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Cross-sectional Analysis of Brain Magnetic Resonance Images for Abnormal cell growth by using Histogram Equalization

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Abstract: The purpose of this work is to highlight importance of digital image processing in bio-medical engineering. Imaging modalities provides vital aid to medical professional in disease prognosis. Brain tumor is a fatal and life threatening disease. Experts suggest Magnetic Resonance Imaging for investigation of brain disease. Computer aided diagnosis has developed rapidly for the last two decades. Image Enhancement is first step of digital image processing after image acquisition. This paper deals with application of histogram equalization image enhancement techniques to normal and brain tumor T1-weighted and T2-weighted magnetic resonance images using MATLAB platform. Solid cum cystic type of brain tumor is selected for this study. Images histogram of normal and tumor are interpreted and compared. Our work provides basic platform for tumor detection and segmentation. Statistical analysis is also presented.

Keywords: Brain, images, MRI, tumor, computers.

I. INTRODUCTION

Engineering has its great influence and dominant factor in terms of technology involvement in medicine [1]. Medical image fusion also open a new dimension for researchers in which images from different modalities are combined together for diagnostics [2]. Cancer is a dangerous life threatening illness [3]. Introduction of non-invasive imaging modalities has revolutionized prognosis of disease, helping professionals in their decision making. Brain is a complex and sensitive human body part [4]. Brain tumor endangers humans' life at highest risk level or deviation from its normal functioning can result with at minimum level of risk. Scientists and researchers work are striving with the same perspective. Magnetic Resonance imaging is suggested by experts for brain tumor diagnosis [5]. There are many types MRI sequences. T1 weighted, T2 weighted, fluid attenuation inversion recovery (FLAIR) and diffusion weighted imaging. T1 and T2 are most commonly used and produced by controlling of repetition time (TR) and echo time (TE) of radio frequency pulses.

The scope of work is to make the best use of technology for health purpose. In the same regard digital image processing deals with the contents present in images and processed it with procedures to produce required results accurately and efficiently [6]. There are four basic steps in digital image processing; image acquisition, image enhancement, image restoration and finally image segmentation. Acquiring images is first step in image processing. Due to continuous light exposure results error in recording series of images. Enhancing an image means to change the appearance of image and produce a good quality image [7] without changing its attributes. Literature review shows a few number of work is done in the same regard. Here publications related to histogram for gray level images are discussed. Histogram equalization is a simple method which shows good results for images with less lighting [8, 9]. In a recent research a novel exposure based Sub-Image Histogram Equalization is proposed for darker images. Sub-Image Histogram Equalization is proposed for darker images. Enhancement rate is controlled by clipping histogram with threshold value. The threshold is the average value of grey level occurrences. This equalization technique has claimed to produce better result than other conventional histogram [10]. Bi-level histogram image enhancement technique is a recent topic of research. 2D histogram approach with multilevel thresholding is presented for gray level images to improve distinction between two objects. For the same purpose, maximum Tsallis entropy is used [11]. An extension of bi-histogram equalization is introduced in which two independent histograms by thresholding results in minimized intra-class variance. This method proved to be successfully separate object from background and highly recommended to be used in consumer electronic products [12]. Detection of brain tumor is discussed using Fuzzy C-means clustering and histogram on MRI images [13].

There is rare work found using histogram technique which shows for Solid cum Cystic brain tumor detection. Our work introduces application of histogram techniques on MRI images. This paper consists of four sections; first is the introduction which includes detailed survey of literature review, next deals with the methodology of research, third section contains results and discussion and last covers the future aspects of work.

II. METHODOLOGY

The selected dataset consist of MRI images of normal and tumor patients in all three planes with their radiology reports. All cases have T1, T2 and contrast enhanced T2 MRI images. The platform used is Matlab stands for Matrix laboratory in which each image is treated in a matrix form. The tumor type selected is Solid cum Cystic type brain tumor. Each image is 512×512 in size. MRI slices are selected with in all planes representing normal and brain tumor each. Both cases consist of 18 slices. For our proposed method, results of T1 9th axial view slice are compared and shown. The processor is Intel (R) Core (TM) with CPU 1.8 GHz with 6 GB RAM. The steps taken are as follows:

1. Selection of MRI image /slice.
2. Specify the number of bins with specified range.
3. Apply and save histogram of both normal and tumor images.
4. Repeat last step for Histogram Equalization.
5. Compare and discuss results.

A. Histogram

It is a type of spatial domain image enhancement technique. Histogram is a graphical scaled display of intensity distribution in indexed and grey scale images. In Matlab it is implemented with imhist function with n number of equally spaced bins considered as bars and plotted on x- axis. Y axis represents the frequency of intensities lying within the interval of bin. Bins are the range of intensities values into a series of non-overlapping intervals. The plot is between the bins and count of number of values falls into each interval. For grey level images imhist function takes 256 as a default bin equals to possible intensity values. In general, mathematically histogram

$$k = \sum_{i=1}^{n} m_i \qquad (1)$$

For a digital image, it is a discrete function in the range [0, L-1]

$$h(r_k) = n_k \qquad (2)$$

Whereas r_k is the k^{th} intensity value and n_k represents number of pixels in the image with intensity r_k. The histogram is a mapping shows the frequency of intensities occurs in an image to store the brightness history of an image. It can also be said that histogram list has same number of elements as quantization levels.

B. Normalized Histogram

Image of $M \times N$ histogram normalization depends on the probability of occurrence of intensity value. It is obtained by dividing each pixel value with total number of pixels:

$$p(r_k) = \frac{n_k}{MN} \quad k = 0,1,.........L-1 \qquad (3)$$

C. Histogram Equalization

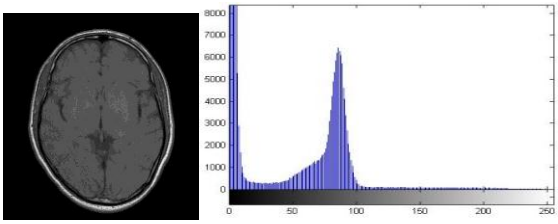
It is a contrast enhancement technique. It allows nonlinear models/transfer function to scan intensity values of pixels between input and output images of dynamic range by using cumulative density function (CDF). The aim of the process is to assign such values to pixels of output images such that distribution becomes uniform [14]. The aim is to equalize the input image such that the resulting image becomes a constant. Sometimes, images are already equalized so equalization produces unrealistic results. For discrete values this process can be represented with following statement [15]

$$s_k = T(r_k) = \sum_{j=0}^{k} p_r(r_j) = \sum_{j=0}^{k} \frac{n_j}{MN} \qquad (4)$$

Output image is produced by mapping each pixel inp ut level r_k with its corresponding output s_k level wit h the above equation. The transformation function is obt ained from histogram of input image.

III. RESULTS & DISCUSSION

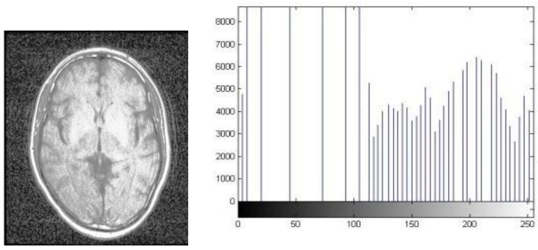
The main purpose of our research as discussed earlier in the paper to find proper methodology for tumor detection. All procedures are performed using inbuilt functions in MATLAB. Fig. 1 shows T1 MRI image of normal brain in axial view and its histogram. Histogram clearly shows, intensities are condensed towards the darker side of grey level. Two peaks are clearly visible; first one is due to background and next show the brain area intensities.



(a) (b)

Fig. 1 (a) Original Image (b) Histogram

Fig. 2 represents results of applying histogram equalization to normal brain tumor and its respective histogram. Histogram of equalized image is spread out towards the lighter grey range. The resultant image is brighter than original image. Fig. 3 demonstrates the treatment of Solid cum cystic type brain MRI T1 image in axial view with histogram equalization. Original image with tumor present shows some artifacts known as ghost images.



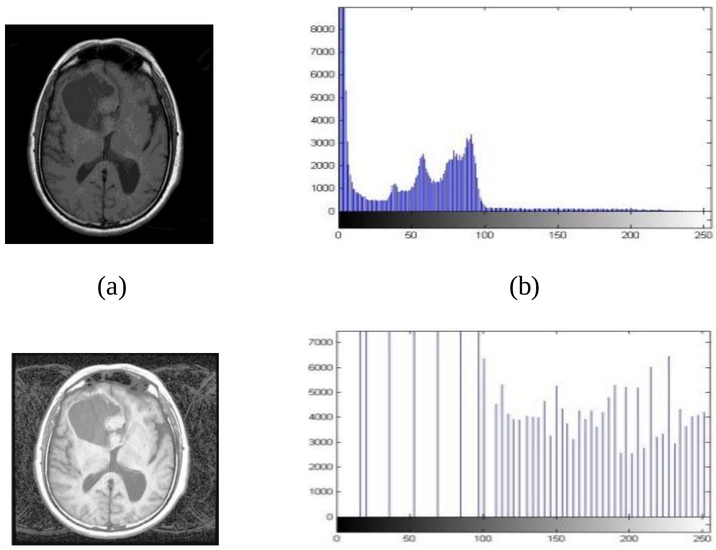
(a) (b)

Fig. 2 (a) Histogram Equalized image (b) Histogram

Table 1 shows the statistical analysis of all original and filtered treated images. Maximum and minimum intensity for all images are 1 and 0, except differs which is histogram equalization of ordered filter tumor image 0.03529. Both means of original images falls around 0.017. The analysis shows means and standard deviation represents very close results (about 0.68 for mean and 0.4 for standard deviation) whereas skewness and kurtosis represents variations in readings. With the help of skewness readings, we can improve enhancement quality by improvising with histogram techniques.

IV. CONCLUSION

Digital image processing is the heart of computer aide d diagnostics. There are four basic steps of DIP;(i) Image acquisition (ii) Image Enhancement & Restoration (iii) Registration and (iv) Segmentation. Our paper deals with the enhancement technique are which Histogram image analysis is discussed in detail. Simple Histogram and Histogram Equalization is shown and discussed in detail. Histogram is a very powerful tool. Our work is just the primary step towards the segmentation of tumor. Statistical analysis also included which shows similarities in mean and standard deviation among histogram equalization treated normal and brain tumor image.



(a) (b) (c) (d)

Fig. 3 (a) Original image with tumor showing distortion (b) Histogram of original image (c) Histogram equalized image (d) Histogram of equalized image

Table 1 Statistical Analysis of Images

Image Type	Maximum Intensity	Minimum Intensity	Mean	Standard Deviation	Skewness	Kurtosis
Original Brain Tumor	1	0	0.1756	0.1887	1.19	1.611
Normal Brain	1	0	0.171	0.1706	0.683	0.05168
Histogram Equalization (Tumor)	1	0	0.6773	0.3327	-0.5301	-1.215
Image Histogram Equalization (Normal)	1	0	0.6754	0.3349	-0.5442	-1.175

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