Contrast Enhancement using modified fast Haar wavelet transform (MFHT) on Lung cancer images

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Abstract-The aim of image enhancement is to improve the perception of information in images for human viewers, or to provide better input for other automated image processing images. Image Enhancement (IE) transforms images to provide better representation of subtle details. Contrast stretching is an image enhancement technique commonly used for medical images for improving the quality of an image by reducing the noise and improving the contrast of an image. This paper presents different methods for enhancing lung cancer images. The paper also attempts to describe the algorithm for image enhancement using MFHWT.

Keywords: contrast enhancement, discrete wavelet transform, modified fast haar wavelet transform

I. INTRODUCTION

Lung cancer is the leading cause of cancer deaths among both men and women, making it the most common cancer in North America and Japan. Despite advances in the detection and treatment, the survival rate for lung cancer continues to be less than fifteen-percent. The reason is that tumors are found at a late invasive stage. The early diagnosis of this cancer may lead to prevention from the inevitable death and this requires detection of small nodules with diameter of only few millimeters so that’s why the need to improve the quality of image emerged [2]. Lung nodule detection is a challenging task in medical imaging as lung nodules may be difficult to detect using computed tomography (CT) scans due to low contrast, small size, or the location of the nodule within an area of complicated anatomy. For this reason, several methods for developing computer aided detection (CAD) methods of nodules have been reported in the literature to assist radiologists[4]. Image enhancement is meant as the improvement of an image appearance by increasing dominance of some features or by decreasing ambiguity between different regions of the image [9]. Image enhancement is a necessary component of any CAD system. The principal objective of any enhancement technique is to improve image quality for either an automated CAD framework (e.g., to improve subsequent image segmentation and feature extraction) or for manual reading. To date, contrast stretching process plays an important role in enhancing the quality and contrast of medical images by highlighting important features embedded in the image data [4].

The evolution of CT scanners technology has played an important role in the development of detection algorithms.

With the introduction of multi-slice scanner with improved z axis resolution in the recent years, the processing of images by 3D methods has become possible. However, due to the great amount of information in CT images, the inspection of these images by radiologist is not always straightforward moreover, diagnosis of lung cancer in its early stages is of interest, and this requires detection of small nodules with diameter of only few millimeters; therefore, Computer-aided diagnosis (CAD) systems are emerging as an auxiliary tool for radiologists. Fabrizio Russo [9] used fuzzy techniques for image enhancement and reported that fuzzy filters are effective in removing noise, and satisfactorily preserve fine details and textures. Recently, evolutionary neural fuzzy filters have been proposed for the removal of impulse noise. Sung In Cho *et. al.* [11] propose an advanced backlight dimming technique that preserves the quality of color and details in images even when the backlight luminance of liquid crystal display devices is lowered. In addition, for the same backlight luminance level, pixel compensation in the proposed method reduced color difference for color distortion evaluation and the loss rate of edge strength, which showed detail loss by up to 3.58% and 40.55%. A new approach to contrast enhancement of image data is presented by Fabrizio Russo [10]. Key features of the proposed technique are better performance than available methods in the enhancement of images corrupted by Gaussian noise and no complicated tuning of fuzzy set parameters. In fact, the overall nonlinear behavior of the enhancement system is very easily controlled by one parameter only. Li Buhong *et. al.* [12], an approach for pseudo color display of image has been presented, and an initial study was performed to demonstrate the feasibility of pseudo color contrast enhancement technique for the diagnosis of early lung cancer.

II. CLASSIFICATION OF IMAGE ENHANCEMENT TECHINQUES

Whenever an image is converted from one form to another such as digitizing, scanning, transmitting, storing etc., some of the degradation occurs at the output. Hence the output image has to undergo a process called image enhancement which consists of a collection of techniques that seek to improve the visual appearance of an image. The image enhancement techniques can be divided into three broad categories:

2.1 Fuzzy Inference system [16]-

A technique is designed based on fuzzy inference system tool in MATLAB 7.5. It includes all pieces that are membership functions, logical operations, if –then rules..The proposed technique is used to improve the contrast of the image. Fuzzy processing system is a collection of all approaches that understand, represent and process the images, their segments and features using fuzzy sets. It is based on gray level mapping into fuzzy plane using a membership transformation function. The aim is to generate an image of higher contrast than the original image by giving larger weight to gray levels that are closer to the mean gray level of the image than to those that are farther from the mean. An image I of size MXN and L gray level scan can be considered as an array of fuzzy singletons, each having a value of membership denoting its degree of brightness. As shown in figure 1, fuzzy image enhancement is based on gray level mapping into fuzzy plane, using a membership transformation function. The aim is to generate an image of higher contrast than original image after defuzzification.

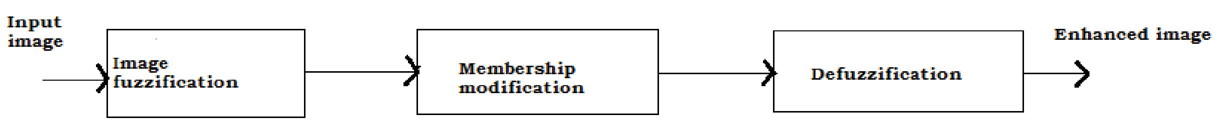

Figure1: The main principles of Image fuzzy enhancement

2.2 Spatial domain Methods [15] –

The value of a pixel with coordinates (*x*,*y*) in the enhanced image $\bar{F}$ is the result of performing some operation on the pixels in the neighborhood of (*x*,*y*) in the input image, *F*. In Figure 2, we have shown the spatial domain representation of an image.

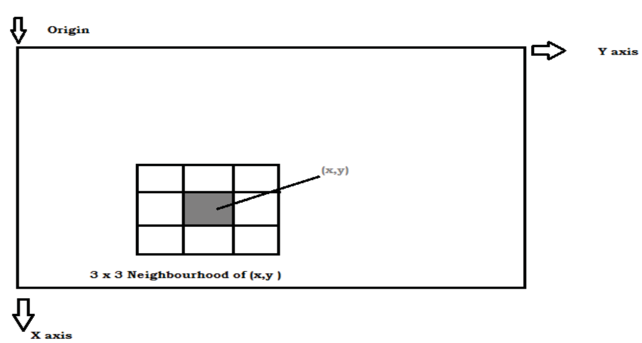

Figure2: Spatial domain of an image

(i) Grey scale manipulation[16]

The simplest form of operation is when the operator *T* only acts on a 1X1 pixel neighborhood in the input image, that is vector F(x ,y) only depends on the value of *F* at (*x ,y*). This is a grey scale transformation or mapping. The simplest case is thresholding where the intensity profile is replaced by a step function, active at a chosen threshold value. In this case any pixel with a grey level below the threshold in the input image gets mapped to 0 in the output image. Other pixels are mapped to 255. Tone scale adjustments of input images are shown in figure 3.

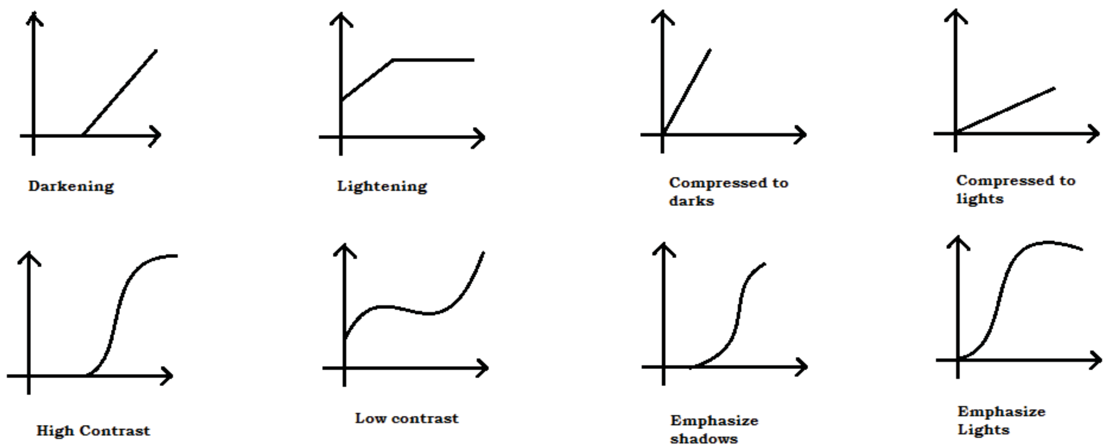

Figure 3: Tone scale adjustments

(ii)Histogram Equalization [16]:

Histogram equalization is a common technique for enhancing the appearance of images. Suppose we have an image which is predominantly dark. Then its histogram would be skewed towards the lower end of the grey scale and all the image detail is compressed into the dark end of the histogram. If we could `stretch out' the grey levels at the dark end to produce a more uniformly distributed histogram then the image would become much clearer.

(iii)Image Smoothing [16]:

The aim of image smoothing is to diminish the effects of camera noise, spurious pixel values, missing pixel values etc. There are many different techniques for image smoothing; we will consider neighborhood averaging and edge-preserving smoothing.

(iv)Image sharpening [16]:

The main aim in image sharpening is to highlight fine detail in the image or to enhance detail that has been blurred perhaps due to noise or other effects, such as motion). With image sharpening, we want to enhance the high-frequency components; this implies a spatial filter shape that has a high positive component at the centre.

2.3 Frequency domain Methods [16]:

Filtering in the frequency domain consists of modifying the Fourier transform of an image and then computing the inverse transform to obtain the result.

(i)Filtering

Low pass filtering involves the elimination of the high frequency components in the image. It results in blurring of the image (and thus a reduction in sharp transitions associated with noise). An ideal low pass filter would retain all the low frequency components, and eliminate all the high frequency components. However, ideal filters suffer from two problems*:* blurring *and* ringing. These problems are caused by the shape of the associated spatial domain filter, which has a large number of undulations. Smoother transitions in the frequency domain filter, such as the Butterworth filter, achieve much better results.

Figure 4

(ii)*Histogram Adaptive Filter:*

This type of filter removes high impulsive noise preserving edge information. Each input pixel is considered a fuzzy variable and a square window of size 3x3 is sided over the entire image and filter output is associated with each center pixel in the window. Three fuzzy sets for dark, medium and bright are created.

(iii)*Gaussian low pass filter:*

GLPF s of one dimension were introduced as an aid in exploring some important relationships between spatial and frequency domain. The form of these filters in two dimensions is given by

$$H(u,v) = e^{-D^2(u,v)/2\sigma^2}$$

III. PROPOSED MFHT METHOD

A wavelet is a mathematical function used to divide a given function or continuous-time signal into different scale components. Modified Fast Haar Wavelet Transform (MFHWT), is one of the algorithms which can reduce the calculation work in Haar Transform (HT) and Fast Haar Transform (FHT).The Haar Wavelet Transformation is a simple form of compression involved in averaging and differencing terms, storing detail coefficients, eliminating data, and reconstructing the matrix such that the resulting matrix is similar to the initial matrix. . A HT decomposes each signal into two components, one is called average (approximation) or trend and the other is known as difference (detail) or fluctuation. HT is suitable for application when the image matrix has number of rows and columns as a multiple of 2. Fast Haar Transform (FHT) involves addition, subtraction and division by 2, due to which it becomes faster and reduces the calculation work in comparison to HT. For the decomposition of an image, we first apply 1D FHT to each row of pixel values of an input image matrix .These transformed rows are themselves an image and we apply the 1D FHT to each column. The resulting values are all detail coefficients except for a single overall average coefficient. In Modified fast Haar wavelet transform algorithm after a DWT transform, the image is divided into four corners, upper left corner of the original image, lower left corner of the vertical details, upper right corner of the horizontal details, lower right corner of the component of the original image detail (high frequency). You can then continue to the low frequency components of the same upper left corner of the 2nd, 3rd inferior wavelet transform.

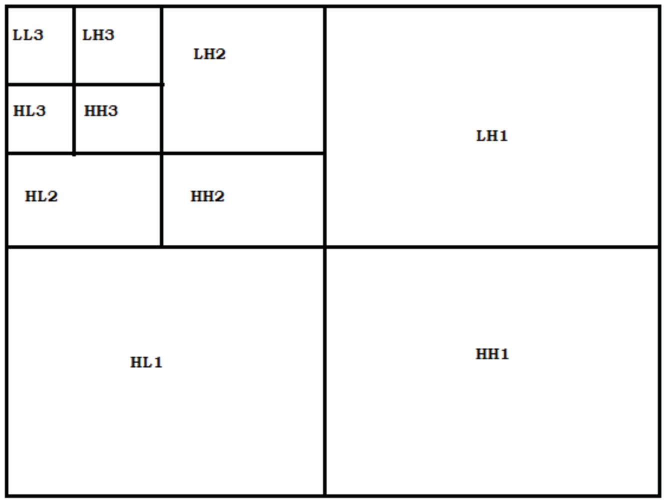

Figure 5. DWT Decomposition model

In MFHT, four nodes are considered at a time instead of two nodes as in HT and FHT. In MFHWT, first average subsignal

$$a^1 = (a_1, a_2, \ldots, a_{N/2})$$

signal of length N i.e. $f = (f_1, f_2, \ldots, f_N)$ Is

$$a_m = \frac{f_{4m-3} + f_{4m-2}}{2}$$

and first detail subsignal, $d^1 = (d_1, d_2, \ldots, d_{N/2})$, at the same

$$d_m = \left\{ \frac{(f_{4m-3} + f_{4m-2}) - (f_{4m-1} + f_{4m})}{4}, m = 1, 2, 3, \ldots, N/4 \right.$$

, m = N/2,……,N .

Here four nodes are considered at a time instead of two nodes as in HT and FHT.

A 2D proposed algorithm MFHT is done by performing following steps:

- Read the image as matrix
- Apply MFHT row wise and column wise on entire image matrix
- We get transformed image matrix of one level of input image
- For reconstruction process, FHT is used on the image matrix.
- Calculate MSE and PSNR of reconstructed image.

IV. CONCLUSION

In this paper, we have discussed medical images that use IE techniques for reducing noise and sharpening details to improve the visual representation of the image. Since minute details play a critical role in diagnosis and treatment of disease, it is essential to highlight essential features while displaying medical images, Wavelet techniques thus provide a powerful set of tools for image enhancement and analysis together with a common framework. The main benefit of MFHWT is sparse representation and fast transformation and possibility of implementation of fast algorithms. At each level in MHWT, we need to store only half of the original data due to which it becomes more and more efficient.

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