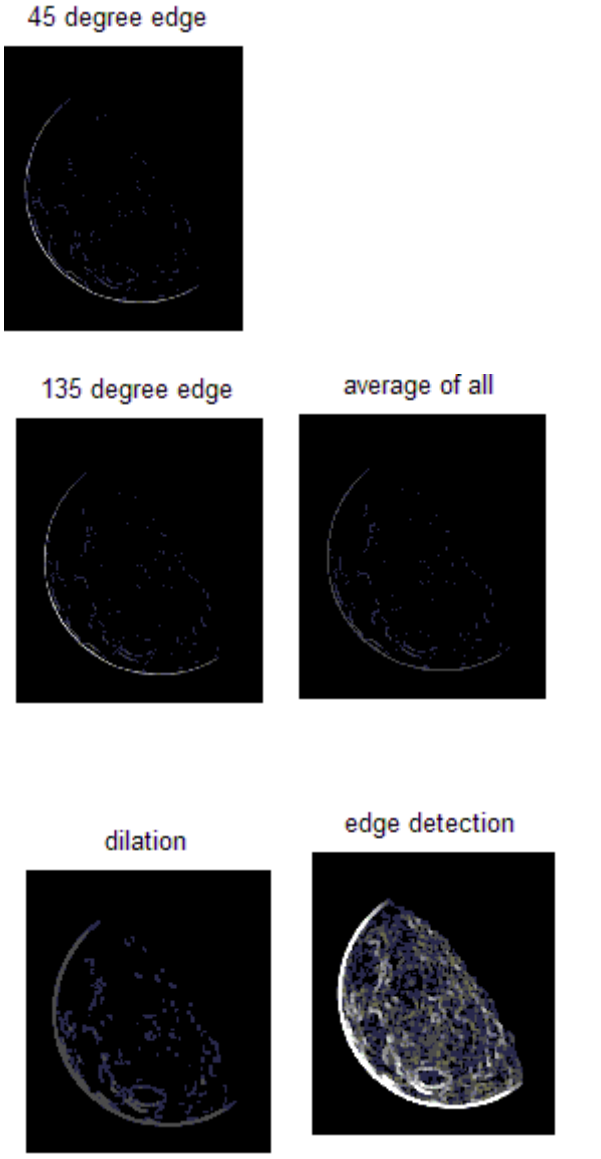
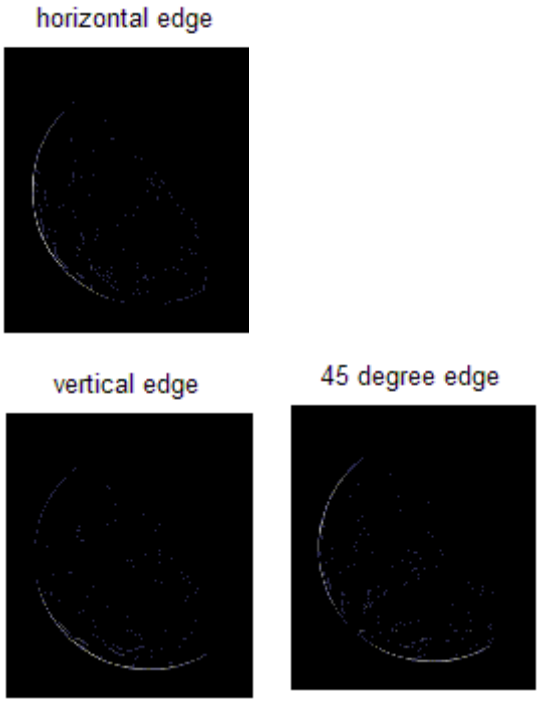


Fig.1: Result of 5*5 structuring element(1st method)



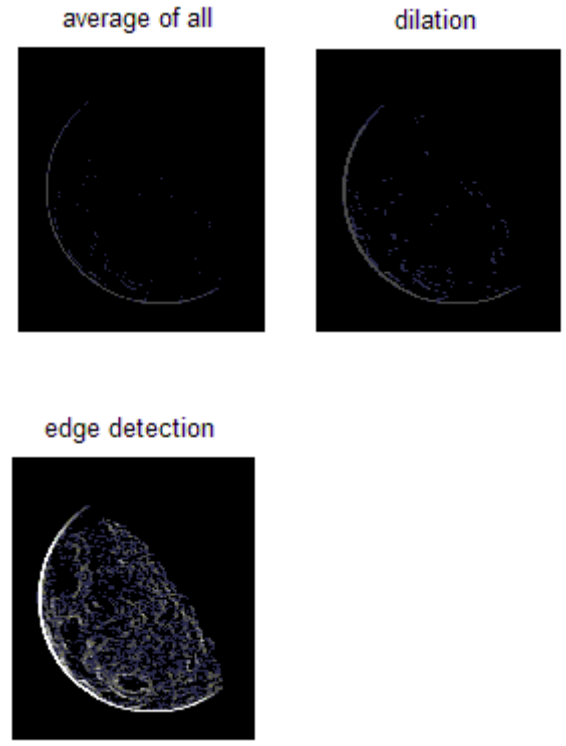
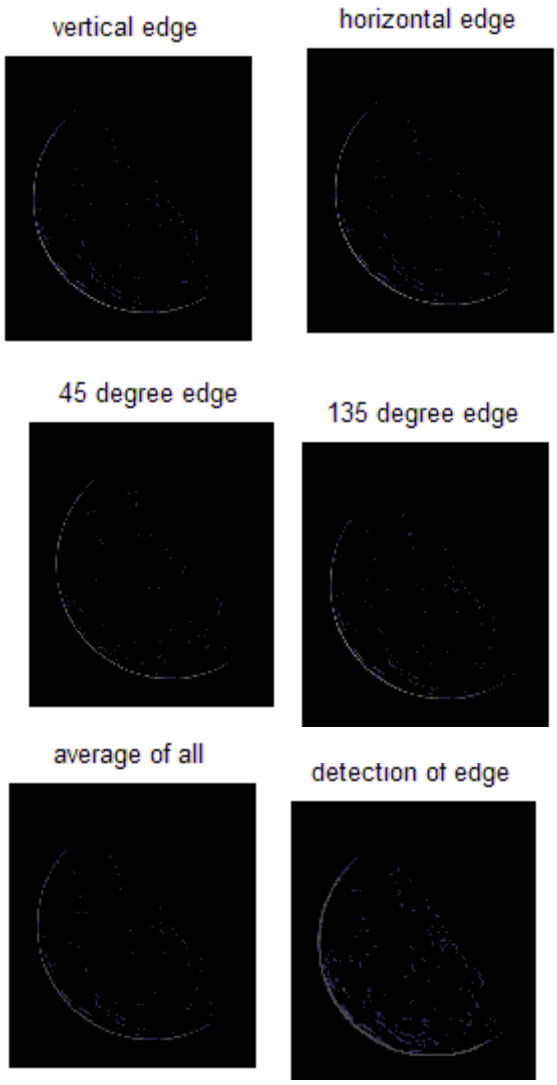


Fig. 2: Result of 5*5 structuring element(2nd method)



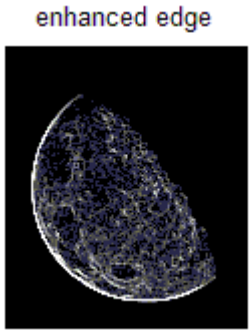


Fig.3: Result of 3*3 structuring element (3rd method)

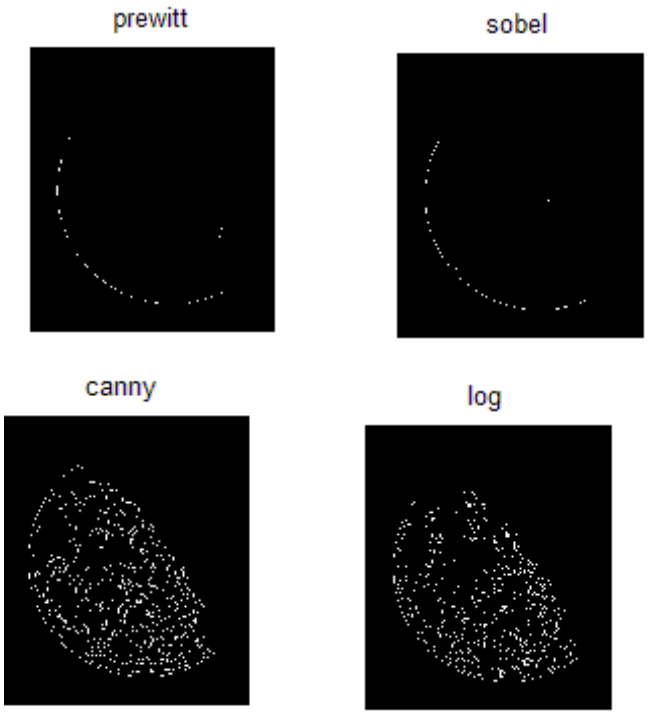


Fig.4: Result of traditional methods of edge detection

VII. Comparision

Method of implementation	RMSE	PSNR
Mathematical morphology(5*5 1st method)	53.4769	36.7261
Mathematical morphology(5*5 2nd method)	61.1186	36.1461
Mathematical morphology(3*3 3rd method)	56.9534	36.4526
Sobel edge detection	77.3096	35.1255
Canny edge detection	77.2679	35.1278

Prewitt edge detection	77.3097	35.1255
Laplician of gaussian	77.2711	35.1276

Table 1: Comparision between different methods of edge detection.

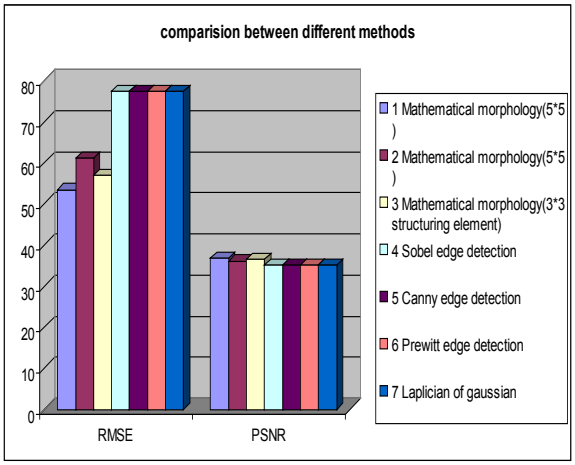


Fig. 5: Comparision on the basis of RMSE and PSNR

VII. Conclusion

From the results, it is concluded that the edge detection using mathematical morphology is more efficient than the traditional methods. The main advantages of mathematical morphology are direct geometric interpretation, simplicity and efficiency in hardware implementation.

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