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An Improved Method for Brain MR Image Enhancement Using Fuzzy Inference System

Ganesh S. Raghtate[1], Suresh S. Salankar[2], Abhilasha K. Tiwari[3]
[1](Electronics Engineering, BDCOE, Sewagram, India)
[2](Electronics & Telecomm. Engineering, GHRCOE, Nagpur, India)
[3](Electronics & Telecomm. Engineering, GWCOE&T, Nagpur, India)

Abstract: *Image enhancement is used to reduce the noise and improve resolution contrast of the image. The images can be improved by improving the quality regarding the pixel values. The pixel values are manipulated with the number of inputs and the gray level values. On the other hand Fuzzy image enhancement is based on gray level mapping into a fuzzy plane, using a membership function. This paper compares the enhancement performance of commonly used Median Filter and Fuzzy Inference System. Both the methods are tested on 15*
MRI brain images. The comparison is based on the parameter Peak Signal to Noise Ration. Fuzzy Inference System shows 17.74 percent improvement in PSNR than Median Filter with improvement in image appearance.
Keywords: *Magnetic Resonance Image (MRI), Image enhancement, Median filter, Fuzzy Inference System.*

I. Introduction

Image enhancement enhances the quality of the MRI brain before segmentation, feature extraction and classification. Image processing and enhancement stage is the simplest categories of medical image processing. This stage is used for reducing image noise, highlighting edges, improving resolution contrast or displaying digital images. It refers to emphasis on sharpening of image features such as edges, boundaries or contrast. It makes a graphic display more useful for display and analysis. Image enhancement consists of gray level and contrast manipulation, noise reduction, edge crispening and sharpening, filtering, interpolation and magnification [1-2]. The enhancement stage includes resolution enhancement; contrast enhancement. These are used to suppress noise and imaging of spectral parameters. For achieving best possible diagnosis it is necessary that the medical image should be sharp and noise free.

Histogram Equalization (HE) usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. It provides better views of bone structure in x- ray images, and detail in photographs that are over or under-exposed. The CLAHE algorithm partitions the images into contextual regions and applies the histogram equalization to each one. This evens out the distribution of used grey values and thus makes hidden features of the image more visible. CLAHE overcome the limitations of standard histogram equalization. Tracking algorithm [3] removes artifacts in Brain MR Images. Here, starting from the first row and first column, the intensity values of the pixels are analyzed and the threshold values of the film artifacts are found. The threshold value, greater than that of the threshold value is removed from MRI. The high intensity values of film artifacts are removed from MRI brain image. It uses highest threshold 255 for gray scale image. It removes artifacts of gray value of 255 only. It leaves all other artifacts on the image. This algorithm also removes data from ROI.

In this paper, we focus on finding the enhancement technique which provides higher value of PSNR for Brain MR Images. The preprocessing techniques used are Median Filter and Fuzzy Inference System. The paper is organized as follows. Section 2 presents the median Filter. Section 3 presents Fuzzy Inference System algorithm to enhance image using Fuzzy technique. Section 4 presents Experiments and Results. Section 5 concludes the paper.

II. Median Filter

The median filter is a nonlinear digital filtering technique, often used improve the quality of an image. It removes the noise, high frequency components from MRI without disturbing the edges and it is used to reduce salt and pepper noise. The main idea of the median filter is to run through the signal entry by entry, replacing each entry with the median of neighboring entries. The pattern of neighbors is called the "window", which slides, entry by entry, over the entire signal. If the window has an odd number of entries, then the median is simple to define. It is just the middle value after all the entries in the window are sorted numerically. This technique calculates the median of the surrounding pixels to determine the new (denoised) value of the pixel. A median is calculated by sorting all pixel values by their size, then selecting the median value as the new value for the pixel. The amount of pixels is used to calculate the median [4].

III. Fuzzy Inference System

The fuzzy systems are knowledge based systems, unfortunately, when it comes to human perception, there is no general theory determining what good enhancement is, if it looks good it is good. However, image enhancement is used as pre-processing tools for other image processing technique. Fuzzy technique mainly contains three steps 1) image fuzzification 2) enhancing intensity component 3) image defuzzification.

The fuzzification and defuzzification steps are due to the fact that we do not possess fuzzy hardware. Therefore, the coding of image data (fuzzification) and decoding of the results (defuzzification) are steps that make possible to process images with fuzzy techniques. Fuzzy image enhancement is based on gray level
mapping into a fuzzy plane, using a membership function transformation.

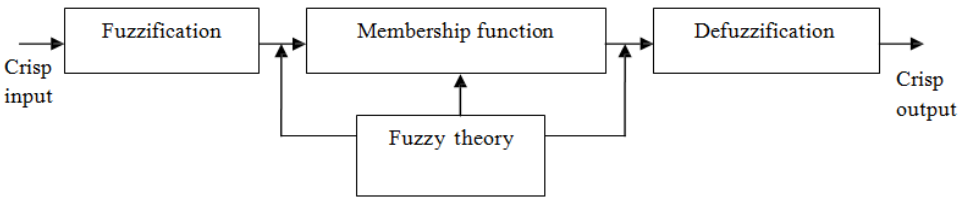


Figure 3.1 Fuzzy Inference System

Fuzzy inference system is the process of formulating the mapping from a given input to an output using fuzzy logic. The mapping provides the basis from which decisions can be made. The process of fuzzy inference involves membership functions, fuzzy logic operators and if-then rules. Fuzzy inference system is associated with fuzzy-rule-based system and fuzzy-expert system.

On the basis of following fuzzy rules, an image enhancement algorithm can be developed and implemented:

If pixel intensity is dark then output is darker. If pixel intensity is gray then output is gray.

If pixel intensity is bright then output is brighter.

IV. Experiments And Results

The MRI data is obtained from open data source http://www. cancerimagearchive. net/ display/ public/ collections. A sample of total 15 MRI brain images is used for enhancement purpose. These images are with the default size of 256 x 256. The Median filter and Fuzzy Inference System are implemented by using mat lab 7.9. The experimental results are tested in Intel Core 2 Duo CPU 2GHz processor with 1GB RAM. Enhancement performance of Median filter and Fuzzy Inference System are analyzed and evaluated by the parameter peak signal-to-noise ratio (PSNR) given in equation 4.1,

$$\text{PSNR in dB} = 10 \log 10(2552/\text{MSE}) \qquad (4.1)$$

$$\text{MAE} = \frac{\sum M,N\ [I_1(m,n) - I_2(m,n)]^2}{M \times N}$$

TABLE 4.1: Performance of Filters For Medical Images.

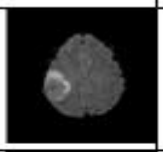
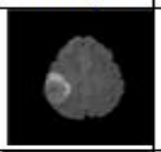
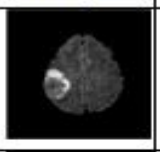
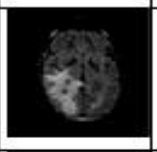
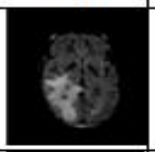
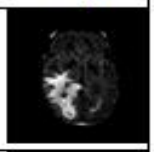
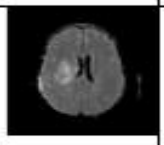
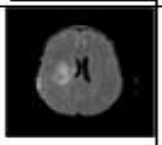
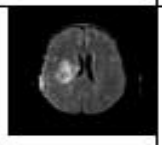
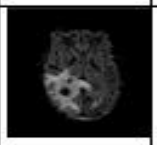
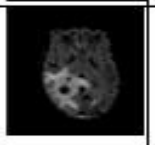
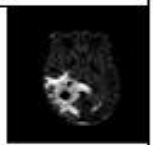
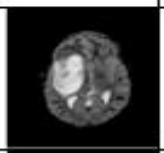
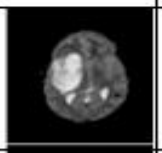
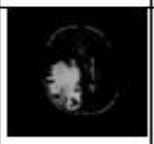
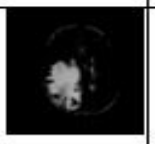
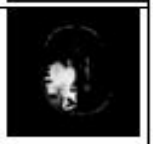
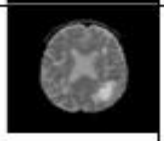
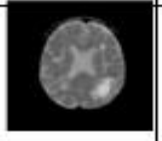
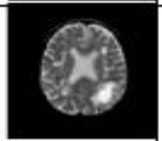
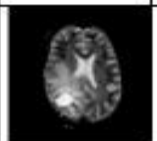
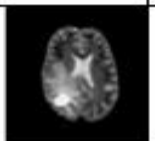
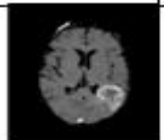
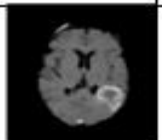
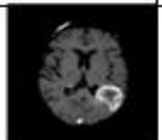
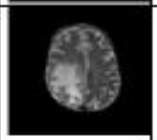
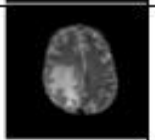
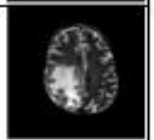
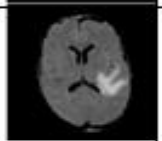
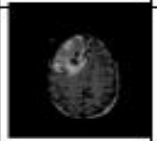
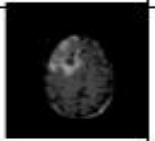
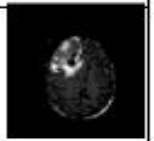
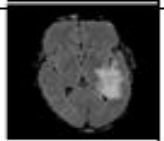
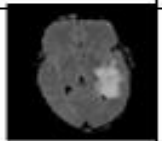
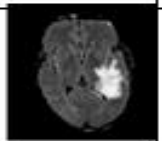
Sr. No	Original Image	Median Filtered Image	FIS Enhanced Image	Sr. No	Original Image	Median Filtered Image	FIS Enhanced Image
1				9			
2				10			
3				11			
4				12			
5				13			
6				14			
7				15			
8							

Table 4.1 shows that the FIS enhanced image appears fine and sharp compared to median filtered image. Such better enhanced image provides good segmentation results which are required for accurate classification of brain MRI.

The statistical analysis of the both the enhancement methods are shown in Table 4.1.

Table 4.2: Enhancement Performance Of Median Filter And Fuzzy Inference System.

Sr. No.	Median Filter PSNR (dB)	Fuzzy Inference System PSNR (dB)	PSNR (dB) Improvement over Median Filter By FIS
1	29.4468	31.2809	1.8341
2	26.0371	30.2992	4.2621
3	25.431	29.1102	3.6792
4	27.9945	31.1785	3.184
5	26.0596	30.5213	4.4617
6	24.7907	30.1348	5.3441
7	25.4547	29.1035	3.6488
8	26.0799	29.5089	3.429
9	24.6856	28.9625	4.2769
10	24.6691	28.9069	4.2378
11	24.7911	30.0568	5.2657
12	24.2957	29.262	4.9663

13	24.9866	29.2388	4.2522
14	25.0514	30.9047	5.8533
15	21.9018	30.9187	9.0169

From Table 4.2, it is observed that the PSNR values of Fuzzy Inference System are better than median filter. The improvement in PSNR value by Fuzzy Inference System over Median filter is shown in above table.

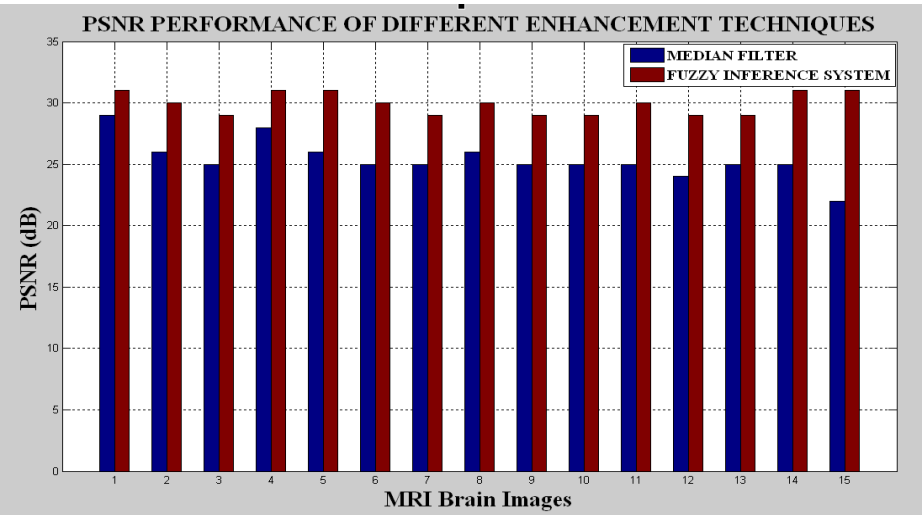


Fig.4.1: Performance of various filtering methods for medical images.

V. Conclusion

The fuzzy Inference System is able to get good contrasted image which increases the brightness and improves the contrast of the low contrasted images. This method achieves good noise discrimination and enhances the quality of the image to a great extent. The comparison of enhancement performance in terms of PSNR values of Median filter and Fuzzy Inference System shows that the Fuzzy Inference System improves the enhancement quality of MRI brain image over Median Filter with improved image appearance. It removes noise with high contrast from MRI brain images.

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