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Contrast and Brightness Enhancement for Low Medical X-Ray Images

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Abstract— Image enhancement techniques have been widely used in many fields, especially in medical scope, where the subjective quality of images is important for human interpretation (diagnosis). Denoising and contrast enhancement are important factors in any subjective evaluation of image quality. In the recent research work some techniques have been used to enhance medical images in the spatial domain using spatial filter (like, Sobel, Laplacian, and Smoothing). In additional, some logical and arithmetic operators have been used (like, AND, sum, subtract).A Hybrid strategy for image enhancement by combining spatial enhancement with power-law transforms function has been implemented. The effectiveness of this technique was evaluated using tested low medical x-ray images. The assistance criteria such as MAE (mean absolute error), and human visual was tested. The final results show that the suggested method is over tested images.

Index Terms — arithmetic operator, contrast enhancement, transform function, medical images.

1 Introduction

THE enhancement is widely used for medical image processing and as a preprocessing step in speech recognition, texture synthesis, and many other image/video processing applications. Exising enhancement approaches fall into two broad categories: spatial domain methods and frequency domain methods [1].

As medical images are poorly illuminated, edges/boundaries are fuzzy/vague in nature; direct edge detection techniques will give discontinued and broken edges. So, preprocessing is required to obtain good and clear edge images. Pre processing is the image enhancement that plays an important role in image processing. It highlights the important features or the features that are not properly visible and suppresses unwanted information that is not relevant to image processing tasks. Enhancement may be edge enhancement or contrast enhancement. Edge enhancement enhances the edges/boundaries of the image thereby suitable for edge detection where as contrast enhancement enhances the overall quality of the image. Median filtering is a good technique that preserves the boundaries and then on calculating the tohtal variation with respect to the central pixel of the filter window, an image with enhanced boundary is obtained. The image is then edge detected using any edge detection methods [2].

Medical imaging is concerned with the development of the imaging devices that help to identify different aspects of the tissue and organs based on various properties and reveal new properties of the tissue and internal structure. Medical image processing is a field of science that is gaining wide acceptance in healthcare industry due to its technological advances and software breakthroughs. It plays a vital role in disease diagnosis and in improved patient care. It also helps medical practitioners during decision making with regard to the type of treatment. Several state-of-the-art equipments produce human organs in digital form which includes X-ray-based devices, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Ultrasound (US), Positron Emission Tomography (PET) and Single Photon Emission Computed Tomography (SPECT). [3]

In the last several decades, because of dramatically development of making x-ray images, it has been widely applied to clinical diagnose. But it needs far more effort to attain the degree that x-ray image diagnose independently by computer can replace the work of physician. One reason is that the analysis needs strong medic experience. The other is the x-ray image often not very clear which make the image processing can not distinguish all useful characteristic and make right judgment every time[4].

2 Procedure for Paper Submission

The proposed scheme elements related to the current research work of interest are showed in this fig. 1.

2.1 Spatial Differentiation: 1st Derivitive (Sobel Operators)

First derivatives in image processing are implemented using the magnitude of the gradient. For a function f(x, y), the gradient of f at coordinates (x, y) is defined as the two-dimensional column vector:

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$$\nabla f = grad(f) = \begin{bmatrix} gx \\ gy \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix} \quad .....(1)$$

This vector has the important geometrical property that it Points in the direction of the greatest rate of change of *f* at location (x, y). The magnitude (length) of vector ∇f , denoted as M(x, y), where the follwing equation:

$$M(x,y) = mag(\nabla f) = \sqrt{g^2x + g^2y} \quad ..(2)$$

represent the value at (x, y) of the rate of change in the direction of the gradient vector. [5].

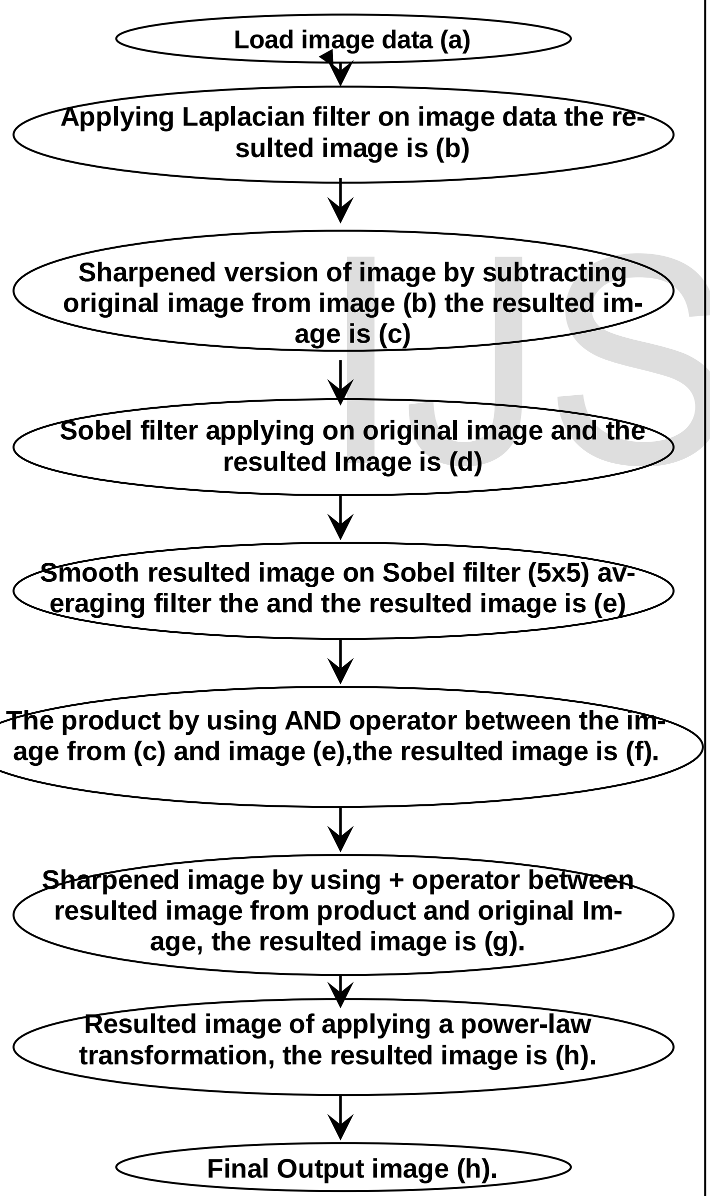

Fig. 1. A Block Diagram shows the proposed method scheme.

2.2 Spatial Differentiation: 2nd Derivitive (Lapalcian Operator)

It can be shown that the simplest isotropic derivative operator is the Laplacian, which, for a function (image) f(x, y) of two variables, is defined as:

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} \quad ..(3)$$

2.3 Spatial Differentiation: 2nd Derivitive (Lapalcian Operator)

This technique has numerous applications in image enhancement and segmentation (where an image is decomposed into several Interesting' pieces like edges and regions). The fundamentals are based on the subtraction of two images defined as the Computation of the difference between every pair of corresponding pixels in the two images it can be expressed as: [7].

$$g(x, y) = f(x, y) - h(x, y) \quad ....(4)$$

2.4 Sharpening by using Subtract (-) & Sumation (+) arithmetic operators

In its most straightforward implementation, this operator takes as input two identically sized images and produces as output a third image of the same size as the first two, in which each pixel value is the sum of the values of the corresponding pixel from each of the two input images. More sophisticated versions allow more than two images to be combined with a single operation. A common variant of the operator simply allows a specified constant to be added to every pixel. The addition of two images is performed straightforwardly in a single pass. The output pixel values are given by: [9].

$$Q(i,j) = P_1(i,j) + P_2(i,j) \quad ...... (5).$$

2.5 Smoothing Spatial Filters

Smoothing filters are used for blurring and for noise reduction. Blurring is used in preprocessing tasks, such as removal of small details from an image prior to (large) object extraction, and bridging of small gaps inclines or curves. Noise reduction can be accomplished by blurring with linear filter and also by nonlinear filtering. [6].

2.6 Logical Operators

Logical operators are generally derived from Boolean algebra, which is a mathematical way of manipulating the truth values

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of concepts in an abstract way without bothering about what the concepts actually mean. The truth value of a concept in Boolean value can have just one of two possible values: true or false. Boolean algebra allows you to represent things like: The block is both red and large by something like: A AND B where A represents `The block is red', and B represents `The block is large'. Now each of these sub-phrases has its own truth value in any given situation: each sub-phrase is either true or false. [8].

2.7 The Power-Law (Gamma) Transformation

Power-law transformations have the basic form:

$$s = c\, r^{\gamma} \quad \ldots (6)$$

Where c and γ are positive constants.

A variety of devices used for image capture, printing, and display respond according to a power law. By convention, the exponent in the power-law equation is referred to as gamma.The process used to correct this power-law response phenomena is Gamma correction is important if displaying an image accurately on a computer screen is of concern. . [6].

3. The Results of Suggested Image Enhancement Method:

The proposed algorithm is applied on tested low luminance medical x-ray images. The evaluation was made in terms of statistical measures MAE.

The evaluation of the results of image enhancement in spatial domain is performed by using object error criterion MAE (mean absolute error) as showing in following equation [10]:

$$MAE = 1/(M \times N) \sum_{X=0}^{M-1} \sum_{Y=0}^{N-1} \left| B(X,Y) - A(X,Y) \right| \ldots \quad (7)$$

So, for all experiments performed on the proposed project table (1), (2) summarize the results of the error measurement as an average of nine runs.

TABLE 1
Performance of Image Enhancement Algorithm Applied on Skeleton Image.

Smooth filter size	Power-law value	MAE
3x3	1	1.87715
5x5	1	1.89421
7x7	1	1.94190
3x3	1.05	2.70291
5x5	1.05	2.72292
7x7	1.05	2.78251
3x3	0.9	1.50661
5x5	0.9	1.49691
7x7	0.9	1.52992

TABLE 2
Performance of Image Enhancement Algorithm Applied on Bone Image.

Smooth filter size	Power-law value	MAE
3x3	1	1.87715
5x5	1	1.89421
7x7	1	1.94190
3x3	1.05	2.70291
5x5	1.05	2.72292
7x7	1.05	2.78251
3x3	0.9	1.50661
5x5	0.9	1.49691
7x7	0.9	1.52992

The results in tables (1), (.2) reflect the following behaviors:-

1- For, using power-law value =1, As it is shown it is the best, Results, in spite of the value of result are greater than the value of power-law which is equal of 0.9
2- When using the power value greater than 1, we shown that the result is so Brightness and value of results is increased.
3- For image filter size, we shown that the result value it is increased, whenever increased the size of filter.
4- Finally, we shown that the best visual image and result is applied, When the power-law is equal to 1, and the size of filter is equal of 5x5.

Figures (2&3) shows the original tested images and the resultes after implemented the suggested system enhancement system. While figure (4) show the detailed stages implementation suggested enhancement method.

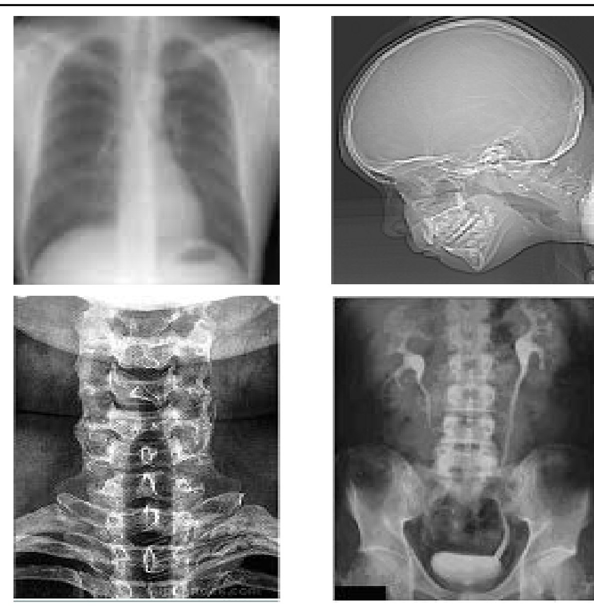

Fig. 2. Original tested x-ray dark images.

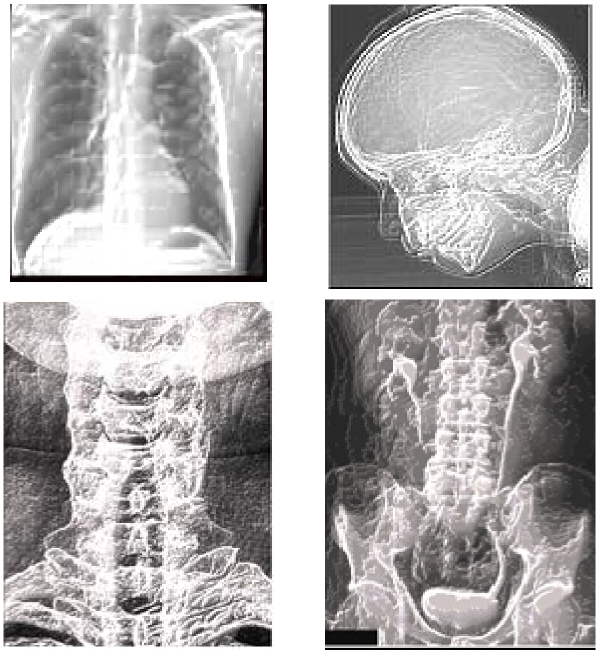

Fig. 3. Final results after enhancements.

4. Conclusions and Future Works

Medical imaging is one of the key fields of biomedical engineering, which aims to apply engineering principles in field of medicine and biology. Cumulative development of medical imaging science provides intense improvement in diagnosis, prognosis, and therapy. Accuracy in analysis of medical imaging data is at least as important as reliability of data acquisition process. Analysis of medical imaging data requires application of techniques involving image processing, which is one of the most studious topics of engineering and computer science.

Planned future expansions of this thesis study can be listed as follows:

1. Filtering module will be enriched by appending implementations of various filter classes; such as, histogram-based filters, directional filters, and logarithm-based filters.will be implemented and plugged into the system.
2. Intensity Transformations functions module will be enriched by appending implementations of various functions; such as log transformations, piecewise-linear transformation functions.
3. Also, image regularization methods based on minimization of total variation

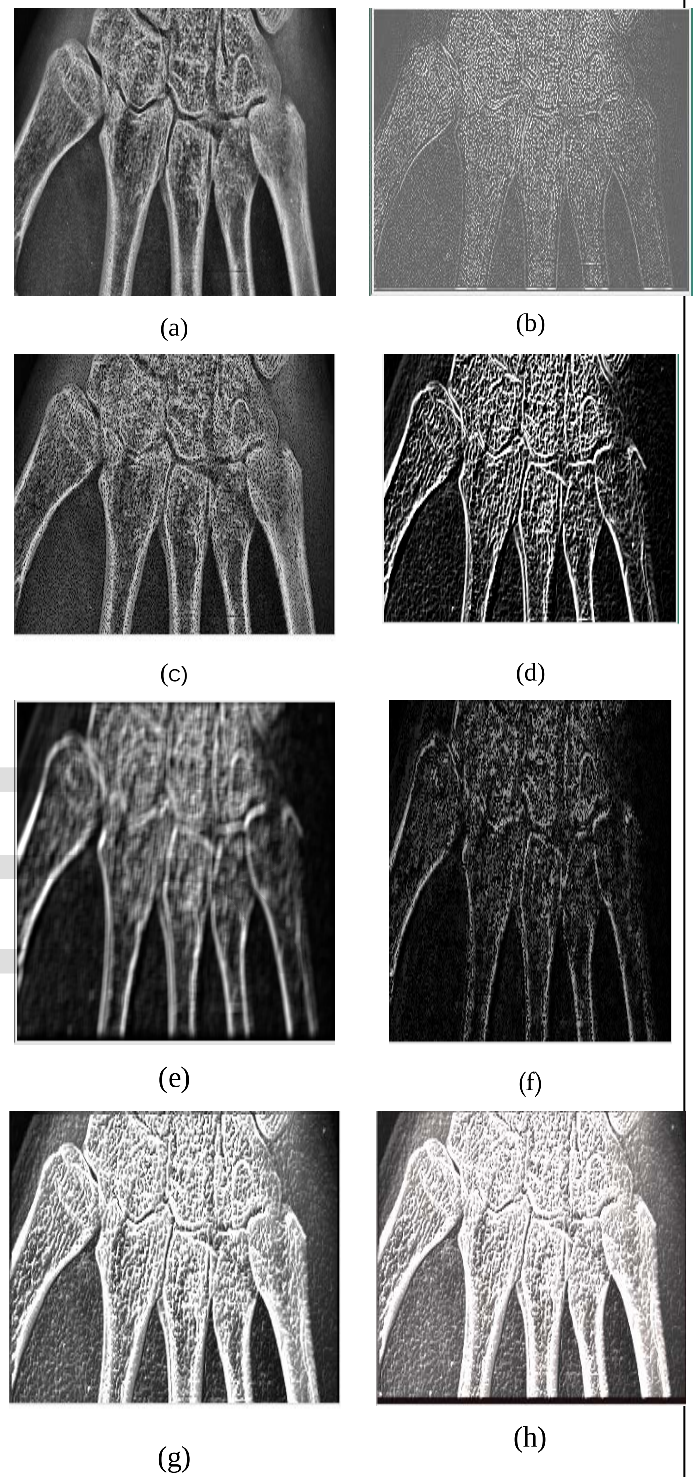

Fig. 4.

(a) ORIGINAL PICTURE
(b) RESULT OF THE LAPLACIAN OPERATOR
(c) RESULT OF THE SHARPENED IMAGE (A)-(B)
(d) RESULT OF THE SOBEL OPERATOR
(e) RESULT OF THE SMOOTHING FILTER
(f) RESULT OF THE PRODUCT AND OPERATOR
(g) RESULT OF THE SHARPENED (F)+ (A)
(h) FINAL RESULT AFTER APPLYING POWER-LAW TRANSFORM

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