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Interpolation of the Histogramed MR Brain Images for Resolution Enhancement

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Abstract: ***Magnetic resonance imaging (MRI) is an incredible testing method which provides appropriate anatomical images of the body. For the diagnosis, high resolution MR images are essential to extract the detailed information about the diseases. However, with the measured MR images it's a challenging issue in extracting the detailed information associated to disease for the posterior analysis or treatment. Usually to improve the resolution of the MR image, histogram equalization process has to be applied. In this paper, interpolation method is applied to improve the resolution of MR brain images for the histogram-ed images. And for the assessment of the skillfulness of introduced method, performance metrics such as peak signal to noise ratio (PSNR) and absolute mean brightness error (AMBE) are measured. The peak of signal for the enhanced images through interpolation will be much better and may have the good variation to the mean brightness error. With this there can be potential to the artificial intelligence for better diagnosis in complex decisive instances.***

Keywords: ***Histogram Equalization, Interpolation, MR images, Resolution Enhancement.***

I. INTRODUCTION

Magnetic Resonance Imaging (MRI) of the brain is an effortless risk-free custody test that uses a strong magnetic field gradients and radio waves to generate detailed (careful) images of the brain and the brain stem. MRI machines are supportive for patients with simple phobia. In medical image processing, to accent the important features for posterior analysis or for image display it is essential to perform the operations like contrast improvement and resolution enhancement because of medical images distinctly suffers from high level of noise, geometric contortions and mien of imaging artifacts. To incur high contrast in the image, intensity equalization method has to be done and high resolution images are essential to obtain absolute anatomical information to watch over the maturity of human brain. Usually different Histogram Equalization methods are used to have better resolution of the images like Histogram equalization (HE), adaptive histogram equalization (AHE) etc.

A. Histogram Equalization

Histogram equalization (HE) is applicable when the distribution of pixel values is resembles throughout the image (Abdullah Al et al., 2013; David M et al., 2007; Fernandez G C et al., 2013; Chen C et al., 2015; G. Senthamaraiand K et al., 2015; Rubina Khan et al., 2012; Senthikumaran N et al., 2014;) Particularly when the regions are lighter or darker for those regions the contrast will not be adequately enhanced. With the help of non-linear function, re-distribution of intensity values of the pixels will be implemented. This can be achieved with the help of the cumulative distribution function (CDF). With CDF, the intensities are almost uniformly distributed. Hence, without changing its median value the dynamic range of the histogram is increased. Unlike HE, in adaptive histogram equalization (AHE) rather applying on complete image, separately it is performed on sub images i.e. each pixel is altered based on the pixels that are in a contextual region (Rajulath B A.K et al., 2015). But it is very expensive as it takes more time for calculations. So, interpolation process is applied to improve resolution of MR brain image after the adaptive histogram equalization.

B. Interpolation

Histogram intensity equalization is discrete in nature so it is difficult to represent an analytic function to these set of data measurements. Therefore Interpolation is a utility function for the measurements for which the data is discrete in nature. Interpolation is the logical estimation of an unknown arbitrates value within the data range. Interpolation is a process in which a new pixel can be generated by analyzing the surrounding pixels. Interpolation may be deterministic interpolation or statistical approximation. In deterministic, interpolation is based on the assumption of definite variability between the samples where as in statistical it depends on the approximation of signals by reducing the estimation error. As statistical approach is computationally inefficient, deterministic approach is implemented in the proposal. However, while interpolating an image it is necessary to take finite number of samples and these can be selected in three ways: (1) Nearest neighbor Interpolation, (2) Linear interpolation and (3) Cubic B-spline interpolation. Best adapted interpolation will result in best quality of the image. The choice of good interpolation method is based on finding an optimal counterbalance between three unsuitable artifacts: edge halos, blurring and aliasing. It is important to note that for interpolation it should have finite support region. A commonly used function which fulfills all the requirements of the interpolation is B-spline function (Bn), There 'n' is order. The zeroth order B-spline (B0) function is used to represent the nearest neighbor interpolation which covers two numbers of pixels i.e. inter-pixel distance is 1. Linear interpolation is described by, B1 which covers the three number of pixels -1, 0, +1.Cubic

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B-spline interpolation function, B3covers five number of pixels -2,-1, 0, +1, +2 and is more preferable when image does not have high frequency components. B3 is defined for two regions (0, 1) and (1, 2) as shown in “(1),”and “(2),”respectively.

$$f(x) = \frac{x^3}{2} - x^2 + \frac{4}{6} \tag{1}$$

$$f(x) = \frac{-x^3}{6} + x^2 - 2x + \frac{8}{6} \tag{2}$$

II. PROPOSED METHOD

In the proposal, histogram equalization along with cubic B-spline interpolation is used to increase the resolution of the MR brain image and the information from the image enhancement can be helpful to work in deep learning concepts as shown in the flowchart Fig.1.

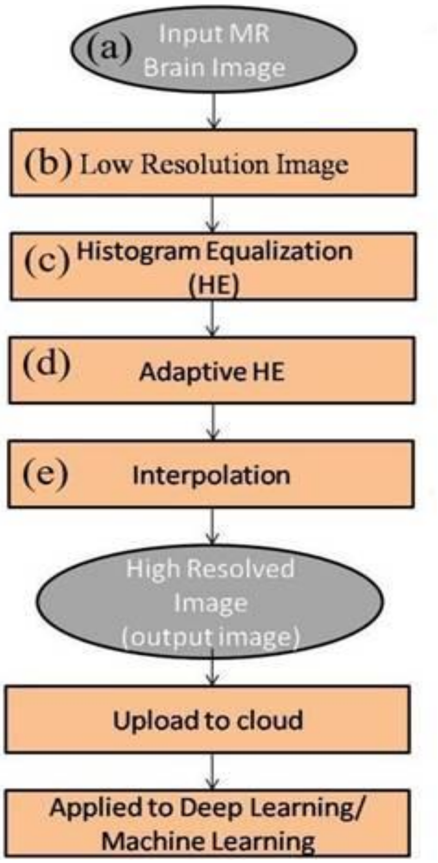

Fig.1: Flow Chart

The process flow chart processing from low resolution image into improved resolution output image with improved PSNR is shown in the figure 1. A reference image data set is taken from MRI brain images data base as an input image for processing for which low resolution image is formed by scaling the intensity of input as shown in figure 2(b). Then by distributing the irregular intensity levels over a constant range, histogram equalization is obtained as in figure 2(c). But, to spread out the intensity level maximum as possible over total range of the pixels adaptive histogram equalization is obtained with the help of cumulative distribution function (CDF) which is shown in figure 2(d).

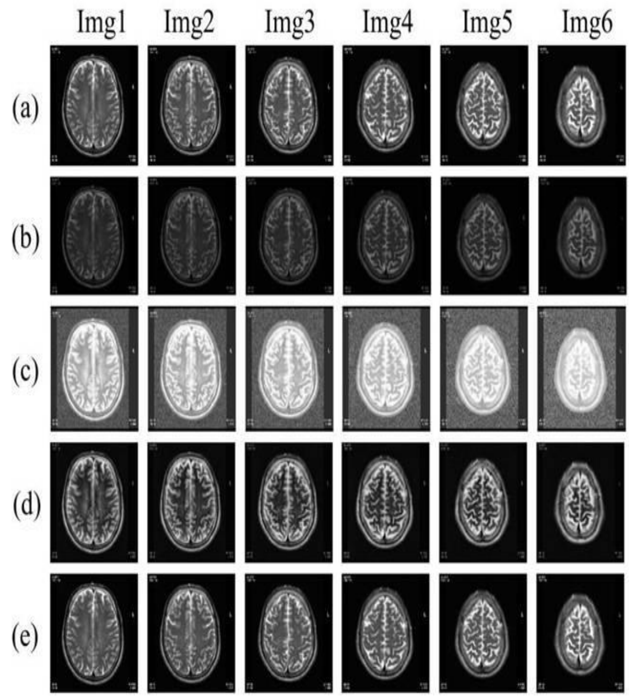

Fig.2: MR Brain images set (a). Data Set of images (references), (b) LR Images for data set, (c) Images after Applying HE to LR images, (d) Images after applying AHE and (e) Resolved Images with Interpolation technique.

To increase the resolution of the image, adaptive histogram equalized image is interpolated in which dimensions will be increased in both horizontal and vertical directions as in figure 2(e) meanwhile PSNR get increased. Further it can be uploaded to cloud and applied for deep learning and/or machine learning to analyze the brain MR image data to percept more information for treatment/diagnosis.

III. EVALUATION METRICS

Finally, to assess the performance of the proposed method, performance parameters are necessary to estimate the quality of the output images. Here two parameters are considered for comparison between different results namely peak signal to noise ratio (PSNR) and absolute mean brightness error (AMBE).

A. PSNR

It is a feature bringing similarity to human perception of reconstruction quality. This ratio is a qualitative peak error measurement between the original image maximum power and the power of corrupted image which is measured in decibels. The higher the value of PSNR better will be the quality of the reconstructed image.

$$PSNR = 20\log_{10}\left(\frac{MAX_f}{\sqrt{MSE}}\right) \tag{3}$$

Where, MAX_f is the maximum possible power of an image and MSE is the mean square error which represents the power of corrupting noise.

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B. AMBE

AMBE is defined as difference between the mean intensities of two images and is given by

AMBE =|Xm – Ym| (4)

Where Xm is mean intensity of input image and Ym is mean intensity of output image. The value of AMBE should be low for the better resolution preservation.

IV. RESULT AND DISCUSSION

In order to evaluate the effectiveness of the proposal, tests were performed on 4 different data sets of MR brain images which were taken from a reference database. The results shown in the figures 3, 4 and 5 are for the data set-1 and these results are compared with other data sets (2, 3&4) as shown in table-I and II. Figure 3(a)-3(e) shows the histogram processing of the data set-1 images, LR images, HE, AHE and interpolation process respectively. And it is determined that the peak of the histogram of the interpolation mechanism is high when compared with the conventional methods. Figure 4 and 5 shows the PSNR and normalization of the AMBE respectively. And it shows that the better value for proposed and good brightness variation. Table-I and II shows quantitative analysis between the obtained results (for data set-1) with different data sets for HE, AHE and proposed methods.

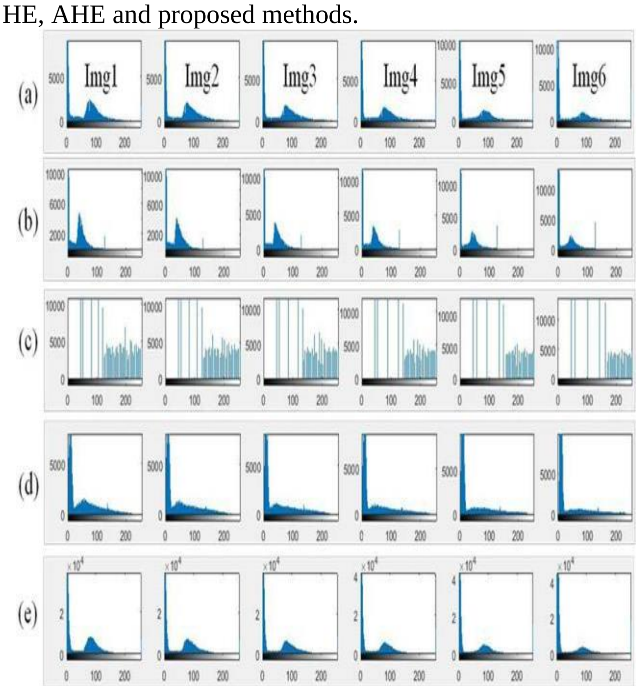

Fig.3: MR brain images histogram intensity equalizations. (a) Histogram of Data Set, (b) Histogram for LR Images, (c) HE for LR Images, (d) AHE for LR Images and (e) Histogram for Interpolated Images.

And it is observed that the proposed method gives high precise measurements which can be examined by observing the analysis of results obtained for the different data sets shown in table I and II.

Table I: Average PSNR values for different data sets

Technique	PSNR in dB(for 4 data sets)			
	Set-1	Set-2	Set-3	Set-4
HE	8.79	2.55	2.95	6.68
AHE	23.73	26.79	29.93	25.58
Proposed	33.88	40.04	37.19	35.42

Table II: Average AMBE values for different data sets

Technique	AMBE (for 4 data sets)			
	Set-1	Set-2	Set-3	Set-4
HE	87.31	190.2	180.11	111.66
AHE	1.207	7.747	3.574	5.519
Proposed	0.122	0.101	0.109	0.205

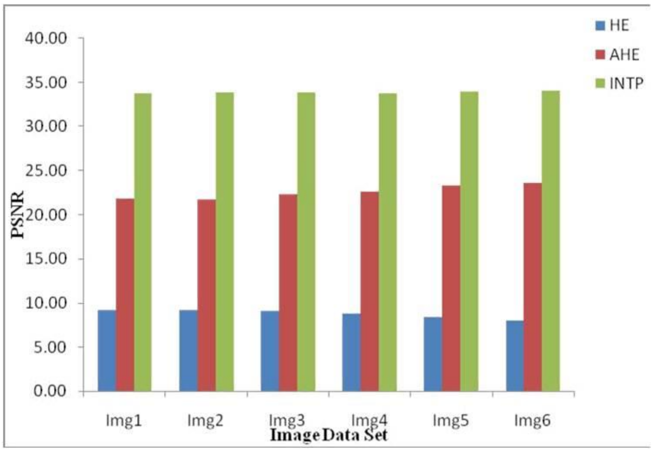

Figure 4: PSNR results for data set of images for HE, AHE and Interpolated algorithms.

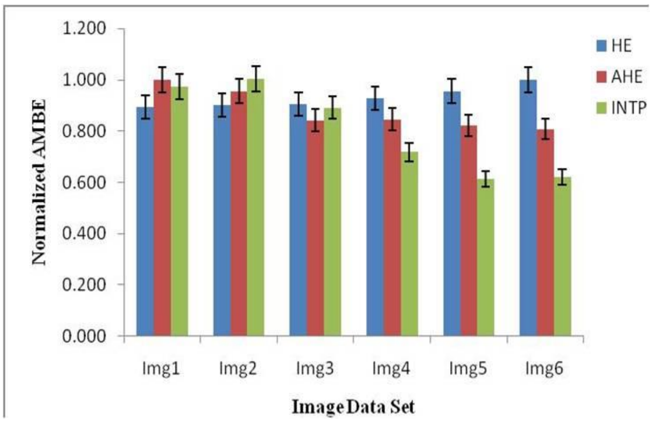

Figure 5: Normalized AMBE results for data set of images for HE, AHE and Interpolated algorithms.

V. CONCLUSION

From the above investigated measurements and graphical records it is concluded that the good resolution is obtained with good performance metrics i.e. high PSNR and less AMBE by acquaint interpolation for histogram intensity equalized images which are shown in figure 4 and 5. Further it can be analyzed with any branch of Artificial Intelligence (deep learning) to reduce the computational time to provide the diagnosis in decisive instances.

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