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MATLAB Techniques for Enhancement of Liver DICOM Images

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Abstract – DICOM has become a standard for medical imaging. Its purpose is to standardize digital medical imaging and data for easy access and sharing. There are many commercial viewers that support DICOM image format and can read metadata, but image displaying is not always optimal. One of the most common degradations in medical images is their poor contrast quality and noise. The DICOM image consists of speckle noise. While the image is enhanced, the different types of noises present in the image are also enhanced [5]. During our study we find there is problem in correct displaying for DICOM images in MATLAB. And in this paper we develop new method for correct displaying and de-noising of DICOM images concentrating on liver images.

Keywords—DICOM, Histogram, Medical Imaging, Computed Tomography (CT), Grayscale.

I. INTRODUCTION

As digital technologies are incorporated in every aspect of our lives, they are also the key part of medical diagnosis. DICOM (Digital Imaging and Communications in Medicine) standard was developed to make sharing of medical information safe and above all standardized [1]. With the improvement of medical devices level, most hospitals have been already equipped with a variety of digital imaging equipments, and, PACS, picture archiving and transmission system, has been established. PACS is very important in modern hospital, the key technical problem needed to be solved is to unify the image data formats and data transmission standards of all various digital imaging devices. DICOM is generated for this purpose [2].

II. MATERIAL AND METHOD

The datasets were acquired from ELMOGY scanning center in MANSOURA city and these images are 512 by 512 pixel and these results are obtained using MATLAB R2014a.

III. PROPOSED ALGORITHM

A systematic overview of the proposed technique is shown in the following figure:
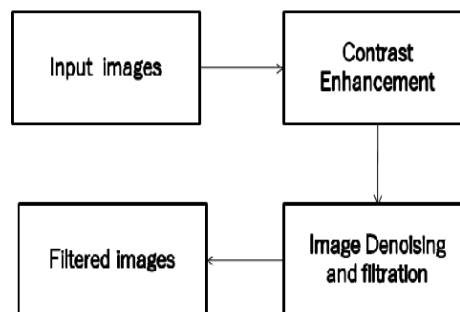

Figure 1: Flow chart of the proposed algorithm.

IV. MATERIAL AND METHOD

The datasets were acquired from known scanning centre in MANSOURA city and these images are 512 by 512 pixel and these results are obtained using MATLAB R2014a

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A. Read Medical Image

DICOM files contain metadata that provide information about the image data, such as the size, dimensions, bit depth, modality used to create the data, and equipment settings used to capture the image. To read metadata from a DICOM file, use the dicominfo function. dicominfo returns the information in a MATLAB structure where every field contains a specific piece of DICOM metadata. You can use the metadata structure returned by dicominfo to specify the DICOM file you want to read using dicomread [2].

B. Convert a data matrix to a greyscale image

A gray scale image (also called gray-scale, gray scale, or gray-level) is a data matrix whose values represent intensities within some range. MATLAB stores a gray scale image as an individual matrix, with each element of the matrix corresponding to one image pixel [3].

Gray scale imaging is sometimes called "black and white," but technically this is a misnomer. In true black and white, also known as halftone, the only possible shades are pure black and pure white. The illusion of gray shading in a halftone image is obtained by rendering the image as a grid of black dots on a white background (or vice versa), with the sizes of the individual dots determining the apparent lightness of the gray in their vicinity. The halftone technique is commonly used for printing photographs in newspapers [6].

C. Intensity Transformation (Gamma Transformation)

The command (in MATLAB) that implements contrast processing is the *imadjust*. Using this, the contrast in an image can be enhanced or degraded if needed. Moreover, a very useful result can be the inversion of colours, especially in gray scale images, where an object of interest can be efficiently outlined.

D. Image De-Noising

Medical images are subject to a wide variety of distortions, during acquisition, processing, compression, storage, transmission and re-production, any of which may result in a degradation of visual quality. Images such as magnetic resonance imaging, computed tomography, ultrasound, X-ray images are collected by different types of sensors and they are contaminated by different types of noises. Noises include speckle noise, Gaussian noise ….etc.

Normally, low quality images are not effective and very difficult to measure. Therefore, there is a fundamental need of noise reduction form medical images. Generally speckle noise; Gaussian noise noises mostly occurred in the MRI, CT scan and ultrasound images. In medical image processing many methods are used for noise reduction. Each method can effectively working any one of the noise only not for all types of noises. Noise removal filters can produce the best results depends upon its parameter [11].

1) *Median Filter:* The median filter is a popular nonlinear digital filtering technique, often used to remove noise. Such noise reduction is a typical pre-processing step to improve the results of later processing (for example, edge detection on an image). Median filtering is very widely used in digital image processing because under certain conditions, it preserves edges while removing noise [12].

2) *Wiener filter:* Wiener filters are basically the optimum linear filters which involves linear estimation of a desired signal sequence from another related sequence while solving the linear filtering problem certain important parameters like mean and correlation functions of useful signal and unwanted additive noise are assumed. Now the aim is to design a linear filter whose input is the noisy data and output is required to minimize the effect of noise. The filter optimization problem is to minimize the value of MSE that is defined as mean square value of error.

3) *Gaussian filter:* Gaussian filter are a class of low-pass filter, all based on the Gaussian probability distribution function used to blur images and remove noise and detail. In one dimension, the Gaussian function is here in the following equation:

$$G(x) = \frac{1}{2\pi\sigma^2} \cdot e^{-\frac{x^2}{2\sigma^2}}$$

Equation (1): 1D Gaussian filter equation

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Where σ is the standard deviation of the distribution .The distribution is assumed to have a mean of 0. Shown graphically, we see the familiar bell shaped Gaussian distribution, where a large value of σ produces to a flatter curve, and a small value leads to a "pointier" curve. Figure 2 shows examples of such one dimensional Gaussian.
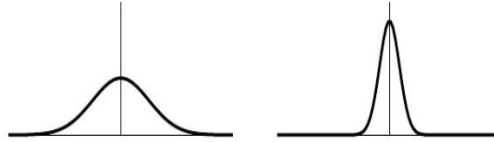

Figure 2: One Dimensional Gaussians.

4) *Diffusion Filter:* The key point in effective speckle noise removing is balance between speckle suppression and feature preservation. Diffusion filter is an effective technique for goal achievement. Behind this development is solution of partial differential equation (PDE) of transient permeability for 2D domain. Due to its nonlinear nature and adaptive anisotropy the filter has excellent both speckle reduction and detail preserving properties [15].

V. IMAGE QUALITY EVALUATION PARAMETERS

A. Pixel Difference Measurement

1) *Mean Square Error (MSE):* Mean square error is a dominant quantitative performance metric in the field of image processing. It is used for the assessment of image quality and fidelity. The cumulative squared error that occurs between compressed and original form of image is termed as MSE. It is mathematically defined in the following equation [13].

$$MSE = \frac{1}{m\,n} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2$$

Equation (2): Mean Square Error Equation

Where m is the number of rows in the image, n is the number of column in the image I(i,j) is noisy image and K(i,j) is de-noised image.

2) *Peak Signal to Noise Ratio:* PSNR is mathematically described as in the following equations:

$$PSNR = 10 \cdot \log_{10} \left(\frac{MAX_I^2}{MSE} \right)$$
$$= 20 \cdot \log_{10} \left(\frac{MAX_I}{\sqrt{MSE}} \right)$$
$$= 20 \cdot \log_{10}(MAX_I) - 10 \cdot \log_{10}(MSE)$$

Equations (3): Peak Signal To Noise Ratio Equations

Here, MAX_I is the maximum possible pixel value of the image [12]. When the pixels are represented using 8 bits per sample, this is 255and if the input image has a double precision data type, $MAX_I =1$[7]. The PSNR value approaches infinity as the MSE approaches zero. Higher value of PSNR of de-noised and original image implies that the performance of the de-noising filter method and visual quality of the de-noised image is good [11].

B. Human Visual Based Measurement (HVS)

Human Visual System (HVS) is another approach of measuring image quality .The HVS is a method that uses human eye as a reference. The main idea is that humans are interested in different attributes of the image other than taking it as a whole. These attributes include brightness, contrast, texture, orientation…etc.

Structural Similarity Index: The structural similarity (SSIM) index is a method for measuring the similarity between two images. The SSIM index is a full reference metric; in other words, the measuring of image quality based on an initial uncompressed or distortion-free image as reference. SSIM is designed to improve on traditional methods like peak signal-to-noise ratio (PSNR) and

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mean squared error (MSE), which have proven to be inconsistent with human eye perception.

The difference with respect to other techniques mentioned previously such as MSE or PSNR is that these approaches estimate perceived errors; on the other hand, SSIM considers image degradation as perceived change in structural information. Structural information is the idea that the pixels have strong inter-dependencies especially when they are spatially close. These dependencies carry important information about the structure of the objects in the visual scene [14].
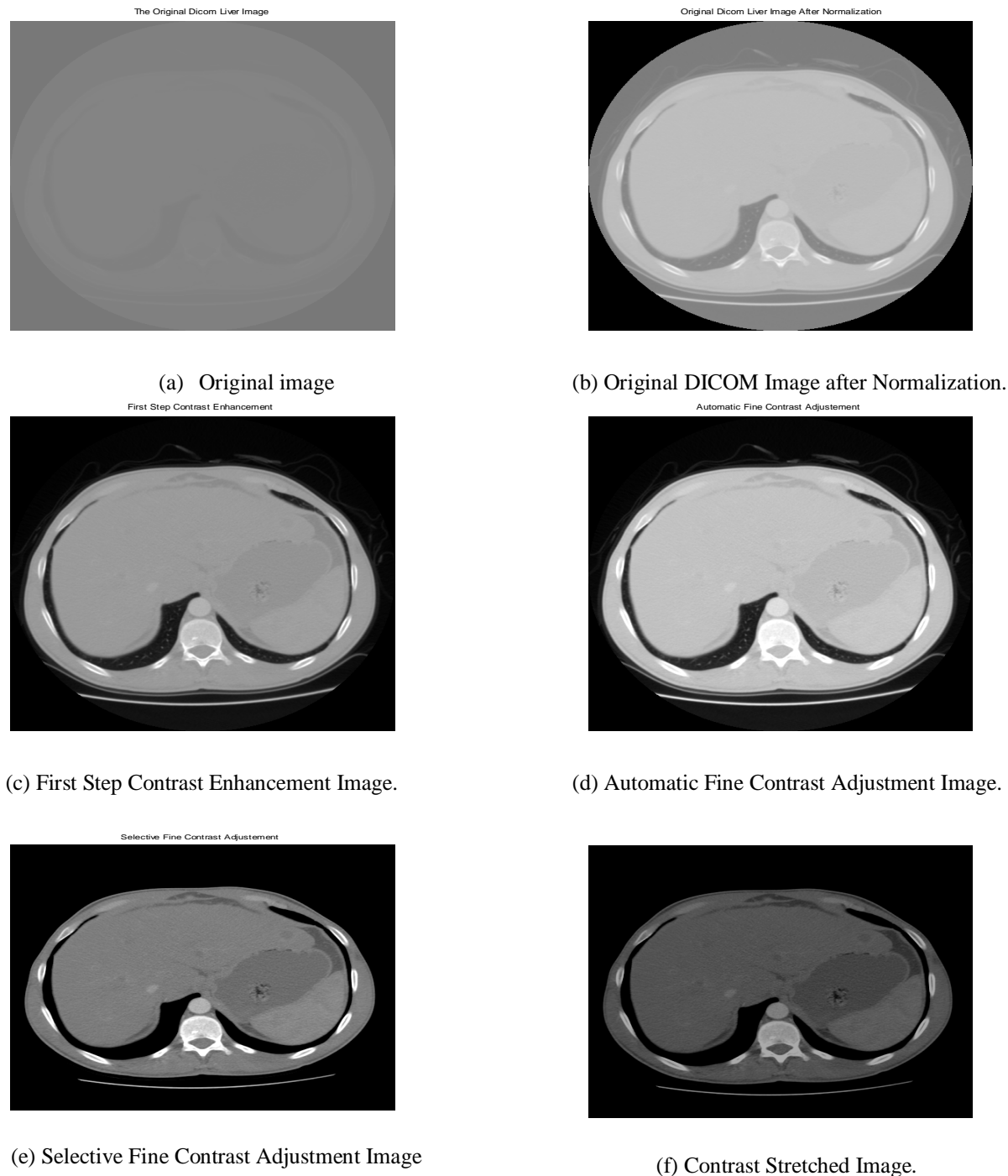
VI. SIMULATION AND RESULTS

(a) Original image

(b) Original DICOM Image after Normalization.

(c) First Step Contrast Enhancement Image.

(d) Automatic Fine Contrast Adjustment Image.

(e) Selective Fine Contrast Adjustment Image

(f) Contrast Stretched Image.

Figure 3: The Steps of DICOM Liver Image Enhancement

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VII. IMAGE QUALITY EVALUATION PARAMETERS VALUES

A.   Images with applied speckle noises on it

TABLE 1: IMAGE QUALITY PARAMETER AFTER APPLYING SPECKLE NOISE AND FILTERED THE IMAGE.

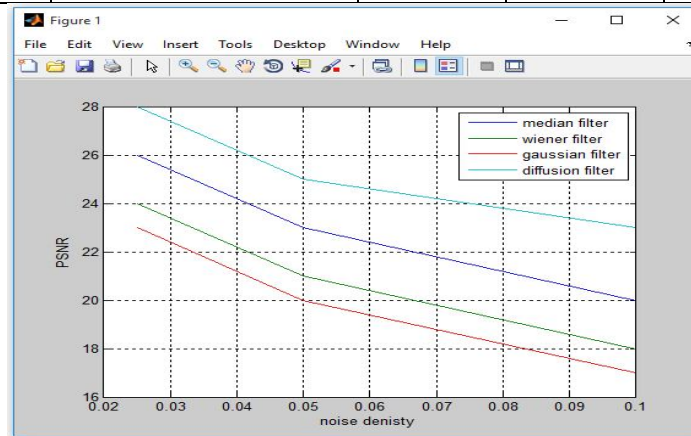| Parameters		PSNR	MSE	SSIM
Median filter	Noise Density =0.025	26.76	204.70	0.82
	Noise Density =0.05	23.85	296.79	0.78
	Noise Density =0.1	20.93	502.78	0.75
Wiener filter	Noise Density =0.025	24.79	215.33	0.91
	Noise Density =0.05	21.29	450.01	0.92
	Noise Density =0.1	18.67	610.14	0.92
Gaussian filter	Noise Density =0.025	23.92	263.52	0.96
	Noise Density =0.05	21.14	469.89	0.96
	Noise Density =0.1	18.27	630.04	0.95
Diffusion Filter	Noise Density =0.025	28.14	190.42	0.80
	Noise Density =0.05	25.92	210.61	0.79
	Noise Density =0.1	23.39	280.26	0.77

Figure 4: The Relation between PSNR and Noise Density.

B.   Images with applied Gaussian noises on it

TABLE 2: IMAGE QUALITY PARAMETERS AFTER APPLYING GAUSSIAN NOISE AND FILTERED THE IMAGE.

Parameters		PSNR	MSE	SSIM
Median filter	Noise Density =0.025	21.78	475.41	0.63
	Noise Density =0.05	21.41	486.68	0.64
	Noise Density =0.1	13.19	1115.	0.65
Wiener filter	Noise Density =0.025	18.61	620.00	0.79
	Noise Density =0.05	16.6	903.39	0.77
	Noise Density =0.1	12.97	1076.49	0.75
Gaussian filter	Noise Density =0.025	17.16	786.77	0.89
	Noise Density =0.05	15.49	835.96	0.89
	Noise Density =0.1	12.32	1106.51	0.89
Diffusion Filter	Noise Density =0.025	24.27	216.49	0.54
	Noise Density =0.05	23.85	238.83	0.52
	Noise Density =0.1	23.30	267.85	0.50

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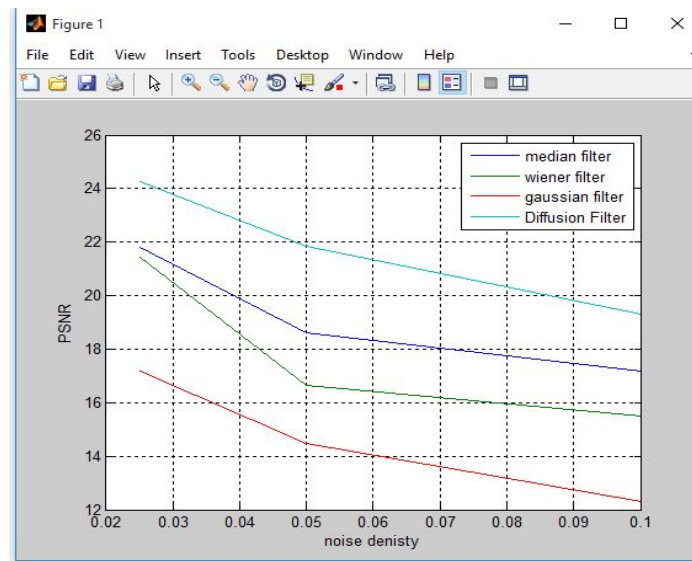

Figure 5: The relation between PSNR and Noise Density

Figure 6: The Image after Applying Diffusion Filter

VIII.   CONCLUSION

This study describes the method to improve the quality of DICOM image. The goal of the image enhancement technique is to improve a characteristic or quality of an image and removing the noise of these images, such that the resulting image is better than the original. Also from the above study diffusion filter is suitable for denoising the most of noises forms.

IX. FUTURE WORK

 In the future we will develop an algorithm for liver tumour extraction and liver tumour analysis and propose an algorithm for classification for the type of tumour

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