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AN INNOVATIVE MORPHOLOGICAL APPROACH FOR NOISE REMOVAL CUM EDGE DETECTION FOR DIGITIZED PAINTINGS

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ABSTRACT

The older paintings suffer from breaks in the substrate, the paint, or the varnish. When we digitized these paintings, they can be modified using mathematical algorithms and cracks are eliminated so as to maintain the quality. The field of computer vision is concerned with extracting features and information from images in order to make analysis of images easier, so that more and more information can be extracted. The primary goal of this study is to use novel approach for noise removal cum unwanted edge from digitized paintings. The method used for both noise removal and edge detection is mathematical morphology. On the basis of set theory, mathematical morphology is used for image processing, analyzing and comprehending. It is a powerful tool in the geometric morphological analysis and description. The results exhibit that the new method overcomes the deficiency of conventional methods and efficiently removes the noise and detects the edges for digitized paintings.

Keywords: Mathematical Morphology, Noise Removal, Edge Detection, Digitized Painting

1. INTRODUCTION

Noise removal and edge detection are the two most important steps in processing of any digital images for improving the information in the picture so that it can be easily understand by human and to make it suitable and readable for any further processing which works on those images (Karuppiah and Srivatsa, 2012). There are many edge detection methods like Sobel, Prewitt, Canny edge detectors and noise removal techniques like filters according to the type of noise present for digital image processing. With advancement in technology in image acquisition and analysis systems new methods are still required for high level of noise removal and for low contrast edge detection. Mathematical Morphology (MM) is a new mathematical theory which can be used to process and analyze the images. In the MM theory, images are treated as sets and morphological transformations which derived from Minkowski addition and subtraction are defined to extract features in images.

In this study, a new morphological approach for noise removal cum edge detection is introduced for digitized paintings. For detecting edges in an image efficiently, first the noise is to be removed. Noise is removed using morphological operations and further morphological operations are applied on this image to extract the edges.

2. FUNDAMENTAL OPERATIONS OF MATHEMATICAL MORPHOLOGY

On the basis of set theory, mathematical morphology is used for image processing, analyzing and comprehending. It is a powerful tool in the geometric morphological analysis and description. In the MM theory, images are treated as sets and morphological transformations which derived from Minkowski addition and subtraction are defined to

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extract features in images. The image which will be processed by mathematical morphology theory must be changed into set and represented as matrix.

Mathematical morphology is extremely useful in many image processing and analysis applications. Mathematical morphology denotes a branch of biology that deals with the forms and structures of animals and plants. It analyzes the shapes and forms of objects. In computer vision, it is used as a tool to extract image components that are useful in the representation and description of object shape. It is mathematical in the sense that the analysis is based on set theory, topology, lattice algebra, function and so on (Gonzalez and Woods, 2008). Another use of mathematical morphology is to filter image. It is a well know non-linear filter for image enhancement (Maragos, 1996; Yu-Qian *et al*., 2005; Xu *et al*., 2008).

The basic idea in binary morphology is to probe an image with a simple, pre-defined shape, drawing conclusions on how this shape fits or misses the shapes in the image. This simple "probe" is called structuring element, which is also a binary image (i.e., a subset of the space or grid). A structuring element is a small image used as a moving window whose support delineates pixel neighbourhoods in the image plane. Mathematical morphology involves geometric analysis of shapes and textures in images. An image can be represented by a set of pixels (Qiyuan *et al*., 2007).

The basic mathematical morphological operations namely dilation, erosion, opening, closing are used for detecting, modifying, manipulating the features present in the image based on their shape. In the following, some basic mathematical morphological operations of gray-scale images are introduced.

Let J (x, y) denote a gray-scale two dimensional image, SE denote structuring element. Dilation of a gray-scale image J(x, y), by a gray-scale structuring element SE (a, b) is denoted by Equation 1:

$$(\mathrm{J\ SE})\ (x,y) = \max\{J(x-a,y-b)+SE(a,b)\} \quad (1)$$

Erosion of a gray-scale image J (x, y) by a gray-scale structuring element SE(a, b) is denoted by Equation 2:

$$(\mathrm{J\ SE})(x,y) = \min\{J(x+a,\ y+b)--SE(a,b)\} \quad (2)$$

Opening and closing of gray-scale image J (x, y) by gray-scale structuring element SE(a,b) are denoted respectively by Equation 3 and 4:

$$J \circ SE = (J SE)SE \quad (3)$$

$$J \bullet SE = (J\ SE)SE \quad (4)$$

Erosion basically decreases the gray-scale value of an image by applying shrinking transformation, while dilation increases the gray-scale value of the image by applying expanding transformation. However, both of them are sensitive to the image edge whose gray-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.

3. THE NOVEL APPROACH FOR NOISE REMOVAL CUM EDGE DETECTION

In the proposed method, closing then followed by opening is performed using an appropriate Structuring Element (SE) on the image to be processed. Again closing operation is performed on the resultant image. This removes the noise from the image and hence is used to pre-process the image. The choosing of structuring element is a key factor in morphological image processing. The size and shape of the structuring element decide the final results of detected edges and put de-noising in both binary and gray scale images.

Three methods are proposed to detect edges in the image:

Method 1

The edge of the image can also be detected by the following process. The edge of an image J which is denoted by E (J) is defined as the difference set of the domain of J and the eroded domain of J.

It can be depicted by the following Equation 5:

$$\{[(J\bullet SE)\circ SE]\bullet SE\}--\{[(J\bullet SE)\circ SE]\bullet SE\}\Theta SE \quad (5)$$

Method 2

The edge of the image is detected by the following process. The edge of an image J which is denoted by E (J) is defined as the difference set of the dilation domain of J and the domain of J.

It can be depicted by the following Equation 6:

$$\{[(J\bullet SE)\circ SE]\bullet SE\}\updownarrow SE-\{[(J\bullet SE)\circ SE]\bullet SE\} \quad (6)$$

Method 3

The edge of the image can also be detected by the following process. The edge of an image J which is denoted by E (J) is defined as the difference set of the dilated domain of I and the eroded domain of J.

It can be depicted as follows Equation 7:

$$\{[(J\bullet SE)\circ SE]\bullet SE\}\updownarrow SE-\{[(J\bullet SE)\circ SE]\bullet SE\}\Theta SE \quad (7)$$

4. EXPERIMENTAL RESULTS

A possible solution for detecting cracks located on very dark image areas would be to apply the crack-detection algorithm locally on this area and select a low threshold value. For the case of the border between regions of different color, a possible solution would be to perform edge detection or segmentation on the image and confine the filling of cracks that cross edges or region borders to pixels from the corresponding region.

The proposed method are applied the 2-d digitized painting first to eroded the image, then the dilated the image, then opening and final close the image. Method 1 deals with erosion of an image, Method two deals with dilated of an image and method three opening and closing of an image. Calculate PSNR value for each step is calculated and to find the optimum structuring element is found.

The following **Table 1-5** shows statistical analysis of error value comparison among the various structuring elements to find the optimal solution for choosing the structuring element.

As can be seen from **Fig. 1-5**, the results of the proposed method with structuring elements such as Diamond (2,3), Disk (3,2), Line [(7,10),(3,3)], Rectangle [(2 2),(3 3)] and Square (2,3). Among the above mentioned structuring elements, the better image quality is obtained by Line (3,3) where the parameter represents the length and angle of an image for detection of edges.

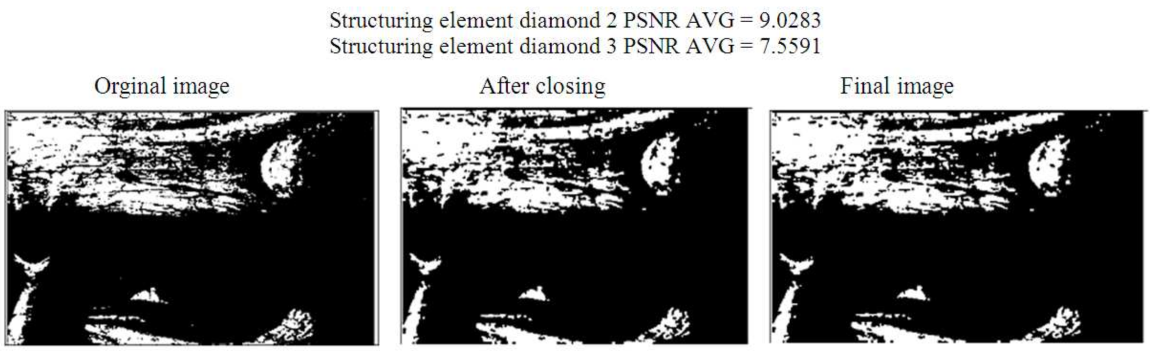

Fig.1. An example input image (original, diamond 2 and diamond 3) for structuring elements

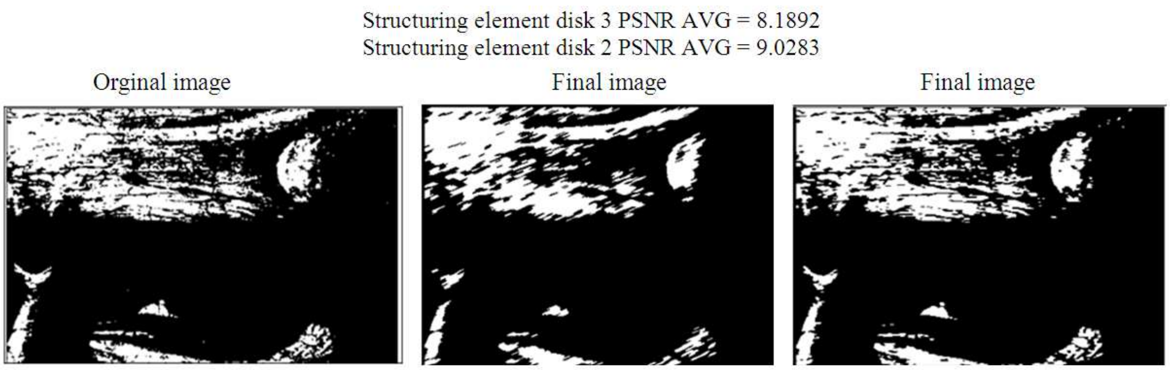

Fig. 2. An example input image (original, disk 3 and disk 2) for structuring elements

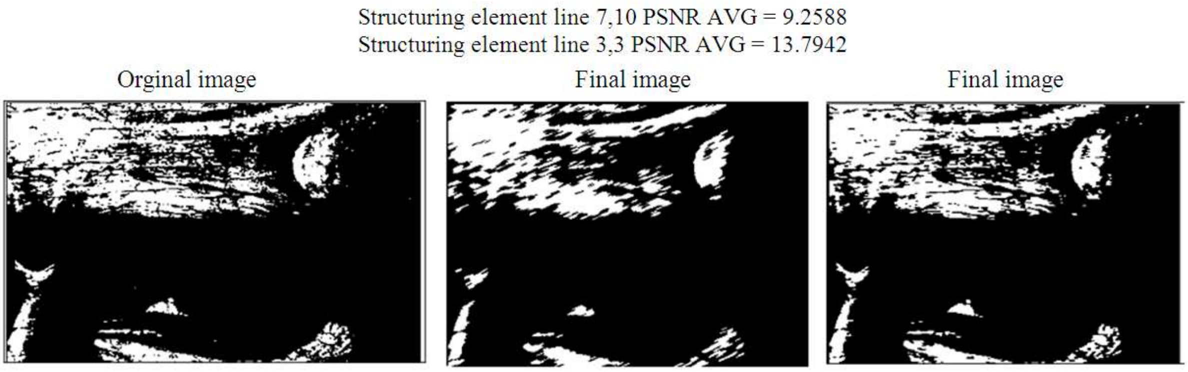

Fig. 3. An example input image (original, line (7,10), line (3,3)) for structuring elements

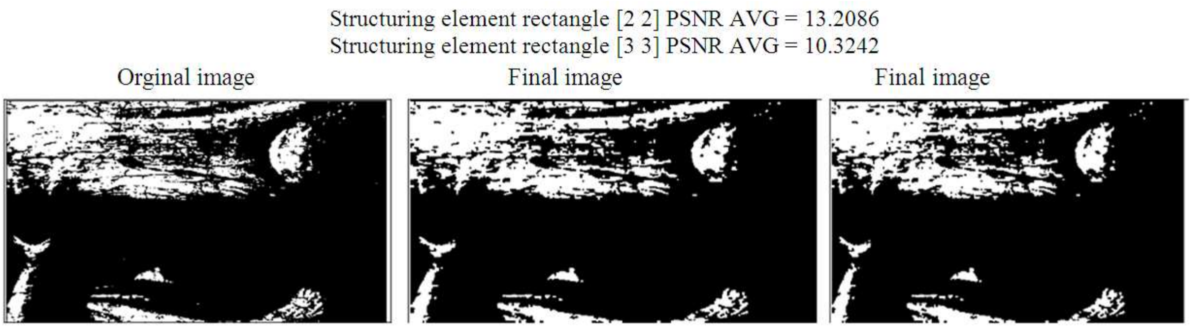

Fig. 4. An example input image (original, Rectangle [2 2], Rectangle [3 3]) for structuring elements

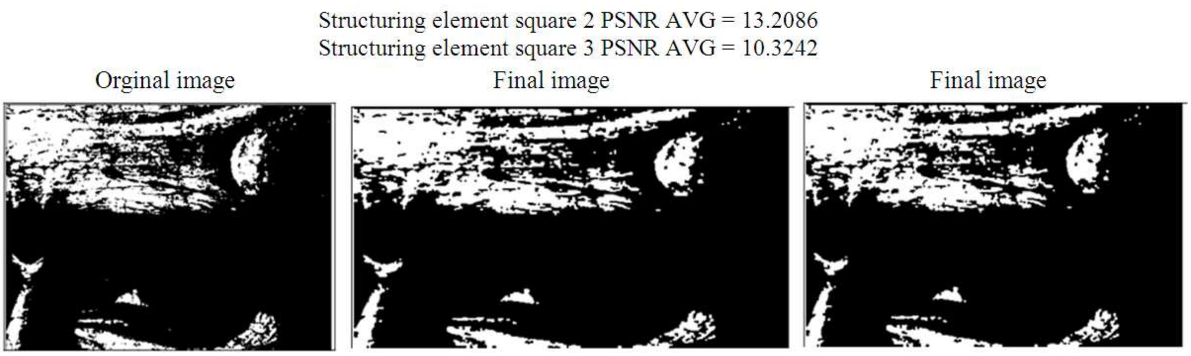

Fig. 5. An example input image (original, Square 2 and Square 3) for structuring elements

Table 1. Performance comparison (PSNR) for the structuring element-square

Square W-Width	Img1	Img2	Img3	Img4	Tot	Avg	Sd	Sd/M
11	6.7611	7.5310	7.5310	7.5618	29.3847	5.8769	11.7539	2
6	7.5098	9.7497	9.7497	9.6153	36.6246	7.3249	14.6498	2
5	7.9628	11.1333	11.1333	10.7164	40.9459	8.1892	16.3784	2
3	9.7778	14.4010	14.4010	13.0411	51.6208	10.3242	20.6483	2
2	12.2060	18.8246	18.8246	16.1880	66.0432	13.2086	26.4173	2

Table 2. Performance comparison (PSNR) for the structuring element-disk

Disk-radius	Img1	Img2	Img3	Img4	Tot	Avg	Sd	Sd/M
15	6.5547	6.5548	6.5550	6.5551	26.2192	5.5438	10.9876	2
10	6.5825	6.8582	6.8584	6.8854	27.1843	5.4369	10.8737	2
5	7.0056	8.4949	8.4949	8.5007	32.4962	6.4992	12.9985	2
3	7.9628	11.1333	11.1333	10.7164	40.9459	8.1892	16.3784	2
2	8.6194	12.4140	12.4140	11.6939	45.1415	9.0283	18.0566	2

Table 3. Performance comparison (PSNR) for the structuring element-line

Line-length and angle	Img1	Img2	Img3	Img4	Tot	Avg	Sd	Sd/M
10,45	8.2183	10.1632	10.1632	9.9696	38.5143	7.7029	15.4057	2
15,25	7.7109	9.6457	9.6457	9.5142	36.5165	7.3033	14.6066	2
5,10	11.2810	16.2460	16.2460	14.8843	58.6573	11.7315	23.4629	2
7,10	9.3100	12.5604	12.5604	11.8633	46.2941	19.2588	18.5177	2
3,3	13.5359	19.1852	19.1852	17.0645	68.9708	13.7942	27.5883	2

Table 4. Performance comparison (PSNR) for the structuring element-diamond

Diamond distance	Img1	Img2	Img3	Img4	Tot	Avg	Sd	Sd/M
20	6.5547	6.5547	6.5548	6.5549	26.2191	5.2438	10.4876	2
15	6.5579	6.6552	6.6552	6.6554	26.5239	5.3047	10.6094	2
10	6.6182	6.9967	6.9967	7.0200	27.6316	5.5263	11.0526	2
5	6.9955	8.4218	8.4218	8.4484	32.2875	6.4575	12.9150	2
3	7.7146	10.6895	10.6895	9.9017	37.7954	7.5591	15.1182	2

Table 5. Performance comparison (PSNR) for the Structuring Element-Rectangle

Rectangle Row, col	Img1	Img2	Img3	Img4	Tot	Avg	Sd	Sd/M
20	6.5547	6.5547	6.5548	6.5549	26.2191	5.2438	10.4876	2
15	6.5579	6.6552	6.6552	6.6554	26.5239	5.3047	10.6094	2
10	6.6182	6.9967	6.9967	7.0200	27.6316	5.5263	11.0526	2
5	6.9955	8.4218	8.4218	8.4484	32.2875	6.4575	12.9150	2
3	7.7146	10.6895	10.6895	9.9017	37.7954	7.5591	15.1182	2
2	8.6194	12.4140	12.4140	11.6939	45.1415	9.0283	18.0566	2

5. CONCLUSION

In this study, a novel MM based algorithm is proposed to remove the cracks in digitized paintings. The proposed method is applied to 2-d digitized painting first to erode the image, then dilated the image, then opening and finally close the image. Method 1 deals with erosion of an image, Method two deals with dilated of an image and method three opening and closing of an image. We calculate PSNR value for each step and to find the optimum structuring element .The efficiency of proposed algorithm to find edges is compared with edge detectors like SOBEL, PREWITT and CANNY by using quality assessment parameter PSNR . This can be tried to other structuring element and comparison for another error like SNR, MSSIM, RMSE can be carried out. The limitations of these for only 2Dimages and tried to other structuring element and comparison for another error like SNR, MSSIM, RMSE can be carried out.

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