



## An Image Enhancement by Fuzzy Logic and Artificial Neural Network using Hybrid Approach

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**Abstract**— Researchers of many computer vision or machine vision has mainly focused on the field of image enhancement because of the additional knowledge and hidden information provided by the results of this procedure which will further be used for many different useful purposes. Different algorithms were purposed for enhancing an image like Histogram Equalization, Spatial Averaging, Median Filter, Un-sharp Masking & High Boost filtering etc. In this paper we proposed a new hybrid technique by optimizing two techniques Fuzzy Logic and Artificial Neural Network (ANN). Experimental results are obtained and compared against different parameters like MSE (Mean Square Error), RMSE (Root Mean Square Error), SNR (Signal to Noise Ratio), and PSNR (Peak Signal to Noise Ratio). The results show that Fuzzy Logic and Artificial Neural network is best technique that help to improve the image visibility and preserving the significance features of images which can further used in many useful purposes.

**Keywords**— Fuzzy Logic, ANN, Histogram Equalization, Spatial Averaging, Median Filter, Un-sharp Masking & High Boost filtering, MSE, RMSE, SNR, PSNR.

### I. INTRODUCTION

An image may be defined as two-dimensional function  $f(x,y)$  where  $x$  and  $y$  are spatial (plane) coordinates and amplitude of  $f$  at any pair of co ordinates  $(x,y)$  is called intensity or gray level of the image at that point. When  $x$ ,  $y$  and the amplitude values of  $f$  are all finite discrete quantities, we call the image as digital image. A digital image is composed of a finite number of elements, each of which has a particular location and value. These elements are referred to as picture elements, image elements, and pixels. Pixel is the term most widely used to denote the elements of a digital image [4]. Image enhancement processes consist of a collection of techniques that seek to improve the visual appearance of an image or to convert the image to a form better suited for analysis by a human or a machine.

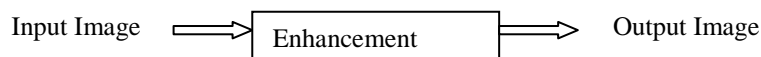


Fig 1: Image Enhancement

Whenever an image is converted from one form to another, such as, digitizing, scanning, transmitting, storing, etc. some degradation occurs at the output. Hence, the output image has to undergo a process called image enhancement. Fuzzy image processing is the collection of all approaches that understand, represent and process the images, their segments and features as fuzzy sets. The representation and processing depend on the selected fuzzy technique and on the problem to be solved. The idea of fuzzy sets is simple, natural and on the basis for human communication. Because fuzzy logic is built on the structures of qualitative description used in everyday language, fuzzy logic is easy to use. A filtering system needs to be capable of reasoning with vague and uncertain information. This suggests the use of fuzzy logic. However when image enhancement techniques are used as pre-processing tools for other image processing techniques, then quantitative measures can determine which techniques is most appropriate. Fuzzy image enhancement is based on gray level mapping into a fuzzy plane, using a membership transformation function. The aim is to generate an image of higher contrast than the original image.

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. The main power of fuzzy image processing is in the middle step (modification of membership values). After the image data is transformed from gray-level plane to the membership plane (fuzzification), appropriate fuzzy techniques modify the membership values. This can be a fuzzy clustering, a fuzzy rule-based approach, and a fuzzy integration approach and so on.

## II. RELATED PREVIOUS WORK

### A. Histogram Equalization

Histogram equalization is contrast enhancement technique in a spatial domain in image processing using histogram of image. Histogram equalization usually increases the global contrast of the processing image. This method is useful for the images which are bright or dark [2].

Consider the discrete grayscale input Image  $X = x(i, j)$ , with the  $L$  discrete levels, where  $x(i, j)$ , represents the intensity levels of the image at the spatial domain  $(i, j)$ . Let histogram of Image  $X$  is  $H(X)$ . Now the probability density function  $pdf(X_k)$  can be defined as-

$$pdf(X_k) \text{ or } p(X_k) = \frac{n_k}{N}$$

Where,  $0 \leq k \leq (L-1)$

- $L$  is the total number of gray levels in the image,
- $N$  is the Total number of pixels in the image,
- $n_k$  is the total number of pixels with the same intensity level

### B. Spatial Averaging

This is the simplest of the mean filters. Let  $S_{xy}$  represents the set of coordinates in a rectangular sub image window of size  $m \times n$  centered at point  $(x, y)$ . The arithmetic mean filtering process computes the average value of the corrupted image  $g(x, y)$  in the area defined by  $S_{xy}$ . The value of the restored image  $f$  at any point  $(x, y)$  is simply the arithmetic mean computed using the pixels in the region defined by  $S_{xy}$ . In other words,

$$\hat{f}(x, y) = \frac{1}{mn} \sum_{(s,t) \in S_{xy}} g(s, t)$$

This operation can be implemented using a convolution mask in which all coefficients have value  $\frac{1}{mn}$ . A mean filter simply smoothes local variations in an image. Noise is reduced as a result of blurring [5].

### C. Median filter

The best known order-statistics filter is the median filter, which replaces the value of a pixel by the median of the gray levels in the neighborhood of that pixel

$$\hat{f}(x, y) = \text{median}_{(s,t) \in S_{xy}} \{g(s, t)\}$$

Median filters are quite popular because, for certain types of random noise they provide excellent noise reduction capabilities, with considerably less blurring than linear smoothing filters of similar size [3].

The input pixels is replaced by the median of the pixels contained in a window around the pixel, that is

$$v(m, n) = \text{median}\{y(m - k, n - l), (k, l) \in W\}$$

Where  $W$  is a suitable chosen window. The algorithm for median filtering requires arranging the pixel values in the window in increasing or decreasing order and picking the middle value. For example, if  $y(m) = \{2, 3, 8, 4, 2\}$  and  $W = [-1, 0, 1]$ , then the median filter output is given by:  $v(0) = 2$  (boundary value),  $v(1) = \text{median}\{2, 3, 8\} = 3$ ,  $v(2) = \text{median}\{3, 8, 4\} = 4$ ,  $v(3) = \text{median}\{8, 4, 2\} = 4$ ,  $v(4) = 2$  (boundary value).

### D. Un sharp Masking & High Boost filtering

In the un-sharp masking (UM) approach for image enhancement, a fraction of the high-pass filtered image is added to the original one to form the enhanced image [8]. The input/output relation for the un-sharp masking filter can be written as follows:

$$x' = x + \lambda z$$

## III. PROPOSED IMAGE ENHANCEMENT METHOD

In digital image processing there are various techniques like Histogram Equalization, Spatial Averaging, Median Filter, Un-sharp Masking & High Boost filtering. We have proposed a hybrid technique by Optimizing two techniques Fuzzy Logic and Artificial Neural Network (ANN). Read the original image. Calculate the size of original image ( $M \times N$ ). Resize the image. Convert it into Gray Scale image if it is RGB image. Add the noise to the image. Preprocess the noisy image. Apply different enhancement methods. Apply proposed algorithm. The fuzzy knowledge base utilized in the proposed technique was 'learnt' using an algorithm to ensure that any ambiguity that may arise from determining the rules using intuition was removed. Normalize of pixel values. Compare enhanced images of proposed technique with the other enhanced images. A simple block diagram of proposed method is shown in figure 2.

#### IV. PERFORMANCE MATRICS

Results are compared according to different parameters like MSE, RMSE, SNR, and PSNR.

##### A. MSE(Mean Squared Error)

MSE the simplest and most widely used quality metric and is computed by averaging the squared intensity differences of original image and enhanced image.

Mean square error (MSE) is given by

$$\frac{\sum((f(i,j) - F(i,j))^2)}{MN}$$

$f(i,j)$  is the original image,  $F(i,j)$  is the enhanced image and  $MN$  is the size of image.

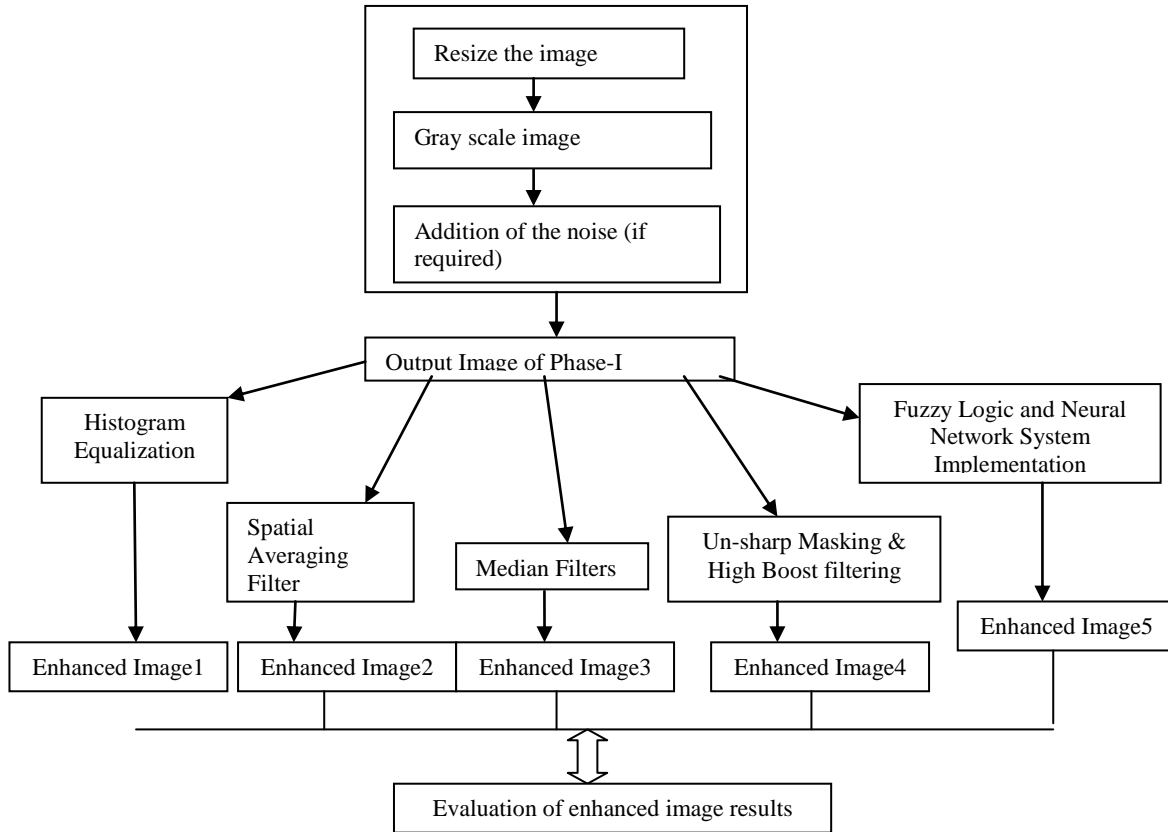


Fig. 2. Block Diagram of Proposed method

##### B. RMSE(Root Mean square error)

Root mean square can be calculated by

$$RMSE = \sqrt{\frac{\sum((f(i,j) - F(i,j))^2)}{MN}}$$

$f(i,j)$  is the original image,  $F(i,j)$  is the enhanced image and  $MN$  is the size of image.

##### C. SNR(Signal to Noise Ratio)

SNR compares the level of desired signal to the level of background noise. The higher the ratio, the less obtrusive the background noise is. Brighter regions have a stronger signal due to more light, resulting in higher overall SNR. SNR in decibels is defined as

$$SNR = 10 \log_{10} \frac{\sigma^2}{\sigma_e^2}$$

$\sigma^2$  is the variance of the noise free image and  $\sigma_e^2$  is the variance of enhanced image  
The noise level is measured by standard deviation of the image.

$$\sigma = \sqrt{\frac{1}{N} \sum (b_i - b)^2}$$

N is total number of pixels in the image, b is the mean gray level of the original image and  $b_i$  is the gray level value of the surrounding region, where  $i=1, 2, 3, \dots, N$ .

**D. PSNR (Peak Signal to Noise Ratio)**

PSNR It is used to calculate the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. An identical image to the original will yields an undefined PSNR as the MSE will become equal to zero due to no error. This shows that a higher PSNR value provides a higher image quality. Because many signals have a very wide dynamic range, PSNR is usually expressed in terms of the logarithmic decibel scale and is calculated as

$$PSNR = 20 \log_{10} \left( \frac{255}{RMSE} \right)$$

**IV. RESULTS**

The results are obtained by taking 6 different images which goes under different filters and in each filter different parameters like MSE (Mean Square Error), RMSE (Root Mean Square Error), SNR(Signal to Noise Ratio), PSNR (Peak Signal to Noise Ratio) are evaluated. Table 1, Table 2, Table 3, Table 4 shows the comparison of the SNR (Signal to Noise Ratio), PSNR (Peak Signal to Noise Ratio), MSE (Mean Square Error), RMSE (Root Mean Square Error) value for each image by using Proposed filter(Fuzzy logic and Artificial Neural technique) and Histogram Equalization, Spatial Averaging, Median Filter, Un-sharp Masking respectively. It is evident that the C# implementation of the Fuzzy logic and Artificial Neural technique has high SNR (Signal to Noise Ratio) and PSNR (Peak Signal to Noise Ratio) than that of Histogram Equalization, Spatial Averaging, Median Filter, and Un-sharp Masking. So hybrid Fuzzy logic and Artificial Neural technique is best filter. Graphical presentation of SNR value as in figure 3.

TABLE I

THE COMPARATIVE STUDY OF SNR VALUES FOR DIFFERENT IMAGE ENHANCEMENT TECHNIQUES

Images	Histogram Equalization	Spatial Averaging	Median Filter	Un-sharp Masking	Proposed Filter
Image-1	14.19	12.20	17.72	18.55	22.05
Image-2	16.17	13.55	19.08	20.38	23.41
Image-3	15.82	12.71	18.23	18.52	22.56
Image-4	23.71	18.24	23.77	25.26	28.09
Image-5	17.22	14.72	20.24	23.70	24.57
Image-6	19.00	16.59	22.11	23.08	26.45

TABLE II

THE COMPARATIVE STUDY OF PSNR VALUES FOR DIFFERENT IMAGE ENHANCEMENT TECHNIQUES

Images	Histogram Equalization	Spatial Averaging	Median Filter	Un-sharp Masking	Proposed Filter
Image-1	1.45	6.98	5.40	3.38	7.81
Image-2	0.03	3.44	3.69	2.37	5.23
Image-3	0.5	5.29	5.75	3.55	8.42
Image-4	0.32	0.19	0.85	0.56	1.25
Image-5	0.14	2.13	2.82	1.84	3.99
Image-6	0.02	3.48	2.58	1.70	3.53

TABLE III

THE COMPARATIVE STUDY OF MSE VALUES FOR DIFFERENT IMAGE ENHANCEMENT TECHNIQUES

Images	Histogram Equalization	Spatial Averaging	Median Filter	Un-sharp Masking	Proposed Filter
Image-1	2474.67	3920.4	1098.97	908.76	405.3
Image-2	1569.30	2869.12	804.22	595.64	296.73
Image-3	1702.43	3482.94	976.46	913.22	360.14
Image-4	276.93	975.22	273.26	193.80	101.01
Image-5	1232.81	2194.79	615.46	277.4	227.13
Image-6	818.53	1424.45	399.54	319.55	147.79

TABLE IV

THE COMPARATIVE STUDY OF RMSE VALUES FOR DIFFERENT IMAGE ENHANCEMENT TECHNIQUES

Images	Histogram Equalization	Spatial Averaging	Median Filter	Un-sharp Masking	Proposed Filter
Image-1	49.77	62.61	33.15	30.15	20.13
Image-2	39.61	53.56	28.36	24.41	17.23
Image-3	41.26	59.02	31.25	30.22	18.98
Image-4	16.64	31.23	16.53	13.92	10.05
Image-5	35.11	46.85	24.81	16.66	15.07
Image-6	28.61	37.74	19.99	17.88	12.14

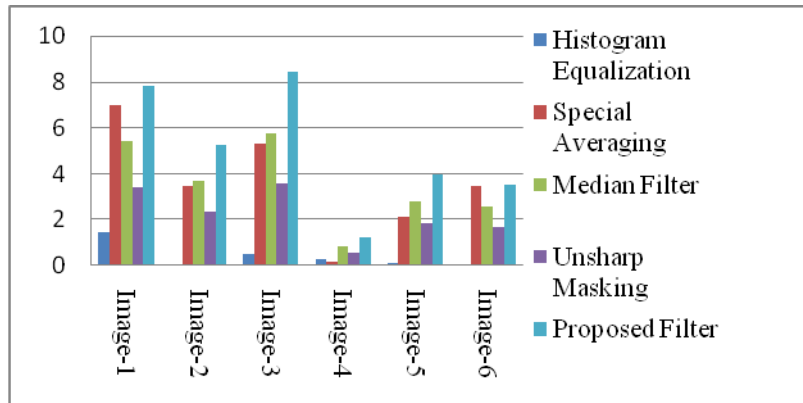


Fig. 3. Graphical representation of SNR values using different filters with 6 different images

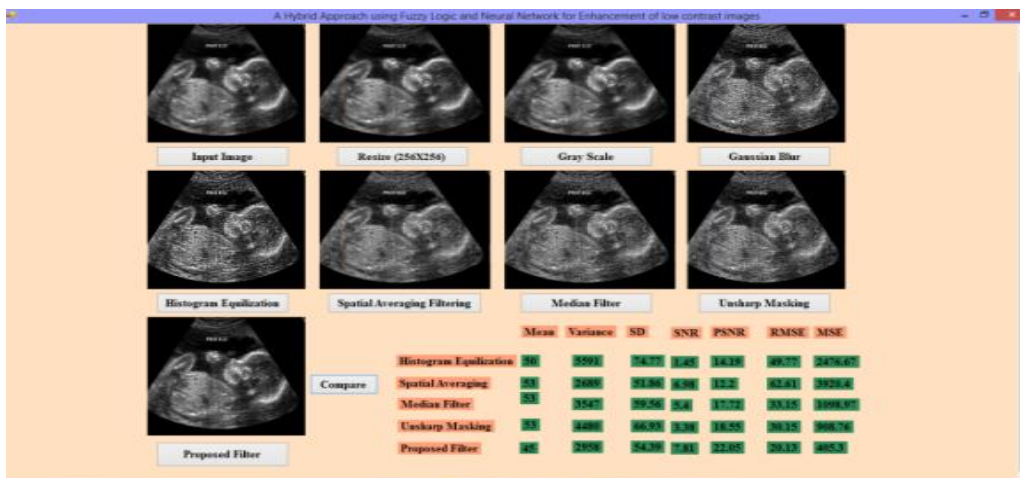


Fig.4 Experimental Result on a image by applying different filters

TABLE 5

THE COMPARATIVE STUDY OF DIFFERENT PARAMETERS FOR DIFFERENT IMAGE ENHANCEMENT TECHNIQUES

Filters	SNR	PSNR	RMS E	MSE
Histogram Equalization	1.45	14.19	49.77	2476.67
Spatial Averaging	6.98	12.2	62.61	3920.4
Median Filter	5.4	17.72	33.15	1098.97
Un-sharp Masking	3.38	18.55	30.15	908.76
Proposed Filter	7.81	22.05	20.13	405.3

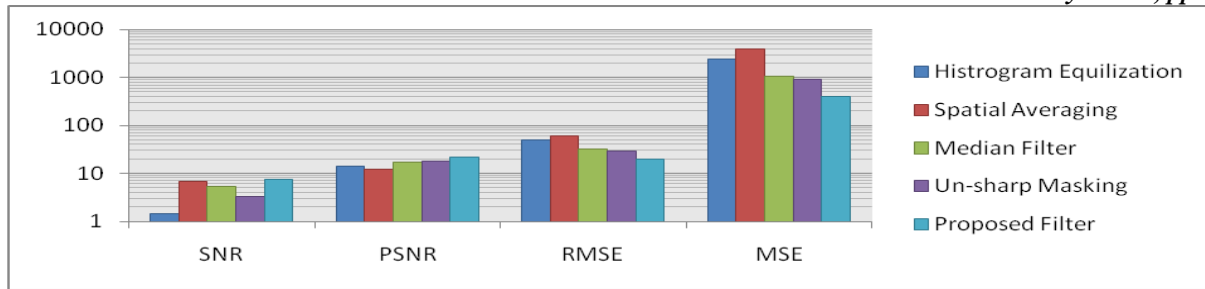


Fig.5. Graphical representation of Different parameter (SNR, PSNR, RMSE, MSE) using different filters.

## V. CONCLUSIONS

In this paper, various techniques of enhancement are implemented and compared. From the experimental results, it is found that hybrid approach using Fuzzy Logic and Artificial Neural Network yields best among the methods under study. In future, for the enhancement purpose more images can be taken from the different application fields so that it becomes clear that for which application which particular technique is better.

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