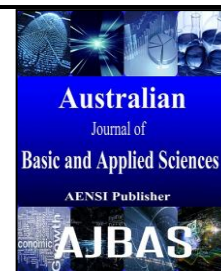




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Medical Image Enhancement Using Adaptive Wiener Filter And Contrast Stretching Techniques

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ABSTRACT

Medical Images obtained from medical acquisition devices may give poor image quality and affected by several types of noises. Image enhancement and noise smoothening techniques introduced to solving these problems. The idea of image enhancement is to improve the quality of an image for early diagnosis. The proposed techniques start by removing noise from medical images using adaptive wiener filter. This filter also preserves edges and retains originality of an image. Then, high frequency coefficients of medical images decomposed using discrete wavelet transform. Followed by a wavelet transformation using multilevel contrast stretching algorithm for enhancing the degraded medical image. This algorithm works on inter object level for approximation of an image and intra object level for error image. The enhanced image obtained through inverse wavelet transform. By using MATLAB coded and tested for different parts of the body and different sizes of CT-scanned images. The performance of resultant image is evaluated using various parameters. The enhanced images improved in quality, contrast, sharpness, free from noise and maintained homogeneity of original image.

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INTRODUCTION

Image Processing:

The digital image can be optimized for the application by enhancing or altering the appearance of structures within it based on: body part, diagnostic task and viewing preferences. It should be possible to analyze the image in the computer and provide indication to the radiologists to help detect important and suspicious structures. Process of an image processing is conversion of input image from one form to another such as digital image; these digital images are play vital in real world application like medical images, satellite images, and so on. During conversion the output images are having possible to the form of degradation, so need to improve the quality of an image. Improvement can be achieved by applying the enhancement techniques.

Image Enhancement:

Image enhancement is a process of an image so the output image is better than original image for a specific application. It is to improve the appearance of an image and also improve the perceptibility of information contained in an image. Because of enhancing structural features can improve perceived

image quality. Here enhances the information inside the image selectively and restrains original information. Due to this, easy to detect and recognize useful information. So, the application is to select the enhancement techniques. The objective of an image enhancement is to change or modify the quality of an image for specific application. Enhancement is preprocessing step for other image processing purposes such as the diagnosis of diseases, object detection, classification, and recognition on sets of images. But the problem will arise when an image enhancement procedure is used as a preprocessing because it requires an objective criterion for enhancement and an external evaluation of quality. To overcome this problem here proposes the automatic image enhancement technique to improve the image quality and contrast.

Enhancement Techniques:

Techniques are to enhance the structural features of an image and also increase the contrast level. The goal of an enhancement techniques are improving the interpretability of information contained in an image and change or modify the attributes for giving better performance of a given task. For choosing of an attributes are depends on techniques and given

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application or task. Image enhancement is to enlarge the object without degradation and extract the hidden details and also increase intensity of an image. Two major techniques are categorized in image enhancement:

- Spatial domain method
- Frequency domain method

First one is spatial domain method, is based on direct manipulation of pixels in an image. The pixel values are modified based on objective. This method denoted by the simple expression:

$$g(x, y) = T(f(x, y))$$

Where,

$f(x, y)$ – is input image

$g(x, y)$ – is output image

T – is function of f

Second method is frequency domain method, it is to compute the Fourier transform of an image then operations are performed on the transformed image. This paper presents the multilevel contrast stretching which is based on spatial domain. One of the simpler piecewise linear functions is the contrast-stretching transformation. Poor illumination, lack of dynamic range in the imaging sensor, or even an incorrect setting of a lens aperture during image acquisition can produce low-contrast images. The method used in contrast stretching consists of increasing the dynamic range of the gray levels in the image being processed. The digital image can be represented by matrices include intensity of pixel in terms of rows and columns, the color image represented by three dimensional matrices as number rows, number of columns and three colors.

Modalities of Medical Images:

The very first x-ray has been captured in the year of 1896 after this, the development of radiology grow up rapidly. Radiology includes the techniques that need not require any radiation like MRI and Ultrasound. It used to guide minimally invasive surgical procedures and to treat diseases like cancer. The scanned images or X-ray images are possibly affected by illumination, sharpness, contrast and noises, due to this degradation, and as result the diagnosis of disease becomes difficult. Medical images especially CT images are blocked by some noise and it also blocked by some form of dense tissue to create an image. Due to this degradation image quality when looking at soft tissue becomes poor.

Some of modalities are given below:

- X - Rays
- Computed tomography (CT)
- Magnetic Resonance Imaging (MRI)
- Ultrasound

X – Rays:

This modality used to create the images and for evaluation of soft tissue. Angiography and fluoroscopy are spatial applications of X-ray imaging.

Computed Tomography (or) Computer Tomography (CT):

The CT scanner, body's interior and soft tissue are identified which are bared with ease and diseased parts identified without causing pain to the patient. The scanned image produced by measuring the attenuation along rows and columns of a matrix. the information obtained from these computations and it presented in the form of two or three dimensional objects.

Magnetic Resonance Imaging (MRI):

It is noninvasive medical test that utilizes powerful magnetic field and it produce detailed images of organs, soft tissues and all other internal body structures for easy diagnosis of disease.

Ultrasound:

It uses high frequency sound waves to visualize the structures in body in real time and does not absorb any radiation.

Related work:

There are several algorithms for medical image enhancement to make an improved perception and increasing medical image quality. Enhancement done by Homomorphic filtering technique (Agarwal, T.K., 2014), image is enhanced using histogram equalization and then homomorphic filtering is applied for image sharpening, this filtering followed by image normalization. The second algorithm for image enhancement is, Non-Linear Contrast Enhancement (Anamika Bhardwaj, 2012), it decompose the high frequency components in the image and also calculating threshold value to reduce the noise. A Partial Swam Optimization (Apurba Gorai, Ashish Ghosh, 2009), is applied for corrupted image and obtained the optimized results but the contrast level limited for color images and also compared the results with other enhancement techniques.

The next algorithm is based on histogram equalization called Weighted Histogram Equalization(WHE)(Govind, V., 2013), enhanced medical images with Perona-Malik filter to remove the noise. Here calculating the weight values of histogram this values replaced with degraded pixels. The contrast enhancement technique is, CLATHE (Contrast Limited Adaptive Histogram Equalization)(Hanan Saleh, S., 2011), here enhancement done by combining contrast enhancement and histogram equalization algorithms. This paper also used median filter to eliminating the noise. This filtering is applied to different modality of medical filed. Drawback of this technique is, enhancement time might be long. The next technique is Histogram Equalization (Kim, T. and J. Paik, 2008), this algorithm works based on graphical representation of given image. Here calculating the intensity value on X-axis and total number pixels in Y-axis in degraded parts of an

image. Disadvantage of histogram equalization is unable to improve entire parts of an image and enhancement time also high.

The medical image enhancement is done using Wavelet Transformation (Kostas Haris, 1998), it uses Haar transformation to improving the contrast and also using the edge detection algorithm to preserve the edge details. The next technique is Range Compression technique (Dr. Muna, F.), objective of this paper is, taking the difference between more dark and brighter parts of an image and the dynamic range of intensity values were calculated and this range is compressed using logarithmic transformation operation. Problem of Range compression technique is dynamic range very high and mapping also complicated while enhancement.

The next algorithm is Gamma Correction (Dr. Muna, F.), which is performing non-linear brightness adjustment based on gamma value. This is suitable for only irregularly illuminated images not for all categories of an image. The next algorithm called Equalized Contrast Stretching (Saruchi, Madan Lal, 2012), Histogram Equalization used in Equalized Contrast Stretching, it reduces the contrast in very high and dark parts of image are associated with normally distributed histogram. If the input image has reduced contrast then this algorithm provide degraded image quality. In Linear Contrast (Saruchi, Madan Lal, 2012), is identify the ranges namely lower and upper bound from histogram and also apply transformation to expand the range to presented in an input image size. Color image enhancement algorithm called Virtual Histogram Approach (Umamaheswari, J. and G. Radhamani, 2012), which is combination of local and global approach and improved the visibility of particular segment of an image. Medical image enhancement is limitation of this approach.

Proposed method:

The scanned images are possibly affected by illumination, sharpness, contrast and noises, due to this degradation, and as result the diagnosis of disease becomes difficult. The proposed algorithm works effectively for medical applications. The objective of proposed work is to improve the image quality using Multilevel Contrast Stretching and eliminating the noises by using Adaptive filtering technique for medical CT scanned images. The framework for the contrast stretching is shown in Fig. 1.

Initial process of proposed work is, to eliminating additive noises from medical input image by adaptive wiener filter. This technique also preserving the edge details and other high frequency parts of an image. In addition, there are no design tasks and also handles all preliminary computations. Then decompose the noise removed image using Discrete Wavelet Transformation(DWT) to obtain the low contrast component of an image. Then Multilevel Contrast Stretching algorithm is applied to high frequency parts of an image. This technique attempts

to improve the contrast of an image by stretching the adjacent pixels, the range of intensity values contains to span a desired range of values. The low contrast components divided into two sub-images namely, approximation image and error image. Structural features enhanced at image approximation level and textural features enhanced in error image level. Finally, apply the Inverse Discrete Wavelet Transformation (IDWT) to obtain the enhanced image.

A. Adaptive Wiener Filter:

Medical images need to be extracted clearly and properly from a noisy background, drift image intensity, and low contrast pose. These noises eliminated by applying the adaptive wiener filtering function. This is a type of linear filter, applied to a medical image adaptively by calculating the local variance of an image. Based on variance filter performs smoothening, if the variance is small then wiener filter performs more smoothening. If variance is large then wiener filter performs slight smoothening.

The adaptive is more selective than a comparable linear filter, preserving edges and other high frequency parts of an image. The wiener filtering function handles preliminary computations and there are no design tasks. This filter does not have constant filter coefficients and also have no prior knowledge. And possible to adjust its parameters called adaptive filter due to this probable to adjust its coefficients to minimize an error signal. Adaptive filter gives better results than the linear filter and provide efficient performance with minimal computational time.

B. Discrete Wavelet Transform:

The Discrete Wavelet Transform (DWT) is a linear transformation that operates on a data vector whose length is an integer power of two, transforming it into a numerically different vector of the same length. It is a tool that separates data into different frequency components, and then studies each component with resolution matched to its scale. The DWT is performed for all image rows and then for all columns. The feature of DWT is multi scale representation of function. By using wavelets, given function can be analyzed at various levels of resolution. The DWT is also invertible and can be orthogonal. Wavelets seem to be effective for analysis of textures recorded with different resolution. It is very important problem in satellite imaging, because high-resolution images require long time of acquisition. This causes an increase of artifacts caused by earth movements, which should be avoided. There is an expectation that the proposed approach will provide a tool for fast, low resolution medical images.

To decompose the input image into a set of band-limited components and passes the input signal through a series of filters. A signal can be

decomposed into a set of band-limited components, called sub-bands, which can be reassembled to completely reconstruct the original image. Let $h_0(n)$ and $h_1(n)$ be analysis filters and then $g_0(n)$ and $g_1(n)$ be synthesis filters. The output of the low-pass filter $h_0(n)$ represents an approximation of $x(n)$ and the output of the high-pass filter $h_1(n)$ represents a detail part of $x(n)$. Both outputs can be down-sampled without loss of information because the bandwidth is reduced by low-pass and high-pass filtering. The input image is divided into four sub-bands depends upon Low and High intensity (LL, LH, HL, HH) with Gradient based Laplacian Transformation. Both outputs are down sampled without loss of information

because the bandwidth is reduced by low-pass and high pass filtering.

$$f(x) = \sum_{m=0}^{\infty} \sum_{n=0}^{\infty} C_n^m \psi_{m,n}(x) \quad (1)$$

Where $\psi_{m,n}(x) = 2^{-m/2} Y(2^{-m}x-n)$, are obtained by translates and dilates of the wavelet function $Y(x)$. The discrete wavelet transform coefficients C_n^m are calculated by inner products $(\psi_{m,n}(x), f(x))$ which are the estimation of signal components at $(2^{-m}, 2^m)$ in the time frequency plane.

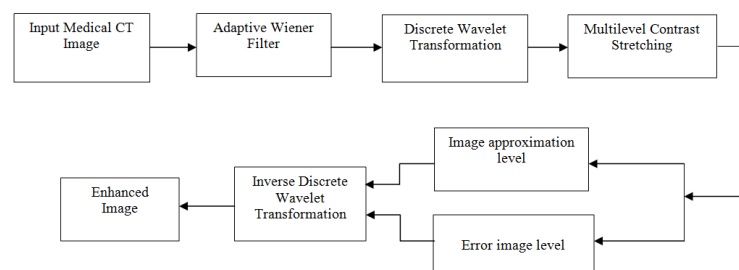


Fig. 1: Proposed approach for image enhancement.

This transformation also done analysis of the signal in many frequency bands and multi resolution analysis is carried out using two channel filter banks composed of a low-pass (G) and a high-pass (H) filter and each filter bank is then sampled at a half rate of the previous frequency. By repeating this procedure, it is possible to obtain wavelet transform of any order. The down sampling procedure keeps the scaling parameter constant ($n = 1/2$) throughout successive wavelet transforms.

Multilevel Contrast Stretching:

Contrast Stretching is image enhancement technique that attempts to improve the contrast in an image by stretching. The range of intensity values it contains to span a desired range of values. It enhances information inside the image and retains other details. And preserve the edge details while enhancing contrast in images with varying illumination (Anamika Bhardwaj, 2012).

Applying Multilevel Contrast Stretching algorithm to high frequency components which is obtained from wavelet transformation, the regions featuring homogeneous intensity and bearing contrast to their adjacent neighbors. The low contrast image is split into sub images, namely object- approximation image selected by inter object level and object – error image chosen by intra object level. Contrast stretching operation[23] is, to apply the following equation on each pixel in an image.

$$I(x,y) = ((I(x,y) - \min) \quad (2)$$

$$\left(\frac{\text{number of regions}}{\max - \min} \right) + \text{initial region} \quad (3)$$

$I(x,y)$ – Input image

min & max – minimum and maximum intensity values

Here, minimum intensity value is '0' and the maximum intensity value is '255' for gray scale input image. The pixels are stretched to maximum of 255. The number of pixels in the region is equally distributed to each gray level. To finding number of pixels in the region using the following equation:

$$P_{avg} = \frac{P_{CR-X} * P_{CR-Y}}{R_{GL}} \quad (4)$$

P_{avg} – Average number of pixels

P_{CR-X} – Pixels in the X – dimension of contextual region

P_{CR-Y} – pixels in Y – dimension of contextual region

R_{GL} – Gray levels in the contextual region

1) Approximation Image Level :

This approach is stretching the pixels between adjacent regions by local extremes. Directly to enhance the medical input image having poor contrast either contrast at any other undesired level. The structural features enhanced in this level and it adequately enlarge the local dynamic range of luminance level. Due to enhancement of structural features, the images sharpened and edges are preserved. Inter level enhancement also improves the overall contrast of an image.

2) Error Image Level:

The linear stretching is applied to pixels within the region, the degraded parts of an image enhanced in this level. Initially identify the error and low contrast pixels in each region that is replaced with its neighboring pixels. This is to enhance the textural features of an image and also avoided excessive

noise. The following equations perform contrast stretching and additional noise in an image.

$I(x,y)$ – Input image representation

$R(x,y)$ – Regions of an image

$\mu(x,y)$ – Mean value of intensity in different regions - Inter object level

$I_e(x,y)$ – Difference between pixel value in same region –Intra object level

The Contrast Stretching is done at local contrast technique; it is to calculate contrast at each point of image to enhance the variation of contrast across the image. The perception of contrast is directly related to local luminance difference. The local contrast for sub-images defined for inter object level is, $S\mu(R_i, R_j)$ is between a pair of adjacent regions R_i, R_j are proportional to difference between mean value of region defined by,

$$S\mu(R_i, R_j) \propto |\mu(R_i) - \mu(R_j)| \quad (5)$$

The local contrast for object error image, $S_e(x,y)$ at each point of (x,y) is proportional to deviation between pixel value and mean value of the region denoted by,

$$S \in (x,y) \propto |I(x,y) - \mu(R(x,y))| \quad (6)$$

Relationship between pixels within same region in object error image is closer and object approximation image is stretching between adjacent local extremes increase the image contrast. The contrast enhancement follows Weber law, it gives,

$$1 \leq \frac{\mu(R_i) - \mu'(R_j)}{\mu(R_i) - \mu(R_j)} \leq \tau \quad (7)$$

$$1 \leq \frac{I'(x,y) - \mu'(R(x,y))}{I(x,y) - \mu(R(x,y))} \leq \tau R(x,y) \quad (8)$$

If the limit of lower bound is equal to 1 then the contrast reduction does not occur. If the upper bound is greater than 1 then the contrast stretching is achieved by inter object level.

By stretching between adjacent local extreme are enlarged. This same procedure is applied all regions of an image. Finally the enhanced image is received by combining the approximation image and error image level outputs. The enhanced image is improved quality of an input medical image and free from ringing and blocking. The enhanced image better in contrast level with less computational time. Then

Inverse Discrete Wavelet Transform is applied to output image to getting the original image.

II. Experimental Results

The proposed techniques applied to different parts of CT scanned images. The medical images used as inputs were collected from the medical images database website. Some results are shown below:

Image enhancement perform major role in enhancing medical image quality. The proposed technique evaluated using MATLAB; input images used are of brain, lungs and liver of normal and abnormal images. Table 1 shows the comparison of different enhancement techniques with different parameters namely, PSNR (Peak Signal to Noise Ratio), it defines in terms of logarithmic scale, the MSE (Mean Square Error) is, one image is considered a noisy approximation of other image.

The next parameters are, Enhancement Time, Contrast Level, and Homogeneity. Compared with other enhancement techniques, the proposed technique reduces the enhancement time and noise ratio. And Homogeneity of an image is preserved and contrast also improved. The resultant image is enhanced, sharpened, edges preserved, and good in quality without distorting the images.

Conclusion:

In the proposed method, enhanced medical images by efficient techniques which are adaptive wiener filter, wavelet transformation and multilevel contrast stretching. Medical images are possibly affected by illumination, sharpness, poor contrast and noises due to this, the diagnosis of disease more complicated. The goal of proposed enhancement technique is to improve the quality of Computer Tomography images, such that the resulting image better than original image. The proposed methods have been implemented by MATLAB and tested medical images in different parts of the body have been used to evaluate the performance. The experimental results have achieved and improved the accuracy of CT images for early and easy diagnosis.

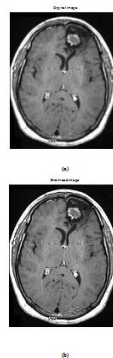


Fig. 2: Brain Image (a) Original image, (b) Enhanced image.

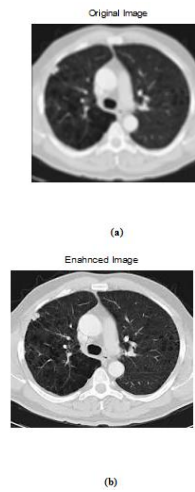


Fig. 3: Lung image (a) Input image with noise, (b) Output image.

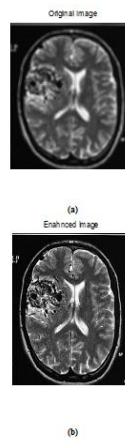


Fig. 4: Brain Image (a) Original image, (b) Enhanced image.

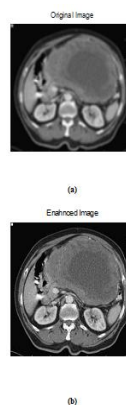


Fig. 5: Liver Image (a) Input image, (b) Enhanced image.

Table 1: Parameter evaluation and comparison for Image Enhancement techniques.

Method	PSNR	MSE	Enhancement Time (ms)	Contrast Level	Homogeneity
Multilevel Contrast Stretching	43.42	41.32	1.01	82.38	94.13
Anisotropic Diffusion	38.51	82.71	1.85	81.02	92.34
Histogram Equalization	30.63	1152.44	2.61	74.31	84.24
Adaptive Histogram Equalization	35.92	558.65	2.01	79.24	91.54
Contrast Limited Adaptive Histogram Equalization	40.35	67.93	1.94	80.26	91.51

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