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Image Enhancement Using Multilevel Contrast Stretching and Noise Smoothening Technique for CT Images

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Abstract— Image enhancement is the process of improving the visual quality of an image. This paper proposes a new algorithm called Multilevel Contrast Stretching and a Noise smoothening technique for enhancement of medical images. 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. The proposed algorithm works effectively for medical applications. The initial step is transforming the medical image using Discrete Wavelet Transformation, the second step consists of enhancing the image by using multilevel contrast stretching algorithm. The Multilevel Contrast Stretching algorithm identifies the regions featuring homogeneous intensity and bearing contrast to their adjacent neighbors. The image split into two sub images, namely object-approximation image selected by using inter object level and object-error image chosen by intra object level. Then the final step involves eliminate the noise by using the median filter. The Proposed enhancement method is implemented in MATLAB and more medical images of different parts of the body are used for evaluating the performance. The resultant image is enhanced, sharpened and edges preserved, increasing the quality without distorting the images.

Index Terms—Medical images, Image Enhancement, Contrast Stretching, Smoothening, Transformation, Wavelet, Median filter.

1 INTRODUCTION

Medical Images: 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 (Computed Tomography) 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. The proposed technique tested for different parts of CT images.

Image processing: Image processing is the processing or altering an image in a desired manner and the next step is to obtaining an image in a readable format. 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.

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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 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 available for improving the image quality. First one is spatial domain method, is directly operated on pixels of an image. The pixel values are modified based on objective.

Second method is frequency domain, 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 d imensional matrices as number rows, number of columns and three colors. Range of RGB color image is from 0 to 255 (Level 0 to L-1) for 8-bit intensity of each pixel. Here image is denoted by 'I', row is defined by 'x', column is by 'y' and color plane is denoted by 'z', then I(x, y, z) is used to represent the pixel position (x, y, z). The value of function I(x, y, and z) is lies between 0 to 255.

2 RELATED WORK

Different algorithms used in enhancement of an image. image enhancement using Range Compression technique [11], Compression is done by calculating the dynamic range by taking the difference between brightest intensity and darkest intensity value. This range is compressed using logarithmic transformation operation. Drawback of Range compression technique could be dynamic range is very high and mapping also complicated while enhancement. The next technique is Histogram equalization [11]; it is a graphical representation of intensity value on X-axis and total number pixels in Y-axis. Disadvantage of histogram equalization is not able to improve all parts of an image. The next algorithm is Gamma Correction [11], 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 contrast enhancement technique is, CLATHE (Contrast Limited Adaptive Histogram Equalization) [4], deals medical image enhancement, here different parts of body have done by median filter. This filtering is applied to different modality of medical filed.

The next algorithm called Equalized Contrast Stretching [15], 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 [15], is identifying the ranges namely lower and upper bound from histogram and also apply transformation to expand the range to present in an input image size.

The application of enhancement in medical field also done using wavelet transformation [9], it uses Haar transformation to improving the contrast and also using the edge detection algorithm to preserve the edge details. Next technique is Non-Linear contrast enhancement [1], it decompose the high frequency and threshold value calculated to reduce the noise. Color image enhancement algorithm called Virtual Histogram Approach [17], which is to combine the local and global, approach. It improves the visibility of particular portion of an image. Medical image enhancement is limitation of this approach. A Partial Swam Optimization [2], is applied for image enhancement to optimize the parameters and also compare the results with other enhancement techniques.

3 PROPOSED METHOD

The objective of proposed technique is to improve the image quality and noise removal of medical images using Multilevel Contrast Stretching and a noise smoothening technique. The following Figure 1 shows process of a proposed system. Here Input is CT scanned images, initially decompose the input image using discrete wavelet transformation to get the low contrast parts of an image. Then Multilevel Contrast Stretching is split the low contrast part into two sub-images namely, approximation image and error image. Structural features enhanced at approximation image and preserve edge details. Textural features enhanced in error image part. Get the output image by merge the two levels and perform Inverse Discrete Wavelet Transformation (IDWT).

Then apply median filter to remove the artifacts and excessive noise from output image. Finally enhanced image having improved quality and free from noise.

3.1 Discrete Wavelet Transformation

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 satellite images.

The DWT 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 h0 (n) and h1 (n) be analysis filters and then g0 (n) and g1 (n) be synthesis filters. The output of the low-pass filter h0 (n) represents an approximation of x (n) and the output of the high-pass filter h1(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 divide into four sub-bands depend upon Low and High intensity(LL,LH,HL,HH) with Gradient based Laplacian Transformation. The DWT shown in the output of the

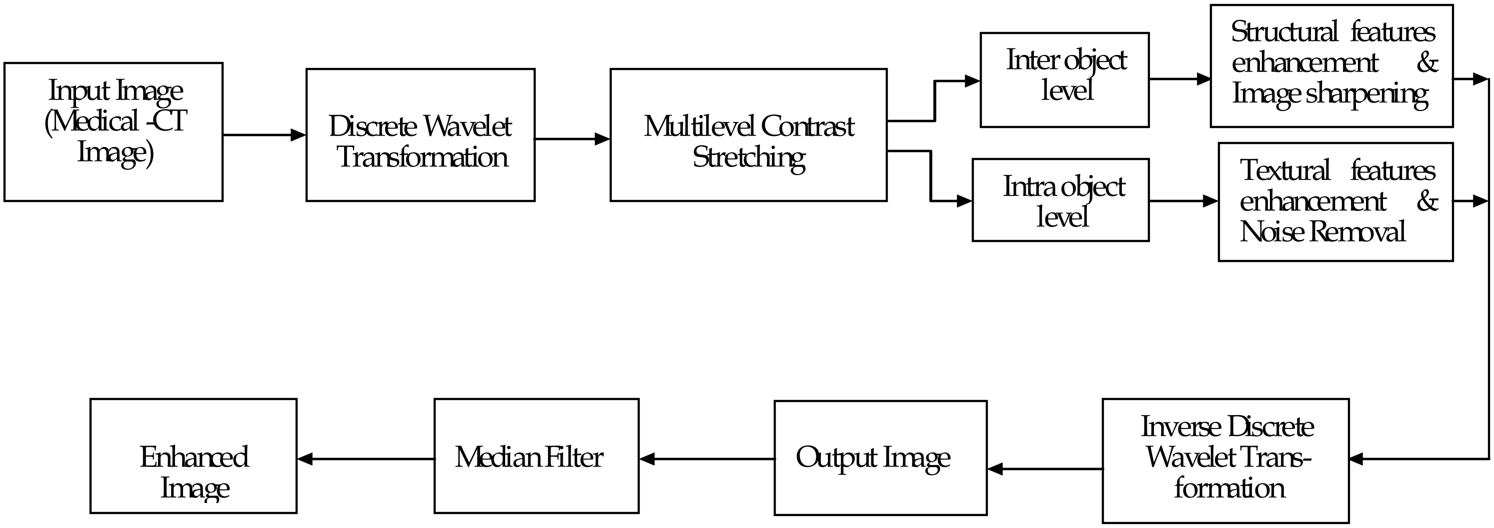

Fig- 1: Proposed System

low-pass filter h0 (n) represents an approximation of x (n) and the output of the high-pass filter h1 (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 divide into four sub-bands depend upon Low and High intensity(LL,LH,HL,HH) with Gradient based Laplacian Transformation. The DWT shown in the output of the low-pass filter h0 (n) represents an approximation of x (n) and the output of the high-pass filter h1 (n) represents a detail part of x (n). Both outputs can be down-sampled without loss of 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 divide into four sub-bands depend upon Low and High intensity(LL,LH,HL,HH) with Gradient based Laplacian Transformation. The DWT shown in the output of the low-pass filter h0 (n) represents an approximation of x (n) and the output of the high-pass filter h1 (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.

3.2 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 [1]. The Multilevel Contrast Stretching is, the regions featuring homogeneous intensity and bearing contrast to their adjacent neighbors. The low contrast image is split into two sub images, namely object- approximation image selected by inter object level and object – error image chosen by intra object level [3].

3.2.1 Inter object level

This approach is stretching the pixels between adjacent regions by local extremes. 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 brightness of an image.

3.2.2 Intra object level

The linear stretching is applied to pixels within the region. The low contrast pixel is replaced with its neighboring pixels. This is to enhance the textural features of an image and also avoided excessive noise.

I(x,y) - Image representation

R(x,y)- Regions of an image

Iμ(x,y)- Mean value of intensity in different regions -Inter object level

Iε(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, Sμ(Ri,Rj) is between a pair of adjacent regions Ri, Rj are proportional to difference between mean value of region defined by,

$$S\mu(R_i,R_j) \infty |\mu(R_i)-\mu(R_j)| \qquad (1)$$

The local contrast for object error image, Sε(x,y) at each

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point of (x,y) is proportional to deviation between pixel value and mean value of the region denoted by,

$$S \in (x,y) \infty \left| I(x,y) - \mu\big(R(x,y)\big) \right| \qquad (2)$$

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 [3], it gives

$$1 \leq \frac{\mu(Ri) - \mu'(Rj)}{\mu(Ri) - \mu(Rj)} \leq \tau \qquad (3)$$

$$1 \leq \frac{I'(x,y) - \mu'\big(R(x,y)\big)}{I(x,y) - \mu\big(R(x,y)\big)} \leq \tau R(x,y) \qquad (4)$$

If the 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 for all blocks of an image. Finally the enhanced image is received by combining inter object and intra object level outputs. The enhanced image is improved quality of an input medical image and free from ringing and blocking. The enhanced image is proper contrast with less computational time.

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

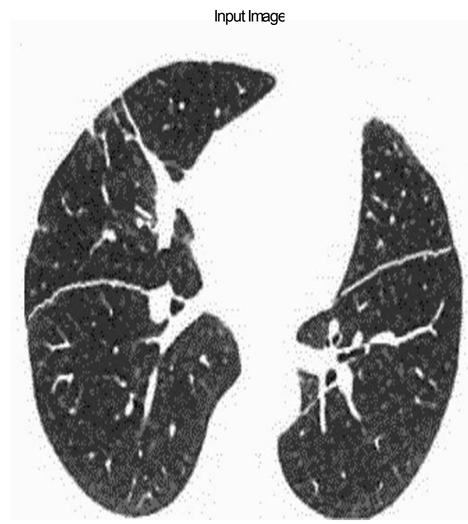
3.3 Median filter

After getting the original image, the filtering is applied to that particular image. The objective of median filter is to remove the noise and eliminate other artifacts from medical images. Here calculate the median value of each block and the noisy pixel is replaced with that median values. This process is applied to all blocks which is having noisy pixel of medical image. The intensity values of input image result with smoothened with noise free image and preserved information contained in image [12].

Median filter replace the center value of an M*N neighborhood with it's of median value. If neighborhood is center element then the block replace median value of the pixel. It also performs median filtering of the matrix of two dimensions. Each output pixel having median value M*N matrix neighborhood around corresponding pixel in an input image. If edge of an image contains '0', then the median values are calculating using [M N] by 2 to restore the edges. The output image improved quality with free of noise so the diagnosis is efficiently done automatically.

4 Experimental Results

The proposed method applied to CT scanned images of Lungs and Brain images. Some results are shown below:



(a)

(b)

Fig-2: (a) CT Lung Image- Input Image, (b) Output Image

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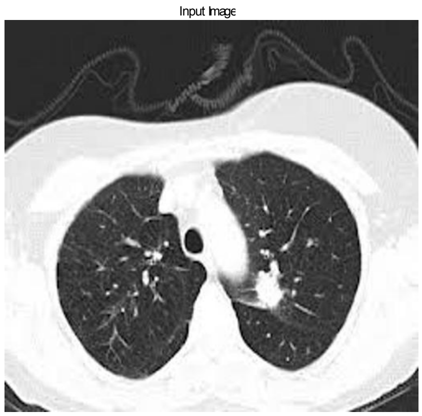
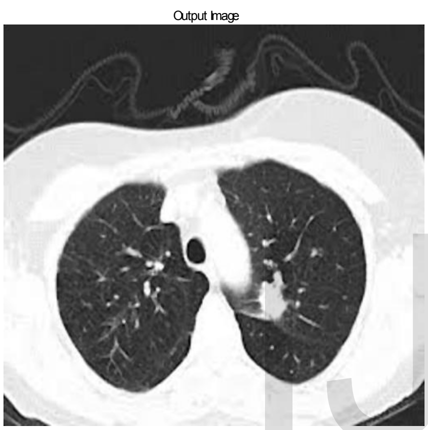
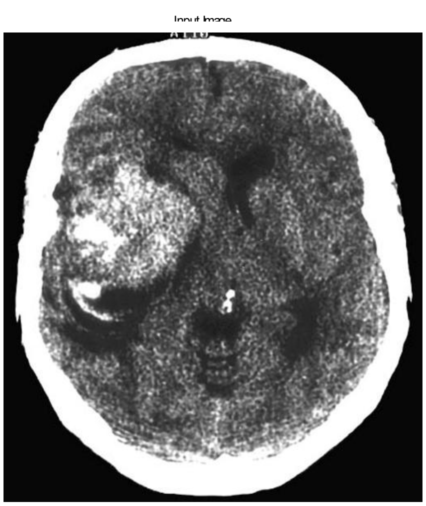


(a)

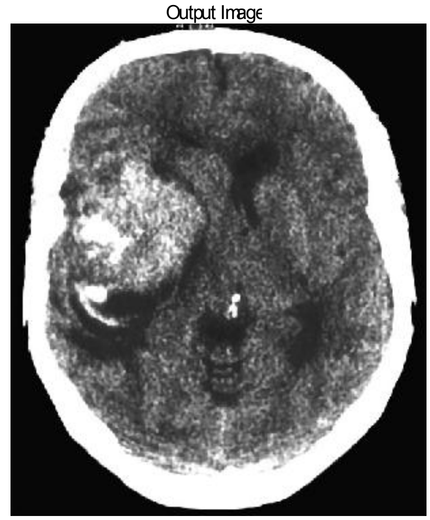


(b)

Fig-3: (a) CT Lung Image- Input Image, (b) Enhanced Image



(a)



(b)

Fig-4: (a) CT Brain Image- Input Image, (b) Output Image

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5 DISCUSSION

Table 1 shows the comparison of different enhancement algorithms with different parameters namely, PSNR (Peak Signal to Noise Ratio), Enhancement time, Contrast level, and Homogeneity. The proposed technique reduces the enhancement time and noise ratio. And Homogeneity of an image is preserved and contrast also improved without degradation of an input image. The resultant image is enhanced, sharpened and edges preserved, increasing the quality without distorting the images.

TABLE 1.

PERFORMANCE COMPARISON OF IMAGE ENHANCEMENT ALGORITHMS

Method	PSNR	Ehancement Time (ms)	Contrast Level	Homogeneity
Proposed Method	41.9	1.01	80.08	93.13
Histogram Equalization	45.6	2.72	76.1	89.24
Adaptive Histogram Equalization	42.3	2.01	78.4	91.25
Contrast Limited Adaptive Histogram Equalization	43.1	1.84	79.2	90.01

6 CONCLUSION

This paper proposes a Multilevel Contrast Stretching and Noise Smoothening techniques for medical image enhancement. Medical images are possibly affected by illumination, sharpness, contrast and noises, all these artifacts rectified by proposed technique. This method implemented in MATLAB for CT scanned images of Brain and lungs. The result shows that PSNR, enhancement time is reduced and contrast level and homogeneity of image is improved as compared to earlier techniques. This work extended to other modality of medical images

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