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ENHANCEMENTOF MRI BRAINIMAGESUSING MATLAB

Thazin Khaing[1 2] & Khin Khin Win[3]

Abstract

Image enhancement aims to increase the visibility of original input images and to convert them into a better form with detail information. Images enhancement is a vital role in image processing because of the poor contrast depending on the nature of the images. In this research, a total of 100 test grayscale images which are normal and abnormal MRI brain (512×512) pixels images have been processed by using enhancement techniques. This research described the methods of enhancement of magnetic resonance imaging (MRI) brain images in spatial domain by using MATLAB. Image data used in this research were obtained from No (2) military hospital 500 bedded, Dagon Township, Yangon (Myanmar). The best technique to be applied for MRI brain images has been identified by comparing the result of peak signal to noise ratio (PSNR). Based on the result obtained, it has been confirmed that the combination of spatial filtering and histogram equalization technique is more suitable for enhancement of the MRI brain images.

Keywords: Image Enhancement, Filtering, Histogram Equalization, Magnetic Resonance Imaging (MRI), Matrix Laboratory (MATLAB)

Introduction

Image processing is a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it. It is the most popular field for image analysis (Gonzalez, R.C.,& R. E. Woods, 2002).The purpose of image processing is divided into five groups. They are visualization, image sharpening and restoration, retrieval, measurement of pattern and image recognition. This paper will present medical image enhancement techniques. Image enhancement is to increase the quality of an image so that the result is clearer and clean than the original image for a specific application. Medical images are a special kind of image that can be used for the diagnostics of diseases in the patients. A number of modalities like Magnetic resonance imaging (MRI), Computed Tomography (CT) and X-rays exit for obtaining these images. MRI is a popular technique to analyze human brain soft tissue because it gives detailed information about the diseases (Cheruku, K. S., R. Ratnadeep, K. P. Archek, and Y. K. Ashwani, 2015). In this paper, normal and abnormal original MRI brain T2-weighted images which having low contrast depending on the MRI machine are applied to get the more detailed information of MRI images. One of the most important stages in medical images detection and analysis is image enhancement techniques which improve the quality of images for human vision, removing blurring and noise, increasing contrast, and revealing details. The techniques of image enhancement can be classified into two broad categories: Spatial Domain Methods and Frequency Domain Methods. This paper describes the methods of enhancement of brain MRI images in spatial domain by using MATLAB. Image data used in this work were obtained from No (2) military hospital 500 bedded, Dagon Township, Yangon (Myanmar).

[1] Assistant Lecturer, Department of Engineering Physics, Technological University (Banmaw)
[2] Third Year PhD Student, Department of Physics, University of Yangon
[3] Professor and Head, Department of Physics, University of Yangon

Materials and Methods

Frequency Domain Methods

Frequency domain image enhancement is a term used to describe the analysis of mathematical functions or signals with respect to frequency and operate directly on the transform coefficients of the image such as Fourier transform, discrete wavelet transform, discrete cosine and sine transform. The quality of the respective image can improve by making changes in the transform coefficient functions. The advantages of frequency domain image enhancement include low complexity of computations, manipulating the frequency coefficient of an image and the applicability of improved version of domain properties. The major drawback of frequency domain method is it cannot produce clear picture of background and it cannot enhance all the parts of the image. It can focus only on particular parts(Gonzalez, R.C.,& R. E. Woods, 2002).

Spatial Domain Methods

Spatial domain techniques directly deal with the image pixels. The pixel values are manipulated to achieve desired enhancement. The main advantage of spatial based domain technique is conceptually simple to understand and the complexity of these techniques is low which favors real time implementations. But they usually enhance the whole image in a uniform manner which in many cases produces undesirable results. The approaches can be classified into two categories: Point processing operation and Spatial filter operations. Point processing operations is the simplest spatial domain operation as operations are performed on single pixel only. Pixel values of the processed image depend on pixel values of original image. The point processing approaches can be classified into four categories as negative transformation, thresholding transformation, log transformation and power law transformations. Spatial filter operations are performed on a pixel along with its immediate neighbors; this is also called as neighborhood operations. Based on type of operations performed on the pixels spatial filters are classified into two categories: Linear and Nonlinear spatial filters. Linear spatial filter process involves convolving a mask with an image that is passing a weighted mask over the entire image. Mask is also referred as window, template, or kernel. Non-linear spatial filter are those filters in which enhanced image is not linearly related to pixels in the neighborhood of original image (Uday, K., P. Vishal, and R.Shekhar, 2013).

Spatial Filtering

Filtering is a neighborhood operation, in which the value of any given pixel in the output image is determined by applying some algorithm to the values of the pixels in the neighborhood of the corresponding input pixel. A pixel's neighborhood is some set of pixels, defined by their locations relative to that pixel. Filtering is a technique for modifying or enhancing an image. Filtering an image is to emphasize certain features or remove other features. Image processing operations implemented with filtering include smoothing, sharpening, and edge enhancement. *Linear filtering* is filtering in which the value of an output pixel is a linear combination of the values of the pixels in the input pixel's neighborhood. Mean and median filters are effective for reducing different types of noise. The effect of low pass filtering in the spatial domain is to blur the sharp edges, and therefore increase the uncertainty about the location of the edges. A high pass filtering technique is to increase the contrast of the edges. As mention above there are a lot of techniques used in image enhancement. The enhancement techniques differ from one field to another according to its objectives and requirements. Depending on nature of an image, appropriate method should be used for enhancement purposes. This paper proposed that the combination of spatial filtering and histogram equalization technique. It is consists of three steps. They are median filter for noise reduction, Contrast Limited Adaptive Histogram Equalization technique for improving the local contrast of images and average filter for smoothing images data (Gonzalez, R. C.,& R. E. Woods, 2002).

Median Filter

Median filtering preserves edges while removing noise. It is a nonlinear operation. To compute the output of a median filter, an odd number of sample values are ranked and the median value is used as the filter output.

For example,

$$\begin{bmatrix} 10 & 20 & 20 \\ 20 & 15 & 20 \\ 20 & 25 & 100 \end{bmatrix}$$

Sort them $\longrightarrow$ 10, 15, 20, 20, 20, 20, 20, 25, 100 then median value = 20.

Histogram Equalization

In an image histogram, the *x* axis shows the gray level intensities and the y axis shows the frequency of these intensities. Numerous spatial domain processes consider histogram as the efficient technique for pre-processing. Histogram equalization is a common technique for enhancing the appearance of images. Suppose 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. The goal in histogram equalization is to approximate the grayscale-value distribution of an image to the uniform distribution (Hardeep, K., and R. Jyoti, 2016). Histogram equalization is useful because it helps in spreading the grayscale values and allows us to see a larger range of grayscale values. The histogram of an image mostly represents the comparative frequency of occurrence of the different grey levels in the image. The advantage of histogram equalization is in full automation and its results are very similar to linear contrast stretching. Histogram equalization automatically computes a transformation function to give a new image with uniform histogram (Gonzalez, R.C.,& R. E. Woods, 2002).

Contrast Limited Adaptive Histogram Equalization

Contrast limited adaptive histogram equalization proposed to improve the over amplification of noise problem present in the histogram equalization technique. It is different from standard histogram adjustment in which it works on small regions in the image are called as tiles and computes several histograms, each compared to a particular area of the picture and use them to redistribute the brightness or contrast estimation of the image. Contrast limited adaptive histogram equalization improves contrast of an image more than standard histogram equalization in which it gives more detail but still has tendency to amplify noise (Cheruku,K. S., R. Ratnadeep, K. P. Archek, and Y. K. Ashwani, 2015).

Average Filter

The average (mean) filter smoothen image data, thus eliminating noise. The filter performs spatial filtering on each individual pixel in an image using the gray level values in a square or rectangular window surrounding each pixel. The average filter computes the sum of all pixels in the filter window and then divides the sum by the number of pixels in the filter window.

$$1/9 * \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix} \longrightarrow 3 \times 3 \text{ filter window}$$

The essential idea of this method is to replace grayscale value of the center pixel by average value of neighborhood pixel grayscale.

PSNR

The following equation is to calculate the Peak Signal-to-Noise Ratio (PSNR):

$$PSNR = 10log_{10}\left(\frac{peakval^2}{MSE}\right)$$

Where peakvalue is either specified by the user or taken from the range of the image data type (e.g. for uint8 image it is 255). MSE is the mean square error, i.e. MSE between A and ref.MSE measures the average squared difference between actual and ideal pixel values.

Results and Discussion

Image data used in this work were obtained from No (2) military hospital 500 bedded, Dagon Township, Yangon (Myanmar). The normal and abnormal original MRI brain (512×512) pixels images have been enhanced with various methods. By using thresholding method, the region of interest of abnormal MRI brain image could be isolated from background. The flaw of the abnormal part of MRI brain image could be seen very clearly by using gray level slicing method. Histogram equalization stretches the contrast by redistributing the gray-level values uniformly. It is found that histogram equalization technique is not very effective for MRI brain images used in this work although it is popular for poor contrast images. The result of enhanced original images using the combination of spatial filtering and histogram equalization method is illustrated in figure 1(b) and figure 2(b). The effective enhanced images are obtained by using these algorithms. According to the human vision, the quality of the enhanced images is found to be better than that of the original images because the internal structure of the image become clearer. The region of interest was appeared as shown in figure 2(b). The simplest and most widely used performance measure is peak signal to noise ratio (PSNR). The value of PSNR obtained by using the combination method is found to be higher than those obtained via the others techniques applied in this research. The higher PSNR indicates the better the MRI brain image results. The measurements of the normal and abnormal MRI brain grayscale images using the three techniques are described in Tables 1 and 2. All of the MRI images are processed through MATLAB code.

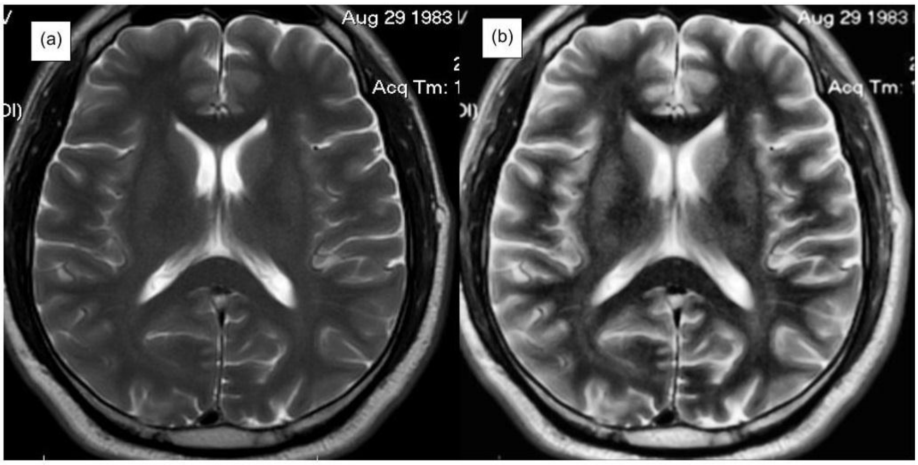

Figure 1 (a) Input MRI normal brain (512×512) pixels image
(b) Enhanced image after using the combination of spatial filtering and histogram equalization

Region of interest

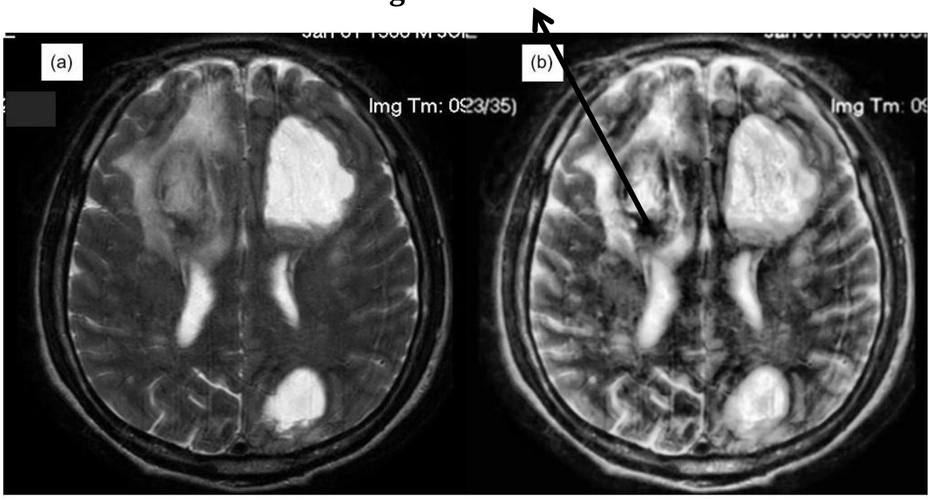

Figure 2 (a) Input MRI abnormal brain (512×512) pixels image
(b) Enhanced image after using the combination of spatial filtering and histogram equalization

Table 1 PSNR values of normal brain (512×512) pixels images

Input images name	Thresholding method PSNR(dB)	Histogram equalization PSNR(dB)	Combination method PSNR(dB)
N1	11.04	14.36	18.53
N2	9.70	17.02	19.07
N3	10.79	13.95	19.49
N4	10.80	14.48	19.97
N5	10.66	12.89	20.19
N6	10.47	12.54	19.49
N7	10.81	12.44	19.58
N8	10.72	12.93	17.23
N9	10.60	14.05	18.79
N10	12.42	10.98	18.47

Table 2 PSNR values of abnormal brain (512×512) pixels images

Input images name	Thresholding method PSNR(dB)	Histogram equalization PSNR(dB)	Combination method PSNR(dB)
Ab1	10.32	12.73	16.80
Ab2	10.77	15.33	20.21
Ab3	10.81	14.68	21.36
Ab4	11.68	10.60	20.79
Ab5	11.15	13.20	18.67
Ab6	10.85	13.15	21.83
Ab7	11.29	11.92	16.94
Ab8	11.39	12.28	19.78
Ab9	13.44	10.12	16.85
Ab10	12.55	10.59	17.20

Conclusion

Normal and abnormal MRI brain images have been applied by the various image enhancement techniques in spatial domain. The techniques like thresholding transformation and intensity level slicing have been analyzed. These techniques are found to be suitable for the brain images used in this paper. The performance of enhancement techniques has been measured using peak signal to noise ratio (PSNR). Based on calculation, the combination of spatial filtering and histogram equalization method could provide the better results with large PSNR value comparable to other methods. It is concluded that the combination of spatial filtering and histogram equalization method are preferable to apply on the original MRI brain images with the poor contrast. Other methods such as negative transformation, log transformation and power law transformation have also been applied to the MRI brain images. Negative transformation is suited for enhancing white detail embedded in dark regions and has applications in medical imaging. Therefore, image enhancement techniques can be used particularly for medical image enhancement to obtain potential results. However, log transformation technique is suitable for security surveillance applications. Besides, power law transformation can be useful for general purpose contrast manipulation. The enhancement techniques differ from one field to another according to its objectives and requirements. Depending on nature of an image, appropriate method should be used for enhancement purposes.

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