A COMPREHENSIVE STUDY OF CONTRAST ENHANCEMENT MEDICAL IMAGE USING VARIOUS WAVELETS TRANSFORM

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Abstract— with the development in the digital imaging techniques, an image enhancement is one of the characteristic of image. The medical image enhancement is one of the application, these data can be suffer from some of the unnecessary noise, lack of contrast, sharpening and distort images due to these flaws we obtain false report for diagnosis of diseases. So for improving the quality of the medical image data various methodologies has been developed and proposed by different researchers. In this paper, we present literature of some of the techniques for enhancing the quality of medical digital image data and also describe their advantage and disadvantages.

Keywords—Contrast Enhancement, Medical digital image, Sharpening, Discrete wavelet transform.

1. INTRODUCTION

Rapid growth of the digital imaging techniques, it is widely used for various application like in forensic, weather forecasting, medical field etc. Due to some reasons unwanted flaws such as noise, blurring image which can disrupt the quality of image and generates the false report by which it becomes much complicated to recognize the particular disease , so it becomes very necessary to diminish these flaws to obtain good quality of image. Image enhancement is the development of processing digital images so that the results are more suitable for display or further analysis. Image enhancement plays an important role; people make important decision based on the image information. The techniques of medical image enhancement are used to improve some useful information in an image for doctors to diagnose, and remove or reduce some unwanted information. It is a very important part in medical image Processing and CAD. Medical imaging plays a leading role in modern diagnosis and contrast enhancement of medical image is useful in helping radiologist or surgeons to detect pathologic or abnormal regions. Enhanced processing of medical images is good for presenting a clear human tissues and organs, and is also good for aided diagnosis.

The traditional technology of the medical image enhancement includes spatial domain method and frequent domain method. Spatial domain method could be divided into point arithmetic algorithms and neighborhood enhancement algorithms concretely. Point arithmetic algorithms include gray-level transform and histogram equalization. Gray-level transform is used to expanding the scope of the gray-level of whole image and extending the contrast of image, but it is very easy to lose the details of image. Histogram equalization is a simple and effective contrast enhancement technique of the medical image processing and many other applications [1]. Histogram equalization may ensure the uniform distribution of gray levels, but it cannot highlight the edges of the image and it is difficult to control the effects of enhancement. Neighborhood enhancement algorithms include image smoothing and image sharpening. The Image Smoothing is used to eliminate image noise in general, but it is also more likely to occur fuzzy edge. The purpose of the image sharpening is to emphasize the edge, but image sharpening also weakens image contrast. The frequency domain method includes low-pass filtering, high-pass filter and homomorphism filtering.

There is a lot of shortcoming of the traditional image processing method in the field of medical image. It usually processes the whole image, and this will hide both partial and specific information partly, and these methods will be interfered by the noise easily. Therefore, it cannot meet the requirements of the medical image processing.

2. PROBLEM STATEMENT

This type of images suffers from following problems:

- Accuracy degraded while multi-region segmentation.
- Some time information losses while processing with intensity preserving with enhancement.
- Combinatorial optimization problem.
- Convex optimization problem.
- Sometime original image patches does not provide correct information specified.

The rest part of the paper is organized as follows: Section III describes about the literature of the image enhancement proposed by the researcher. Section IV explained about the image enhancement techniques, Section V includes the expected outcomes of the proposed approach and last section presents conclusion of the paper.

3. LITERATURE SURVEY

To improve the quality or perception of the image different researchers proposed or implemented various approaches. In this section literature of the related work about the enhancement of the medical digital images is discussed.

In 2014, **Tarun Kumar Agarwal et al. [2**] proposed a new method named (MH-FIL) for medical images. This method uses two step processing, in first step global contrast of image is enhanced using histogram modification followed by histogram equalization and then in second step homomorphic filtering is used for image sharpening, this filtering if followed by image normalization.

To evaluate the effectiveness of our method we choose two widely used metrics Absolute Mean Brightness Error (AMBE) and Entropy. Based on results of these two metrics this algorithm is proved as a flexible and effective way for medical image enhancement and can be used as a pre-processing step for medical image understanding and analysis.

In 2014, Hong-Seng Gan et al. [12] suggested implementing cubic spline to lessen the difference in pixel intensity earlier to histogram equalization whereas retaining the partition of histogram to check dramatic mean brightness shift in resultant image. Qualitative results represent that our suggested contrast enhancement technique is efficient in avoiding extreme brightness elevation and excessive tissue contrast improvement to give holistic views of the knee MR images. Later, we would like to propose the development of adaptive data interval to substitute the uniform data point intervals.

In 2013, Xue Mei Li et al. [4] proposed a novel method of image enhancement with respect to the fractional Fourier transform is presented. This method filters image in the fractional Fourier domain instead of the Fourier domain which is usually applied to the classical image enhancement. The fractional Fourier transform has a rotation angle a, characters of image thus change in different transform domain. In a proper fractional Fourier domain with angle a, ideal low-pass filter makes image smoother and ideal high-pass filter loses less information of image than in the traditional Fourier domain, which provides an alternative way to enhance image with proper filter designing.

In 2013, Bhateja, V. et al. [10] proposed a truncated Volterra filter combination to provide contrast enhancement as well as texture based processing of masses in digital mammograms. Noteworthy improvement in visualization of masses has been observed in the simulation results carried out on cases from DDSM database. The improved performance of the proposed filtering approach is well supported with calculated values of objective evaluation parameters.

In 2012, Akram, M.U. et al. [9] presented a method for improving, locating and segmenting blood vessels in images of retina by employing a method that uses 2-D Gabor wavelet and sharpening filter to augment and sharpen the vascular pattern correspondingly. This method locates and segments the blood vessels using edge detection algorithm and morphological operations. This method is tested on freely accessible STARE database of manually labeled images which has been accustomed to make possible relative studies on segmentation of blood vessels in retinal images. The approval of our retinal image vessel segmentation method is supported by experimental results.

In 2011, Hanan Saleh S Ahmed et al. [3] proposed a method start by the median filter for eliminating the noise from images comply by unsharp mask filter which is close to the accustomed type of sharpening. Medical images were generally poor quality particularly in contrast. For resolving this involvedness, they proposed Contrast Limited Adaptive Histogram Equalization (CLAHE) which is one of the methods in a computer image processing domain. It was used to advance contrast in images. For testing reason, diverse sizes and assorted types of medical images were used and more than 60 images in different parts of the body. From the experts' evaluation, they noted that the enhanced images improved up to 80% from the original images depends on medical images modalities. The proposed algorithms results were significant for increasing the visibleness of relatively details without distorting the images.

In 2011, Maitra, I.K et al. [6] presented a completely automated segmentation and boundary detection technique for mammographic images. Here they have proposed a novel homogeneity improvement method specifically Binary Homogeneity Enhancement Algorithm (BHEA) for digital mammogram. That is accompanied by a novel method for edge detection (EDA) and lastly obtaining the breast boundary by using our proposed Breast Border Boundary Enhancement Algorithm. This fused method have been carry out and applied to mini-MIAS, widely known as mammographic databases consisting of 322 mediolateral oblique (MLO) view obtained via a digitization procedure. To express the potential of our segmentation algorithm it was broadly tested on mammograms employing ground truth images and quantitative metrics to estimate its performance characteristics. The experimental results designates that the breast boundary regions were extracted precisely characterize the corresponding ground truth images. The algorithm is fully autonomous, and is able to preserve skin and nipple (if in profile), a task very few existing mammogram segmentation algorithms can maintain.

In 2010, Kumar Gunturu, V. et al. [8] presented a proficient improvement algorithm of digital mammograms based on wavelet analysis and modified mathematical morphology. In this proposed method, they adopted a wavelet-based level dependent threshold algorithm and modified mathematical morphology algorithm to augment the contrast in mammograms to relieve extraction of suspicious regions known as regions of interest (ROIs). The experimental results show that the proposed algorithm gives considerably superior image quality and improved Contrast Improvement Index (CII). Here, to prove the efficiency of this method, they have compared this with different well-known algorithms like Visu-Shrink and Normal Shrink.

In 2009, Zouari, M. et al. [11] proposed a new approach for enhancing micro-calcifications in digitized mammogram digitized mammogram, emphasizing corresponding gray level details. Accordingly, they proposed an adaptive exponential function which creates a local modification of gray level to highlight details which are potential carriers of micro-calcifications. They have applied the NLS twice: locally and globally. The performance of micro calcification's enhancement method is developing using Farabi Digital Database of Screening Mammography (FDDSM). Performance results are given in terms of the Second-Derivative-like Measure of enhancement (SDME). Our proposed approach achieves 118 of the local NLS and 115 of the Global NLS.

In 2007, Her-Chang Pu et al. [7] proposed a novel HVS-directed neural network based adaptive interpolation scheme for natural image is proposed. The fuzzy decision system designed from the characteristics of the human visual system (HVS) is proposed to organize pixels of the input image into human sensitivity i.e. non-sensitive class and sensitive class. The High-resolution digital images along with supervised learning algorithms are used to involuntarily educate the proposed neural network. Experimental results demonstrated that the proposed new resolution enhancement algorithm can construct advanced visual distinction of the interpolated image than the conventional interpolation methods. The fuzzy decision rules stimulated by human visual system (HVS) are proposed to scrutinize the sensitivity of human eyes to the image for exclamation.

In 2002, Haiguang Chen et al. [5] proposed a filtering algorithm for fast image enhancement. The algorithm tries to compose the minimum modification on the original image structures whereas it performs noise smoothing at a given filtering level. The filtered image is a weighted combination of four sub-images obtained from low-pass filtering the original image along four major directions. The weighting on each sub-image is controlled by the differences between these sub-images and the original image .The resulting image is then non symmetrically sharpened to amplify the image structure boundaries, The whole effect of this filtering structure is effective adaptive noise reduction and edge enhancement with an efficient implementation using array processors. The high regularity and parallelism of the algorithm also makes it acceptable for its efficient implementation using very large scale integrated (VLSI) circuits or multiprocessor systems. The execution of the algorithm in effectively reducing image noise and preserving/enhancing important image structures is discussed and demonstrated using several MR images from a low-field-strength MR imaging system.

4. FORENSIC DIGITAL IMAGE ENHANCEMENT TECHNIQUES

In this section, different image enhancement techniques to improve or to get the better quality and to increase the perception or visibility of images are described below such as histogram equalization, filtering method, wavelet based and Image fusion method etc.

A. Histogram Equalization

The histogram equalization methods which transform the dynamic range & contrast level of an image such that its Concentration histogram has a requisite shape. Histogram equalization [13] operators can be betrothed for non linear & non-monotonic transfer function for mapping between input and output images pixel intensity values.

Histogram equalization utilizes a monotonic and non-linear mapping which re-assigns the flat histogram (uniform distribution of intensities) for the diverse intensity value pixels in the output image as well as input image. This method is used for image comparison & correction in the non linear process. (Because it is used to enhance the image quality), which introduced by a digitizer or display system improvements.

If we transform the input image to get $s = T(r)$
Here s and r represents the probability density function of Ps and Pr respectively then Ps can be represented by a simple formula

$$P_s(s) = P_r(s)\frac{dr}{ds} \qquad \textbf{(1)}$$

Where r =T^{-1}(s)

Consider the transformation

$$S = T(r) = \int_0^r P_r(W)\,dw \qquad \textbf{(2)}$$

Known transformation function T(r) we can get Ps so that Ps(s) tracks nearly uniform distribution which results in histogram equalized image. Histogram equalization increases the intensity values up to its self-motivated range as well as it flatten the histogram. In many images we found the satisfactory result using histogram equalization technique but sometimes it over enhance the image due to its global treatment.

B. Discrete Wavelet Transform (DWT)

The discrete wavelet transform (DWT) [14] is an accomplishment of the wavelet transform using a detached set of the wavelet scales for numerical analysis and functional analysis. A time-scale depiction of a digital signal is obtained using digital filtering method. In the detached wavelet transform, filters of unusual cut-off frequencies are used to investigate the signal at different scales. If the wavelets are discretely sampled, the resulting coefficients are called as discrete wavelet transforms (DWT) [15].

$$f[n] = \frac{1}{\sqrt{M}}\sum_k W_\varphi[j_0,k]\varphi j_{0,k}[n] + \frac{1}{\sqrt{M}}\sum_{j=j_0}^{\infty}\sum_k W_\varphi[j,k]^\varphi j,k[n] \qquad \textbf{(3)}$$

$$W_\varphi[j_0 - k] = \frac{1}{\sqrt{M}}\sum_n f(n)\varphi_{j_{0,k}}[n] \qquad \textbf{(4)}$$

The signal is worked out by a series of high pass filters & a series of low pass filters to investigate the high frequencies & the low frequencies of the detached time domain signal, which is viewed in figure-1and known as the Mallat algorithm or Mallat-tree decomposition [16].

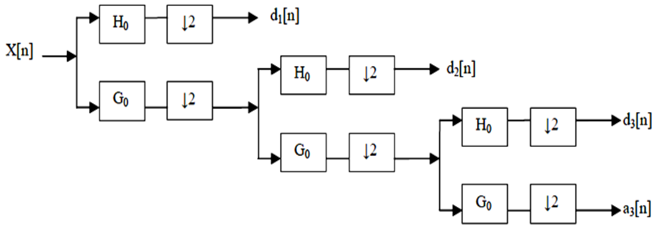

Figure.1 Three- level wavelet decomposition tree

In the figure.1, the signal is represented by the sequence x[n], where n is an integer. The low pass filter is represented by G0 whereas the high pass filter is indicated by H0. At each level, the high pass filter generates brief information d[n], whereas the low pass filter is related with scaling function produces coarse approximations, a[n]. This decomposition is recurring to additional augment the frequency resolution and the projected coefficients divided with high and low pass filters and then down-sampled. This is corresponds to as a binary decomposition tree with nodes representing a sub-space with diverse time-frequency localization. The tree is acknowledged as a filter bank.

C. Median filter

The Filtering is an ingredient of image enhancement which is used to augment definite details such as edges in the image that are pertinent to the application. In addition to that, filtering can also be used to eradicate unwanted elements of noise. Medical images generally contain salt and pepper noise.

This noise appears due to the occurrence of minute gray scale variations in the image. Median filtering is a well-liked technique of the image enhancement for removing impulse noise exclusive of efficiently reducing the image sharpness [17]. Median filter is quite common because it provides excellent noise-reduction abilities, with basically less blurring than similar size linear smoothing filters. Here, the median process was performed by sliding a 3×3 windowing operator over the image. It considers every pixel and its neighbors in images to find out whether or not it is a representation of the surroundings. It replaces the value of pixel with the median of the neighboring pixel elements. We calculated the median by sorting the whole pixel values from the neighborhood into numeral sort and then replaced the pixel being studied with the middle pixel value. If the locality under condition constitutes an even pixels value, the average of the two middle pixel values is the median.

D. Dual Tree Complex Wavelet Transform (DT-CWT)

One effective approach for implementing an analytic wavelet transform, first introduced by Kingsbury in 1998, is called the dual-tree CWT [54], [55], [57]. Like the idea of positive/negative post-filtering of real subband signals, the idea behind the dual-tree approach is quite simple. The dual tree CWT employs two real DWTs; the first DWT gives the real part of the transform while the second DWT gives the imaginary part. The analysis and synthesis FBs used to implement the dual-tree CWT and its inverse is illustrated.

D. Unsharpmask filter

Unsharp filtering is an uncomplicated sharpening process that gains its name from the study that it improves edges and other high frequency components in images through a process that deducts a smoothed or unsharp version of images from the input images. In our study, the use of the classical unsharp masking filters after median filter to reduce of the remained noise and sharpen the edges. Firstly it is obtained a blurred form of the original image.

This is carried out by applying the low-pass filter, in our case Gaussian blur algorithm using a small radius. We used a two pixel radius and applied Gaussian blur filter only two times [3]. The blurred form of the image is then pixel deducted from the original image and so it is obtained the high pass component. The output image is obtained by adding the high-pass component to the original image. Because the output image could also contain pixels with negative values, it is then normalized. No threshold cutoff was used. The two steps for the unsharp mask filter are mentioned below:

- Unsharp mask filter creates edge images g(x, y) from input images f(x, y) in this Eq. 5.

$$g(x,y) = f(x,y) - fsmooth(x,y) \quad \textbf{(5)}$$

Where, $fsmooth(x,y)$ is a smoothed form of f(x, y) as shown in figure 2.

- An edge images from the consequence of subtracting input images from low pass signal could be utilized for images sharpening by adding it backward into the input signal, as demonstrated in Fig. 3. This function is represented as follows:

$$fsharp(x,y) = f(x,y) + k * g(x,y) \quad \textbf{(6)}$$

Where, k is a scaling constant, values for k (k≥0), for generally. When k>1, the process is referred to as high boost filtering. In our process, we have applied k=1.

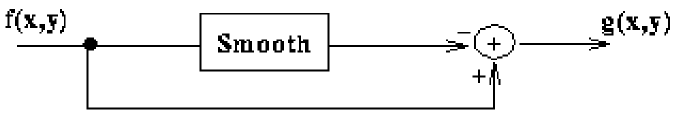

Figure 2: Spatial sharpening

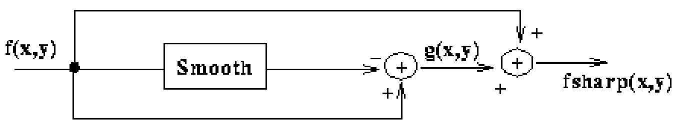

Figure 3: The complete unsharp filtering operator

The basic advantage of the unsharp filtering over other sharpening filters is the control flexibleness, because a vast majority of other sharpening filters do not supply any user-adjustable parameters. Unsharp filtering as other filters enhances fine detail and edges in digital images.

E. Cubic Spline Smoothing

Spline interpolation is perceived to be user friendly to wide gamut of industrial applications. For example, cubic spline representation has been the popular tool in various computer-aided modeling applications such as aircraft, automobile and ship design where the design of precise and smooth shape is of utter importance. Prior to the advent of spline art, designers have to use flexible ruler to draw smooth curves for their product design, which is subjected to human error. Moreover, spline could play vital role in estimating the chemical rates of change and analyzing large scale of numerical data obtained from experiments accurately. Hence, we use spline interpolation to design smooth curve that could taper large pixel intensity fluctuation in MR image of knee. Cumulative density function is sine qua non for the construction of transform function. To initiate HE, luminance levels available in MR knee image are interpreted as random variables in the range [0, L−1]. The probability density function, which is invariably described through histogram, is used to estimate the distribution of the random variables.

The cumulative density function, as illustrated in Figure 4, is derived from the probability density function and then used to remap the intensity distribution to enhance the contrast.

Since transform function derived from statistical information considers only original cumulative density function as the medium to remap the distribution of luminance level, additional effort is necessitated to ensure the transform function does not lead to excessive brightness enhancement of the MR knee image.

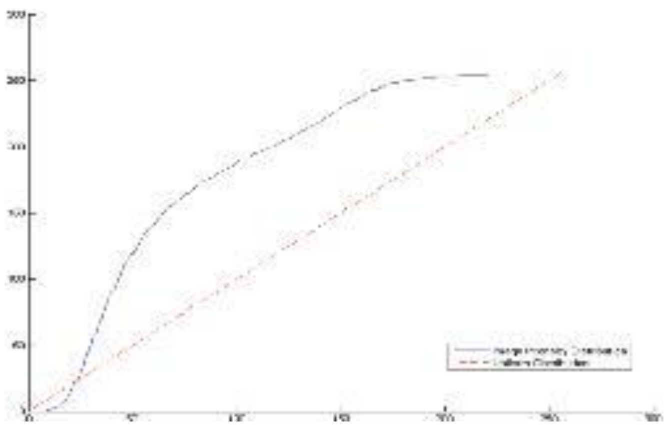

Figure 4: Cumulative density function (blue line) of MR image relative to uniform distribution (red dotted line).

For illustration, up arrow indicates sharp intensity increment in output image as a result of traditional histogram equalization, which led to over-enhancement

5. PROPOSED WORK

In the proposed approach, wavelet transformation is used, where original images will decompose into the sub bands with intensity level and brightness preserving.

Proposed approach consists of two phase's one DTCWT transformation of high band and the image fusion of low band. The contrast enhancement techniques provided here starts with the DWT transformation of images which removes blurriness and provides restoration of image. Here the Low pass band of the images is used for the restoration purpose where we apply adaptive intensity concept and the pixel intensity gets smoothened out which is fused with the other sub bands of the image pixels and then inverse DWT is applied on the fused and the smoothened image to get the restored image consisting of enhanced contrast and brightness preserved.

The expected proposed approach will follows the following major steps:

1. Take medical images as input.
2. Apply segmentation and decompose input image into multilayer.
3. Apply different enhancement process into the each decomposed layer.
4. Preserve brightness level.
5. Apply smoothening with specific filter in one layer.
6. Apply weight function the again smoothing.
7. Apply enhancement process into other layers.
8. Choose soft computing technique for better feature selection and for enhancement of best result.
9. Composed/fuse all enhanced parts with specifies input condition.
10. Performance evolution using: MSE, PSNR, etc.

6. CONCLUSION

Image enhancement is widely used technique to extract the noise, and blurred image from the large set of medical data to diagnosis the diseases of different categories efficiently. This paper, explains several approaches to improve the quality of the medical image dataset such as histogram equalization and filtering method to reduce noise and sharpening the edge of the big medical digital image data. In this also describes the advantages and disadvantages of the methods presented by different authors in table 1. In the future work, we would try to develop an algorithm which can effectively reduce the noise and improve the quality of image without including background noise and preserve the original detail of image.

Table 1: advantages and disadvantages of different approaches presented in the literature survey

Author	Approaches/Method	Publication Year	Advantages	Disadvantages
Hanan Saleh S. et al.	CLACHE	2011	It efficiently improve the visibility of image without Distortion	It is not able to decrease the noise from image
Xue Mei et al.	Fractional Fourier transform	2013	It makes the image smoother and loses less information of images	It is complacency with rotating additives partially
Haiguang Chen et al.	Filtering Algorithm	2002	It is able to reduce the noise from images effectively	It loses the original information of the image
Maitra, I.K et al.	Binary Homogeneity Enhancement Algorithm (BHEA)	2011	It is fairly robust, quick, and parameter free except	It is much expensive and complex
Her-Chang Pu et al.	HVS-directed neural network based adaptive interpolation	2003	Easy to implement and smooth image is formed	It is much costly and bulky in design
Kumar Gunturu, V. et al.	wavelet-based level dependent thresholding algorithm and modified mathematical morphology algorithm	2010	Provide better image quality also enhance the contrast of image	It produce false positive rate and negative rate
Akram, M.U. et al.	2-D Gabor wavelet and sharpening filter	2009	It provide better looking image	It is much time consuming
Bhateja, V. et al.	truncated Volterra filter Combination	2013	This method is able increase the contrast of original image	leads to high estimation-error variance and to slow convergence
Zouari, M. et al.	adaptive exponential function	2014	This approach is able to reduce noise and preserve the original information of image	It is discriminate and include background noise
Hong-Seng Gan et al.	cubic spline method	2014	This method is mainly helpful in sharpening the image efficiently	It introduces cut at the threshold of image

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