Image Enhancement Based Medical Image Analysis

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***Abstract*—Image enhancement is a vital step of medical image analysis and image recognition. X-ray and ultrasound imaging are the most preferred medical imaging technologies which are important for diagnosis of disease. But the edges and borders on image are not as clear as expected due to interference and low intensity in images. This paper presents an images enhancement techniques, specially in the case of medical images. Using image enhancement, it is possible to get the details which are kept hidden as well as to improve the image contrast. In the case of analyzing image, the commencing part is that the edge of an image. Successful results of image analysis depend on edge detection & enhancement. In this research we have developed a method of enhancement by incorporating Laplacian, Sobel operator, addition operation, filter, product operation and power law transformation techniques to enhance medical images. This developed method is tested on low contrast medical images and by observing the results it can be said that this applied methods perform well for enhancing medical images.**

***Index Terms*—Medical image, image analysis, image enhancement.**

I. Introduction

Medical technologies are developing day by day to provide better services for the increasing number of patients. For having better services and better identification of diseases, it is necessary to redouble the medical images like ultrasonography, computer tomography scan, x-ray etc. But some of these images contain low intensity & contrast which is difficult for Physicians to diagnosis the diseases by observing that unclear images. At the time of surgery, it is very important to detect the problems precisely. That is why it is a concern of the medical domain to enhance the intensity of the images & detect the edges of the objects of interest. For diagnosis & research applications, feature extraction of the images is necessary. Proper edge detection & image enhancement are important steps for this purpose. pixel, local and global are the main three features of feature extraction process for an image, in which, feature of visual image is mainly based on pixel value. On the other hand, detecting an edge alleviates the data amount as well as filters the useless data of an image [1]. Image enhancement largely increases the visual perception of human. Combined effect of these two process in a medical image can be of great help in the field of medical sector.

This paper is organized as section II, related works, in which previous related papers are presented which are considered as case study for developing this research, section III, methodology where the main methods for analyzations and developments are presented. Section IV is based on results of this research. Finally conclusion and future aspects are presented in section V.

II. Related works

The improvement of medical images with the help of technology has given medical science a new dimension to fight more accurately with the mesmerizing techniques [2] [3]. Various mordens researches [4] [5] [6] are going on to improve the medical imaging system. Multi-scale Retinex based image enhancement prediction was presented by Wu et al. [7]. According to their research the enhanced mean value of an image was about 125 also the definition can be improved as much as 5% to 25% which helps to improve the image quality. Juliastuti et al. [8] presented a method which showed the evaluation in the case of contrast quality of an image for both transmission mode and reflection mode. According to their result, the transmission mode presents better result. For enhancing low contrast image, fuzzy grayscale image improvement procedure was applied by Khairunnisa et al. [9]. If the image is captured in the absence of ample light, it generates non-uniform illumination which increases noise in the image. This method implemented a maximized fuzzy based membership function with the help of saturation operator as well as power-law transformation process which shows tremendous results for low contrast images having less process time.

For enhancement of THz images a method is presented by Zhang et al. [10]. Their proposed multi-scales nonlinear enhancement method deals with the low contrast and high value of noise in an image. A research on improvement of fingerprint image was analyzed by Selvi M. et al. [11]. The first and foremost step in fingerprint recognition is enhancement as it is used for authentication purposes. The major objective is to produce a noise free image. At first, the noise affected part in an image is detected and fuzzy based enhancement process is applied for cancellation of noise by having four steps which are Preprocessing, Fuzzy based filtering, Adaptive thresholding, and Morphological Operation. In Preprocessing, the original image is cropped to a particular size so that it can be preprocessed. The size of image is decreased to 256 pixels and then fuzzy based inference is applied on it. Low contrast color images enhancement based research was represented by Raju and his research group [12]. They applied fuzzy histogram based method and the result was really outstanding.

At first they convert the RGB image to HSV type so that they can keep the H and S part of the image. V component is stretched with the help of M and K. Though this process was applied to low contrast and less bright color images, it was attracted by research community because of its simple and amazing output.

Image enhancement techniques help to enhance the newly generated image comparing to main image by implementing various features such as edges, boundaries or contrast to make a graphic display more helpful for display and analysis. This research is based on the two image enhancement techniques which are Spatial Domain and Frequency Domain. In spatial domain method the image enhancement is based on direct manipulation of pixels of an image. And Fourier transform based modification is applied in frequency domain technique. This research uses both techniques to enhance the targeted image.

III. Methodology

Image enhancement process is composed of number of techniques that are used for improving the visual appearance of a picture or to transform it for better representation by a human or machine. There are two main objectives of image processing using image processing. The first reason is that it will be helpful for people as well as doctors to identify the patient's problems by observing the noise free images and the second reason is that computer can calculate and process more rapidly comparing to human brain. The edge detection of an image is the most important process in image processing as this edge contains basic characteristics of an image. This research applied mainly operators and filters for detecting and enhancing of image parts. Laplacian and Gaussian operators help to smooth the images or can be used to convolution of images which can be done with the help of Sobel operator as well as logical OR & AND. Finally, power law transformation has been used for having better output. Our applied edge detection and enhancement of image technique performs well for enhancing an image as well as accuracy for anti-noise performance is satisfactory.

A. Sobel operator

For detecting edge sobel operator can be used as it has the feature of parallelism but in the case of complex edge detection, the performance of Sobel operator performs less than the standard requirement. It is sensitive to noise. Researchers tried to improve the Sobel operator to locate the edge more accurately but it has not been found yet as it is tough for software to get the real time requirement. The Sobel operator is a well-established edge detector method [13]. In this case, Euclidean distance calculation is used instead of original difference-based gradient computation. Algorithm vectorization for having desired color information is applied in different steps of this method. Approximation to G_x and G_y using a 3×3 neighborhood centered on z_5 are as follows [14],

-1	-2	-1		-1	0	1
0	0	0		-2	0	2
1	2	1		-1	0	1

TABLE I
Mask co-efficients of Sobel operator (G_x- Left, G_y- Right)

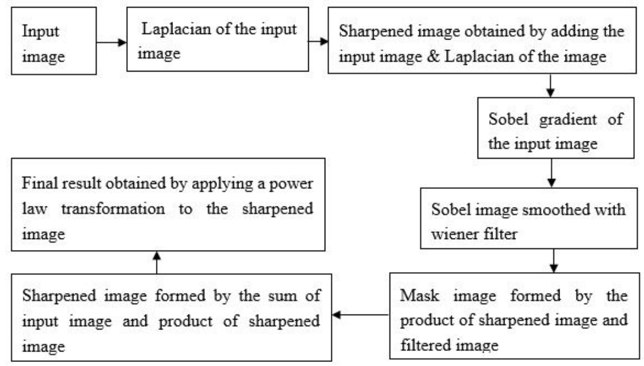

Fig. 1. Block diagram of the proposed technique

$$G_x = (z_7 + 2z_8 + z_9) - (z_1 + 2z_2 + z_3) \quad (1)$$

$$G_x = (z_3 + 2z_6 + z_9) - (z_1 + 2z_4 + z_7) \quad (2)$$

These equations can be implemented using the mask in table 1.

For input images kernel is needed to be applied seperstely for having separate gradient component measurement considering their orientation., G_x and G_y. Now, the gradient magnitude can be represented by,

$$\mid G_x \mid = \sqrt{G_x^2 + G_y^2} \quad (3)$$

An approximate Magnitude can be calculated using equation 3,

$$\mid G \mid = \mid G_x \mid + \mid G_y \mid \quad (4)$$

B. Proposed method

The proposed methodology is presented in figure 1.

The steps are as,

i) At first the Laplacian is used to the input image to highlight the details.

ii) Next we get sharpened image by adding the original image and the output image of the Laplacian image completed instep 1.

iii) Then Sobel operator is used on the original image to enhance the prominent edges. The edges of the output images are much more dominant in the image than in the Laplacian image.

iv) The smoothed gradient image is obtained by the wiener filter. These images are much brighter than the output image of the Laplacian.

v) After that the product of the sharpened image & smoothed filtered image is taken.

vi) Again by adding the product image to the resulted sharpened image is performed for more enhanced analysis.

vii) Increasing of sharpness comparing to original image can be observed in various part of the image.

viii) The last step in this research is to increase the dynamic range of the sharpened image. Power law transformation is a good solution for this problem. As a result Power law transformation is applied.

1) laplacian of an image: Image Laplacian $L(x, y)$ and the density of pixel $I(x, y)$ can be represented by,

$$L(x, y) = \frac{d^2 I}{dx^2} + \frac{d^2 I}{dy^2} \tag{5}$$

As there is a discrete pixel set in inputted image, discrete convolution kernel is needed by having second derivative considering Laplacian definition.

$$LoG = -\frac{1}{\pi\sigma^4}\left[1 - \frac{x^2+y^2}{2\sigma^2}\right] e^{-\frac{x^2+y^2}{2\sigma^2}} \tag{6}$$

2) Addition of two images: With the help of straightforward single pass the image addition can be performed where the pixel output can be represented by,

$$Q(i,j) = P_1(i,j) + P_2(i,j) \tag{7}$$

Now, by adding a constant value (C) it can be written as,

$$Q(i,j) = P_1(i,j) + C \tag{8}$$

In addition, it can be mentioned that, for having vector values in putted image instead of scaler value, then the components of images go for a separate addition process for having output value..

3) Wiener filter: With the help of this method, the target can be used for having an estimate f' of uncorrupted image f by having mean square error and these can be represented as, [15],

$$e^2 = E\left\{f\left(x,y\right) - f'\left(x,y\right)\right\}^2 \tag{9}$$

The approximate image or estimate of f in the frequency domain which satisfies the minimum error function is given by,

$$F'\left(u,v\right) = \left[\frac{1}{H\left(u,v\right)} \frac{\left|H\left(u,v\right)\right|^2}{\left|H\left(u,v\right)\right|^2 + K}\right] G\left(u,v\right) \tag{10}$$

The mean square error (MSE) given in statistical form can be presented as,

$$MSE = \frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}\left[f\left(x,y\right) - f'\left(x,y\right)\right]^2 \tag{11}$$

The signal to noise ratio (SNR) is approximated with the help of frequency domain quantities which can be represented as,

$$SNR = \frac{\sum_{u=0}^{M-1}\sum_{v=0}^{N-1}\left|F\left(u,v\right)\right|^2}{\sum_{u=0}^{M-1}\sum_{v=0}^{N-1}\left|N\left(u,v\right)\right|^2} \tag{12}$$

4) Multiplication of two images: The multiplication is needed for reaching the final out and it can be done in a single pass with the help of [16],

$$Q(i,j) = P_1(i,j) \times P_2(i,j) \tag{13}$$

Scaling by a constant it can be presented as,

$$Q(i,j) = P_1(i,j) \times C \tag{14}$$

Here the constant can be a floating number, sometimes can be less than one or may be a negative number and also may be responsible for low intensities of pictures. If the pixel value of images are vector values then the individual components of an image such as RGB (red, green, blue) components can be multiplied individually. [17].

5) Power law Transform: We can represent the basic form of power law transform as,

$$s = cr^{\gamma} \tag{15}$$

Here, r, s represents pixel value before and after processing of image and c is considered as a constant. For masking OR & AND logical operators are used.

IV. Result

To determine the result of the enhancement method proposed in this research, we have applied the techniques given to the images given in figure 2 (left) . The simulated images are given below:.

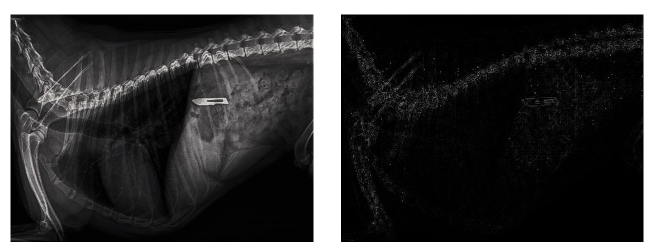

Fig. 2. X-ray image of human body (left), Laplacian of the left image (right)

In Figure figure 2, firstly the Laplacian is used to the input image (figure 2 left) to highlight the details in figure 2 right image. Then we get sharpened image adding the original image and the output image of the Laplacian figure 3 left. Then Sobel operator is used on the original image to enhance the prominent edges. The edges of the output images are much more dominant in the image figure 3 right image.

The smoothed gradient image is obtained by the wiener filter in figure 4 left image. These image is much brighter than the output image of the Laplacian in figure 3 (left). After that the

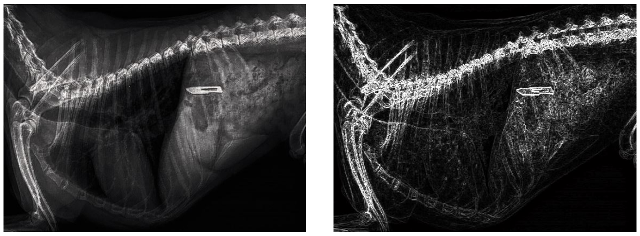

Fig. 3. Sharpened image obtained by adding two images of figure 2 (left), Sobel gradient of figure 2 left image (right)

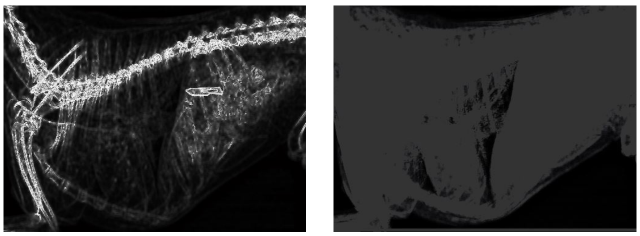

Fig. 4. Sobel image smoothed with filter (left), Mask image formed by the product of figure 3 (left) and figure 4 left image (right)

product of the sharpened image & smoothed filtered image is taken in figure 4 (right). Again by adding the product image to the resulted sharpened image is found in figure 5 (left). The significant increase in sharpness of the detail in this image over the original is evident in most parts of the image. The last step in this research is to increase the dynamic range of the sharpened image. We have used power law transformation to the image resulted is shown in Figure 5 (right). By having this last image it can be said that the final image is much more easier for medical analysis purpose.

V. Conclusion

Digital imaging such as x-ray, MRI, CT etc. help to diagnose, treat and cure patients. Doctors can see inside a patient's body by the virtue of medical imaging. Internal anatomy as well as functionality of body parts can be identified easily with the blessing of technology. In many under developed countries, due to socioeconomic condition developed biomedical devices are not available yet. Doctors & researchers face problems due to low intensity & low contrast of the medical images. The technique presented in this research to process medical images should work very well in various environment. The implementation was made using an object oriented environment for medical image edge detection & enhancement purposes. The processing algorithm can be adopted for other practical applications from other domains. Speckle noise is the main reason behind the degradation of ultrasound images. It is mandatory to remove this noise to get better images. In the future we have a plan to establish the edge detection & enhancement based feature extraction and Image texture technique for the ultrasound images. As this research deals with medical images, so any color image activity using this technique is not tested. Also this method is not tested in continuous images as we tested using single separated images.

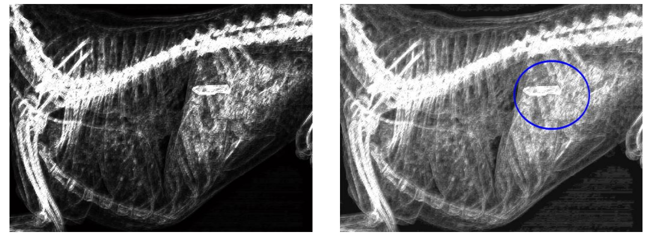

Fig. 5. Sharpened image formed by the sum of figure 2 left & figure 4 right image (left), Final result obtained by applying a power law transformation to figure 5 left [for c=1 & $\gamma = 0.5$] (right)

If it is possible to remove noise from edge of image, the output will be more sharpened.

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