

Objective Evaluation of Mathematical Morphology Edge Detection on Computed Tomography (CT) Images

Emhimed Saffor and Abdelkader Salama

Abstract—In this paper problem of edge detection in digital images is considered. Edge detection based on morphological operators was applied on two sets (brain & chest) ct images. Three methods of edge detection by applying line morphological filters with multi structures in different directions have been used. 3x3 filter for first method, 5x5 filter for second method, and 7x7 filter for third method. We had applied this algorithm on (13 images) under MATLAB program environment. In order to evaluate the performance of the above mentioned edge detection algorithms, standard deviation (SD) and peak signal to noise ratio (PSNR) were used for justification for all different ct images. The objective method and the comparison of different methods of edge detection, shows that high values of both standard deviation and PSNR values of edge detection images were obtained.

Keywords—Medical images, Matlab, Edge detection.

I. INTRODUCTION

THE objective of medical image analysis is to acquire useful information about physiological processes or organs of the body by using external and internal sources of energy. Edges boundaries are a problem of fundamental importance in image proceeding analysis. In a typical image, edges characterize object boundaries are useful for segmentation, registration, and identification of objects in a scene. In real world applications, medical images contain object boundaries and object shadows and noise. Therefore, they may be difficult to distinguish and exact edge from noise. In many cases, traditional methods will not provide the suitable results of edge detection of an image. Moreover, the hidden objects are also not well detected by using these methods.

Mathematical morphology is a new mathematical theory which can be used to process and analyze the images. The morphologic operations work with two images: The original data to be processed and a structuring element. Each structuring element has a shape which can be thought of as a parameter to the operation [1]. Morphological filters are nonlinear signal transformations that an image is probed by a structuring element which interacts with the image in order.

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In this paper we use three methods of edge detection based on morphological operator with multi-structure elements in different directions for objective evaluation on sets of Brain and Chest CT images. The software for this study will be developing using Mat LAB 7.0.

II. MORPHOLOGICAL EDGE DETECTION ALGORITHM

All Morphological edge detection algorithm selects appropriate structuring element of the processed image. The basic theory of morphology includes erosion, dilation, opening, and closing operation. The synthesization operations of them get clear image edge. In the process, the synthesized modes of the operations and the feature of structuring element decide the result of the processed image [2]. However, the morphological operations can be generalized for the design of filter structure and the selection of structuring element. To detect edges of medical image, we must select appropriate structuring element of this image. The size, shape and direction of structuring element must been considered roundly [2] - [7]. In morphological method, dilation operator used to eliminate dark regions in image, where as the bright region can be used to enhanced edges in image. However, erosion operator can be used to eliminate the weakens region of edges [1]. Morphological operations apply structuring elements to an input image, creating an output image of the same size. Irrespective of the size of the structuring element, the origin is located at its centre [8].

A structuring element is a special mask filter that enhances an input images. It can be of different sizes and of different shapes (square, diamond, circle). Following are the main mathematical morphological operators [1].

A. Dilation

Dilation is defined as the maximum value in the window hence the image after dilation will be brighter or increased in intensity. It also expands the image and mainly used to fill the spaces. Dilation process expanding image objects by changing pixels with value of "0" to "1".

Dilation of a grey-scale image $F(x, y)$ by a grey-scale structuring element $B(s, t)$ is denoted by [3] - [4]:

$$(F \oplus B)(x, y) = \max \{F(x - s, y - t) + B(s, t)\}$$

B. Erosion

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. Erosion process shrinking objects or images by changing pixels with a value of (1) to (0). Erosion of a grey-scale image $F(x, y)$ by a grey-scale structuring element $B(s, t)$ is denoted by [3]:

$$(F \ominus B)(x, y) = \min\{F(x + s, y + t) - B(s, t)\}$$

C. 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 the case of closing, firstly image will be dilated and then followed by erosion. Both operations i.e. opening and closing are mutually dual operations [9]. Opening operators are used to break the narrow gap and smooths the counter of an image. While closing operator eliminates small holes fills gaps in contours and fuse narrow breaks.

Opening and closing of grey-scale image $F(x, y)$ by grey-scale structuring element $B(s, t)$ are denoted respectively by [4]:

$$F \circ B = (F \ominus B) \oplus B$$

$$F \bullet B = (F \oplus B) \ominus B$$

In this paper we have presented and studied different mathematical morphology edge detection based on multi-structure elements in different directions.

III. METHODOLOGY

A. Data Collection

Medical images used in this study are Computed Tomography images (CT), where it was collected from the Department of Medical Imaging in Sebha Medical Center in the city of Sebha- Libya. This Department includes two system for CT scan, the first is Hitachi CT system, and the second is more modern on which is Philips CT system. This system is advanced continuous ration computed tomography system suitable for a wide range of computed tomography application. From the Philips CT system two types of CT images were selected (Brain and Chest), 13 images from every type were selected.

B. The Methodology Structure

The methodology structure used in the study can be shown in Fig. 1 which, can be explained as:

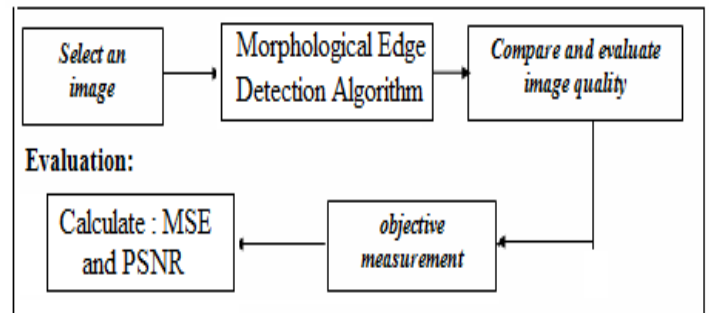


Fig. 1 Methodology structure

D. Implementation of Methods

- First step is to select image.
- Apply different structuring elements of morphological filters. We have taken the following structure elements to be implemented in the edge detection algorithm; which can be show in Fig. 2.

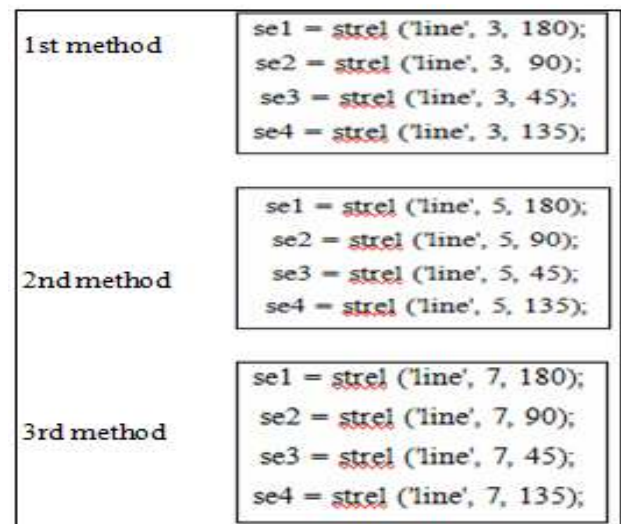


Fig. 2 Different methods used structuring elements

- After the implementation of above all the structuring elements, dilation and erosion operators will be applied to all structuring elements.
- Find the edges by taking difference between dilated and eroded image (in all directions). Then take the average of all the resultant images i.e. suppose in case of 2nd method $(Se1+Se2+Se3+Se4)/4$, similarly find the edges for all the methods.
- Dilate the image if there is any line spacing between the edges.
- Increase the intensity of the image as per requirement.
- Compare the result with the traditional techniques [3].

E. Flow Chart of Matlab Program

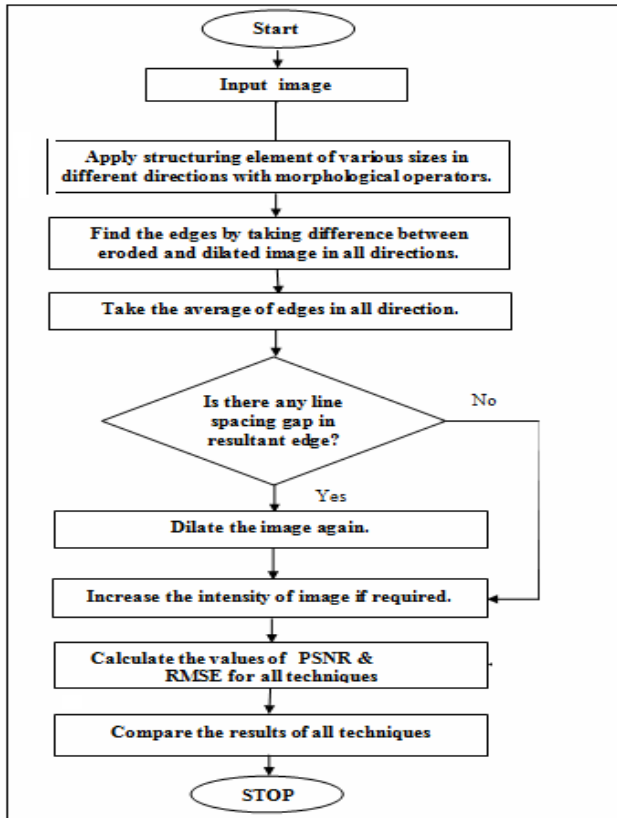


Fig. 3 The flow chart of Matlab program

IV. EDGE DETECTION EVALUATION

Two different methods of evaluation for image quality were used, namely; objective and subjective evaluation methods.

A. Objective Evaluation Methods

We used the following equations for evaluating objective test:

• Mean Square Error

Mean square error of an estimator is to quantify the difference between an estimator and the true value of the quantity being estimated. The mean square error is the squared error averaged over the $M \times N$ array this formula can be written as [6]

$$MSE = \frac{1}{NM} \sum_{i=1}^M \sum_{j=1}^N [f_1(i, j) - f_2(i, j)]^2 \quad (1)$$

where f_1 is output image and f_2 is input image

• Root Mean Square Error (RMSE)

Root Mean Square Error is a square root of MSE which, can be calculated as:

$$RMSE = \sqrt{MSE} \quad (2)$$

• Peak Signal to Noise Ratio(PSNR)

Peak signal to noise ratio is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. It is the logarithmic function of the peak value of the image and the mean square error. This formula can be written as [10] - [5]:

$$PSNR = 10 \log \left(\frac{(255)^2}{MSE} \right) \quad (3)$$

V. RESULT AND DISCUSSION

The results using edge detection based on morphological operators applied on two sets (Brain & Chest) CT images. We had applied the morphological algorithm on (13 images) under MATLAB program environment. Three methods of edge detection by applying line morphological filters with multi structures in different directions have been used. 3x3 filter for first method, 5x5 filter for second method, and 7x7 filter for third method. In order to evaluate the performance of the above mentioned edge detection algorithms Standard Deviation (SD) and Peak Signal to Noise Ratio (PSNR) were used for justification for all different CT images.

A. Peak Signal to Noise Ratio (PSNR) Values

The equations (1), (2) and (3) were used to calculate the Peak Signal to Noise Ratio (PSNR) values for all methods of edge detection applied on brain and chest CT images. The calculated results are summarized and listed in Table I.

TABLE I
 DEFERENT METHODS VARIOUS MSC AND PSNR

Image Method No	Brain CT Image		Chest CT Image	
	MSE x10 ⁴	PSNR	MSE x10 ⁴	PSNR
1 st method	1.153	7.510	2.438	4.259
2 nd method	1.202	7.328	2.302	4.508
3 rd method	1.386	6.710	2.023	5.069

The values of Peak Signal to Noise Ratio (PSNR) for both Brian and Chest images were illustrated in Fig. 4.

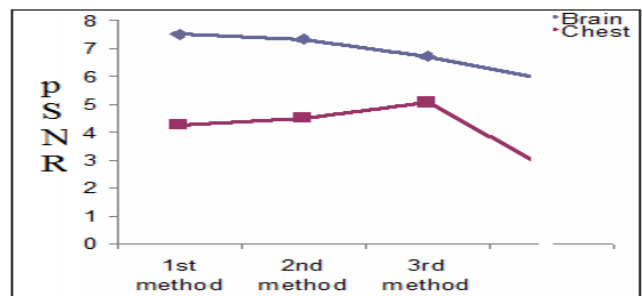


Fig. 4 PSNR values of brain and chest images

Mean square error used to quantify the difference between an estimator and the true value of the quantity being estimated. However, (PSNR) values are high for Brain images compared to Chest. The highest PSNR values are represented in three methods of edge detection based on morphological, which are 7.5101 in first method for brain image and 4.5089 in second method for chest image.

B. Standard Deviation of CT Images

Standard deviation for all original and resulted images after applying edge detection algorithms is computed by using (std2) function. The calculated results are summarized and listed in Table II. Std2 is a MATLAB function used in this study to compare the difference between these methods in terms of the quality [7].

TABLE II
 STANDARD DEVIATION OF CT IMAGE

IMAGE \ METHOD	Brain Image	Chest Image
Original Image	94.343	65.082
1 st method	21.489	16.303
2 nd method	23.329	18.050
3 rd method	25.647	20.192

The (SD) results for both (Brain and Chest images) were illustrated in Fig. 5.

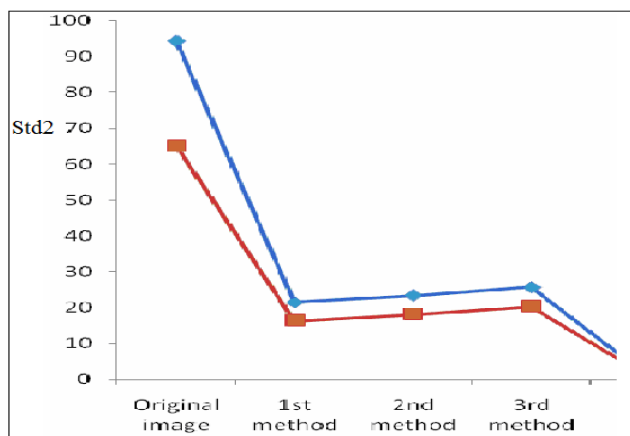


Fig. 5 Different images against (std2)

The original medical images (Brain and Chest image) of size (200 × 225) with the characteristics of more dark and blurry, were implemented using MATLAB program for experimental analysis. The program result shows the difference between these methods. Fig. 6 and 7 illustrated the compression for all methods used in this study for Brain and Chest images respectively.

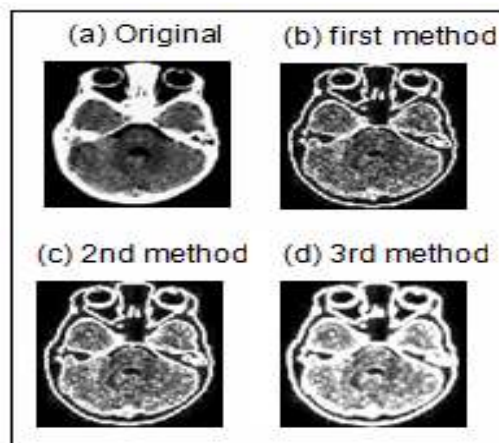


Fig. 6 Results of different methods for brain image

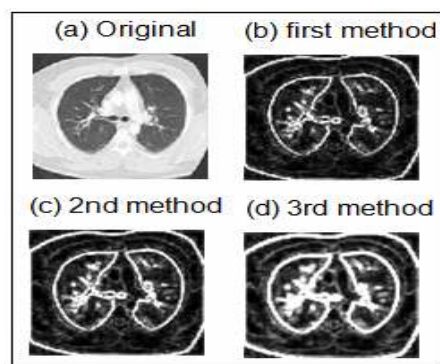


Fig. 7 Results of different methods for Chest image

VI. CONCLUSIONS

The conclusions that were drawn from this study are: the objective method and the comparison of different methods of edge detection, shows that high values of both standard deviation and PSNR values of edge detection based on morphology edge detection techniques. The statistical results in Tables I and II shown that the three used methods gives better results for all the parameters.

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