A comparative analysis of image enhancement techniques

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ABSTRACT: The contents for image processing are highly increasing in the area of biomedical, agriculture, remote sensing, wireless, and medical, etc. In recent years, one can see image processing is at the top in a biomedical imaging application. It can be used in the detection of ailment. In this area it is very tough to identify diseases such as tumors, cancer, etc. All the machines are dependent on image processing algorithms. For this, the image enhancement techniques are needed for a better quality of an image. MATLAB is suitable to design different algorithms for image processing and image enhancement. Without image enhancement, it is not possible to detect images properly. For this, a better quality of an image. In this research work, we have to design a Simulink model that is used to increase the contrast of an image or a better visualization. It is based on the image enhancement histogram equalization (IEHE) and image enhancement using fuzzy logic (IEFL). The algorithm is also based on the fuzzy logic toolbox. This paper presents an efficient flow for the histogram and fuzzy-based image enhancement. This paper stressed various image processing algorithms like sharpness, edges, etc. with the help of the evaluation parameters i.e. are shown in the table. Image enhancement can be obtained by different techniques such as HE, AHE and CLAHE so on but in this, we will focus on enhancement and evaluate various parameters as peak signal to noise ratio, mean square error, and execution of time with the help of a histogram and fuzzy-based image enhancement. We know that fuzzy is used where there is lacking of clarity. In the image processing fuzzy is used in the collection of all approaches. It is a difficult process to understand and represent. A picture in the shape of their features and segments as fuzzy sets are also very difficult to understand. The comparisons are also shown in the form of a table and also in a graphical form. The focal of this research is to compare the different parameters with the help of IEHE and IEFL by using MATLAB Simulink. After this comparison, we found that IEFL gives better results as compare to IEHE.

Keywords – Image Enhancement, Histogram Equalization, MATLAB/Simulink, Fuzzy system, Edge Detection.

I. INTRODUCTION

Improving the visual appearance of the picture the best technique is to use computer vision system enhancement. It is used for modifying the image dark to light or light to dark according to the contrast. The image enhancement technique is deeply stressed on how we can modify or give a better visualization of a picture. The disparity of a picture is the method that is used to give a better appearance i.e. contrast enhancement not only does the quality also upgrade the images feature. [1-3]. Image enhancement is a way or a procedure which is help in adjusting digital images. Image enhancement can be done by different methods such as histogram equalization. This technique is used for adjusting the image intensity by this result found the better enhancement of an image. Image enhancement techniques work with spatial domain and frequency domain method. In spatial domain it works on a plane and it directly manipulate the pixels in an image. In frequency domain technique it modify the Fourier transform coefficient of an image and it take inverse Fourier transform of the modified coefficients to obtain the enhanced image.

Image enhancement is the process of modifying the digital images. There are two types of image enhancement first is qualitative image enhancement and second is quantitative image enhancement. The qualitative image enhancement refers to the modification of images to make it more appealing to human, for example, applying different types of filters on Instagram to make the photos or pictures look better is called qualitative enhancement. On the other hand quantitative enhancement refers to the modification that an image carries. For example in edge detection process, the edge is the necessary information i.e. edges of image detected this type of enhancement is called quantitative image enhancement

Image Enhancement is used to provide a better quality of images as well as videos. If an image appears very dark it's very difficult to understand. So we need to enhance. There are various methods of enhancement histogram and fuzzy we are using in this paper. A histogram is very useful in rearranging the pixels in an image. [5-6]. Histogram is a traditional way for enhancement, it is a type when want to convert image into the form of a graphical representation then used the term histogram in image processing. It gives the graphical representation the total number of pixels with its each value. Figure 1 is here showing the difference between original gray image and enhanced output image.

Fig. 1 (a) Original image (b) Enhanced Image

In statistics, histogram is a graphical representation which brings a visual improving impression of the distribution of information or data. It provide a one variable description of data. Enhancement is more important factor used in the field of image processing. In the fig. 1 (a) is showing the gray or can say that black and white image. Firstly convert the color image into gray image because the intensity of color image is very high. Fig. 1(b) is showing the improved output image which is get after apply the different enhancement method. These Leena images here are showing the difference between the input gray image and output improved image.

The reminder of this research is ordered as: section II is showing histogram for image processing. Section III is demonstrate here the fuzzy logic for image enhancement. Experimental result and implementation is showing in the section IV. Result discussion is explained in section V and section VI demonstrate the future scope and conclusion of the research work.

II.   Histogram

The histogram is a fruitful method use to boost up the image appearance. Histogram of an image is categorized in a diagrammatic representation of the tonal distribution in a digital image. Image enhancement can be done by histogram equalization. It is a graphical representation of pixels. This is used for balancing the intensities to enhance contrast. A histogram is a graphical representation. The histogram equalization for image enhancement provides an easy way to protect the information of the frequency of sample data. For a histogram, the following techniques are used.

- Histogram Equalization
- Adaptive Histogram Equalization
- Global Histogram Equalization
- Contrast Limited Adaptive Histogram Equalization
- Local Histogram Equalization
- Contrast Histogram Equalization
- Bi- Histogram Equalization

III.   Fuzzy Logic

Fuzzy logic deals with clarity that is we can say that approximation value i.e. true or false. Here the range of truth value in between completely true and completely false, it has been worked on this near truth. In the fuzzy, it operates on if-then rules such as: If then a fuzzy hypothesis for example: "Image of the desert image is black" is an atomic fuzzy theory, if "Image desert is white/gray is a compound fuzzy proposition. Fig. 3 is showing a basic fuzzy logic system.
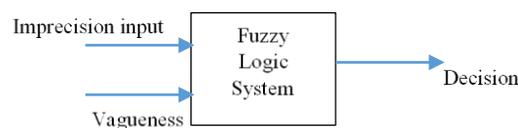

Fig.2 Fuzzy Logic System

In fuzzy input will be an image or output will be an image. Fuzzy is a gathering of various types of fuzzy algorithms. In which it can be understandable, representation, and processing of the images, their divisions, and features a set of fuzzy. Fuzzy image processing classified into three categories:
- fuzzification of image
- Image modification of membership values
- Defuzzification Image.

Fuzzy has been stretched the way of uncomplete truth. Where quality of an image may vary between completely false, completely true, or totally genuine or we can say that yes or no or true and false. The total stress of this paper is to enhance the degraded image using a fuzzy approach & without a fuzzy approach. [2]

- Propose a fuzzy-based algorithm for image enhancement & design a software application.
- Low contrast is converted into more readable.
- Apply image analysis and evaluate parameters.

The image enhancement methods (HE, contrast, sharpened, etc.) are depending on normalization, binarization, and also on Gabor filter of an image, while in gray-scale images enhanced directly. The enhancement of an image algorithms has been following many steps [9] that are below. One of the most is normalization it is applied first as input image by this image may be normalized and decrease the dynamically or we can say that vigorous range of the black and white between elevation and gap of the image approximation and the adjust the filter parameters.
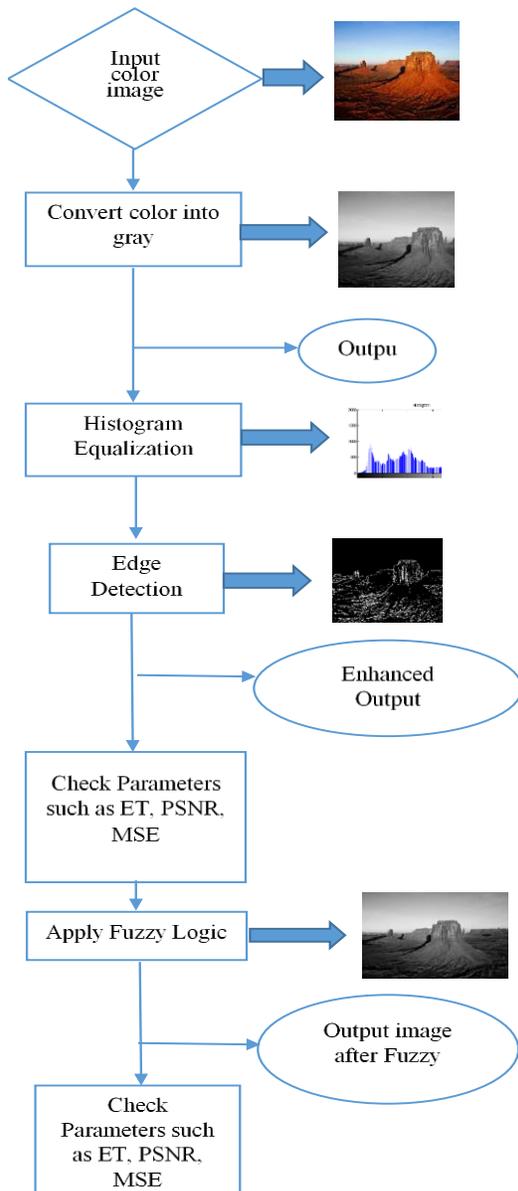

Fig. 4 Workflow for image enhancement for IEH
& IEFL [15]

The following are the method used for image   enhancement:

   I. Normalization and Gabor filter-based image enhancement [4].

   II. Fourier domain filtering [5].

III. CNN   based Gabor-type Filters [6].
IV. M-lattice based image enhancement [1].

Fig. 4 is showing here a workflow of fuzzy-based image enhancement. Fuzzy logic toolbox and Simulink model is used for this in MATLAB. In this figure, a color image has been taken as input. After taking the input image convert this input into a black and white image because have to the high intensity of the input picture. So need the conversion into black and white, the black and white image is also shown in this figure. After converting it into a gray image we will see the output image i.e. phase one output we can say that is the preprocessing step.

After the preprocessing step the output image of phase one we are applying a histogram technique and see the histogram of an image or we can say that the image is in the form of a graph. A histogram is also shown in this figure. Then we are applying the edge detection technique. This technique is helpful in finding the borders of the image, and calculate the different type of parameters like execution time, PSNR, and MSE values. This is phase two output i.e. traditional type of image enhancement technique. Now we apply a soft computing technique. In soft computing, there are many techniques such as fuzzy, ANN, neural, and CNN so on, but we have to apply the fuzzy logic technique. Fuzzy is apply where data is not clear or we can say that there is a lacking of clarity. So we required to apply fuzzy logic. At last, we can see the output image after applying fuzzy is clear than the traditional method. In the end, we will calculate the different types of parameters like PSNR, MSE, and execution time that were taken by an algorithm.

There are some fuzzy based image enhancement methods are as follow:
a. Contrast Adjustment using fuzzy
b. Subjective Enhancement
c. Image Segmentation using fuzzy
d. Edge Detection fuzzy

IV.   Experimental set-up and results Simulation results

In the implementation, we have to focus or implemented different types of images and apply enhancement techniques in a way using histogram equalization and fuzzy logic. We have also created a Simulink model for IEHE and FIE in MATLAB are shown below:

Image enhancement using histogram equalization (IEHE):

In the Simulink, model enhancement is done by the technique of image enhancement using histogram equalization. In this structure, various blocks are used such as image file, color space conversion, histogram equalization, and different video viewers. The model of IEHE is shown in fig.5. In the first block is an image from the file we have to insert a color image and by the video viewer, 1 is showing the original image. In the second block that is color space conversion, it is used for the conversion of a color image to gray and see the output with the viewer. The next block is a histogram, with the help of the viewer third we can see the image after histogram. [14]
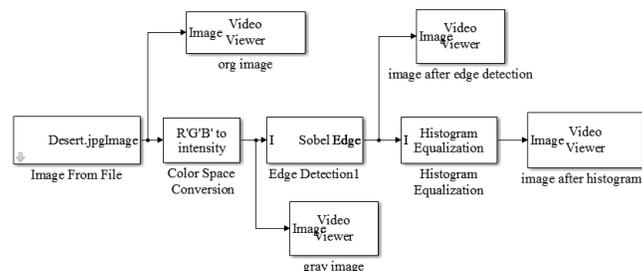

Fig.5 Simulink Model of IEHE [14]

Image enhancement using fuzzy logic and Simulink model:
In the implementation, there are some steps for all the process of this fuzzy design image enhancement using fuzzy logic toolbox and how to create a Simulink model are as follow: [5]
I.   Make a FIS file in MATLAB fuzzy logic window.
II.   Then create/set input-output variables and range.
III.   Then set rules and save the FIS file.
IV.   Write a MATLAB code for this FIS file, in this code variables name, will be the same as in FIS.
V.   At last, make a Simulink model and call the FIS file in this model also.
VI.   Then we can display the output image.

On the Fuzzy based rules, we can create an image enhancement algorithm and implemented it. The fuzzy rules are as following fuzzy:

● If the intensity of the pixel is black or dark then the output is dark.

● If the intensity pixel is gray then the output is gray.

● If the intensity pixel is white or bright then the output is brighter.

At the starting we will open the MATLAB, then type Fuzzy in the command window after giving this command we get a fuzzy window i.e. FIS editor window is shown in fig.6 (a) as below:
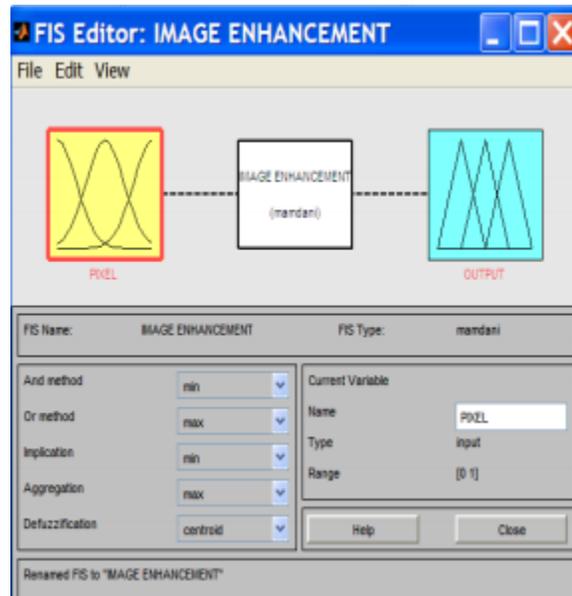

Fig. 6(a) Fuzzy logic Design Implementation of the simulink model for image enhancement [16-20]

In this model stress on enhancing an image of the desert, Leena, and cameraman image with the help of fuzzy and a Simulink model is also created and also finds its execution time taken by algorithm run, PSNR, and MSE. In this, we also apply edge detection and get an enhanced output image. This shows the fuzzy logic window in MATLAB [16-17]. In this, we can design an image enhancement model and set the input-output variables and different range of the variables. Fig.6 (b) is showing the membership function editor window. In this, we set the membership values of the function are as shown below.
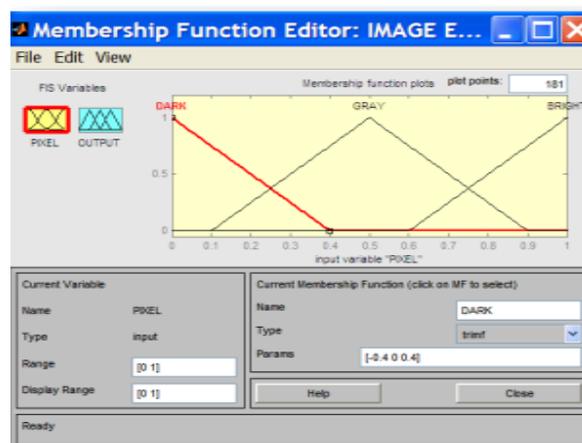

Fig. 6(b) Membership function for image enhancement

After setting these variables we set the rules such as if the input is gray what will be the output so on. The rule window is also shown in fig 5 (b). In this, we make the rule of any function or variable. The rules are showing in the window also. Is showing the membership function of image enhancement, in this, there is define input image and output as IMG f for example element of X is mapped, and value its value lies between 0 and 1. There is also show the intensity level of an image such as black, gray, and

white. Rule editor is based on the discription of input and output variables. In it, we can design rules by choosing an item in each input, and the output variable box is shown in fig 6(c) is a rule editor of fuzzy logic for image enhancement, in this, some rules can be made as if-then function. In its rules may be like as if the intensity of image 1 is black and image 2 is also black then what will the intensity of output.
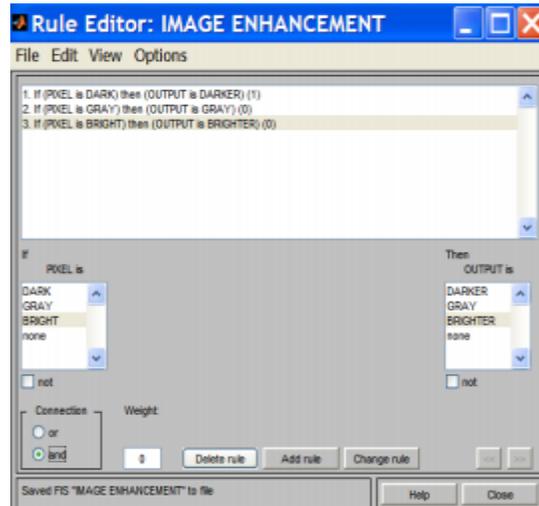

Fig.6(c) Rule editor for Fuzzy Logic Design

Fig. 6(d) is showing the rule viewer window. In this window, it depends upon the rules which are already set. We can increase the inputs also, in the rule viewer window we have to show two inputs and one output. We can increase or decrease the range of the input intensity level. By changing this output will also change.
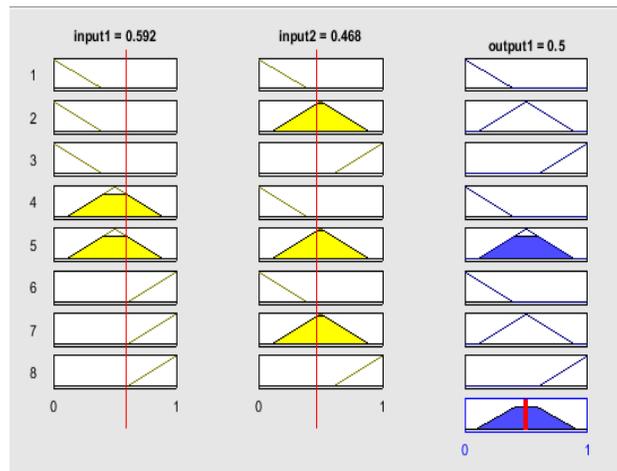

Fig. 6(d) rule viewer

Fig 6(d) is showing the rule viewer, which is used to view the inference process for the fuzzy system. In this, we are adjusting the input values of image and view output of each fuzzy rule such as what will be the effect at the output when we increase and decrease the pixel. At last 6(e) is showing the surface viewer, which is used to view the output of surface like flat, smooth, or curvy. In this, it is a must to specify the input and output variable of the fuzzy inference system (FIS). Fig.7 is showing the Simulink model for image enhancement. In this, we have to do all the functions or find parameters like PSNR, MSE, and execution time during the functioning of fuzzy logic for image enhancement. Simulink model of image enhancement using fuzzy.
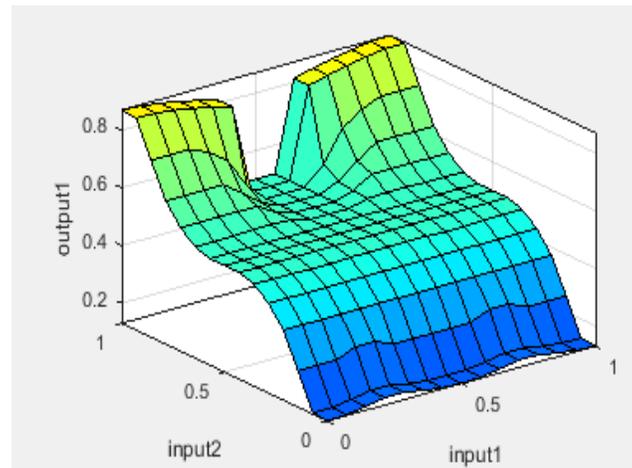
Fig. 6(e) surface viewer

In this model firstly we will browse blocks from the Simulink library as per our requirement. At first, we take will take one block for the input image. In the Simulink model we can see there is a block of the input image, in this, we have to set the same parameters which are set in the FIS file. From the second block i.e. video viewer we can see the image. Then we have required a multiplexer block which is used for multiplex the input and give one output as an image. We are given the output of the multiplexer fed to the fuzzy logic block, in this fuzzy block, when we will set the parameters we will call our FIS file from our fuzzy system which is already made. The output of fuzzy fed to the workspace block, then we can display our image in Simulink also in our m file [18]. Here we are using the block mux in this we can increase or decrease the inputs because we know that multiplexer performs or convert the different inputs to the one or a single output. Then its output is fed to the fuzzy logic controller box. In this block, we will set parameters and during the setting of parameters we call the FIS file which we made in the fuzzy logic toolbox and show the output with the help of the video viewer after fuzzy, we can also see this output image in m file or FIS file. At last, we are connecting a block named workspace showing the variables.
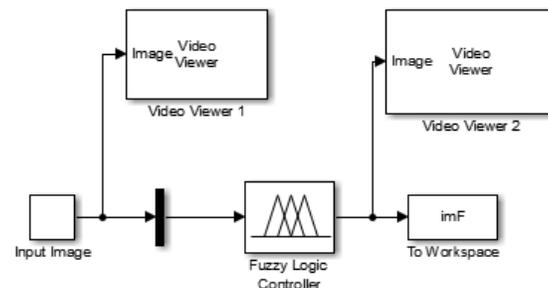

Fig.7 Simulink model for IEFL [8, 9]

Figure 8(i), (ii), (iii), (iv), (v) is displaying the different types of images such as input image, gray image, edge detection, enhanced image, and fuzzy enhanced image. Figure 9(i), (ii), (iii),(iv) are showing the input image, histogram of the input image, enhanced histogram, and histogram after apply fuzzy.

V. Results and Discussion

Performance evaluation is an analysis of measure different parameters like MSE, PSNR, CII, and execution time. In this paper different calculate parameters are shown in the table. 1&2. [5]

PSNR (Peak Signal to Noise Ratio)

PSNR is the ratio of maximum possible power of a signal and power of corrupting noise that affects the quality of an image. Higher PSNR shows the good quality of an image. [1-3][5]

$$PSNR = 10 \log_{10} \left[\frac{\max\{I(i,j)\}^2}{\frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2} \right]$$

MSE (Mean Square Error)

Mean square error [5] is used to measure the average of squares of errors. R and C show the row and columns in the input image with index I and j respectively. f(i j) represents the original image at the location (ij) and f' (ij) represents the degraded image at the location (ij). [5][7][10]
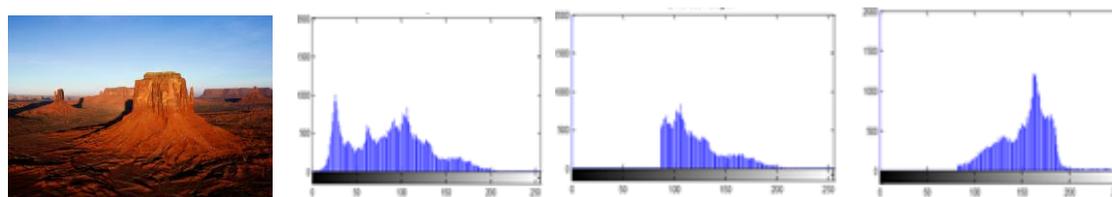
ET (Execution Time)

It is the time taken by an algorithm to process the image. Execution time is taken by the enhancement algorithm shown in table.1. In the below table we can see the comparison of how much time is taken by the algorithm using histogram equalization and fuzzy logic for enhanced an image. In the table, it is clearly shown that the time taken by the fuzzy technique is less as compare to histogram equalization.

In figure 8 (a) is showing here different types of an image such as desert, Leena, and cameraman image as input, these are in the color image that is in the form of RGB. All these are in jpg format. In figure 8 (b) we have to show the images in the gray form or we can say that we have to convert it into intensity i.e. gray form. These steps also we are showing in our Simulink model in IEHE & IEFL. Figure 8 (c) is present here as edge detection. It is used to found the edges of an image. Figure 8 (d) enhanced image after applying the histogram equalization technique of image enhancement and figure 8 (e) is showing the output of the enhanced image after applying fuzzy logic. Figure 9 (a) is showing the histogram of the different images. We can see that in figure 9 (b) displays the histogram of a different input image. It is a graphical representation. In figure 9 (c) is get after apply the image enhancement histogram equalization and figure 9 (d) is showing the histogram after applying image enhancement fuzzy logic.

Fig. 8(i) Input image; (ii) Gray Image; (iii) Edge Detection; (iv) Enhanced histogram image; (v) Fuzzy enhanced image.
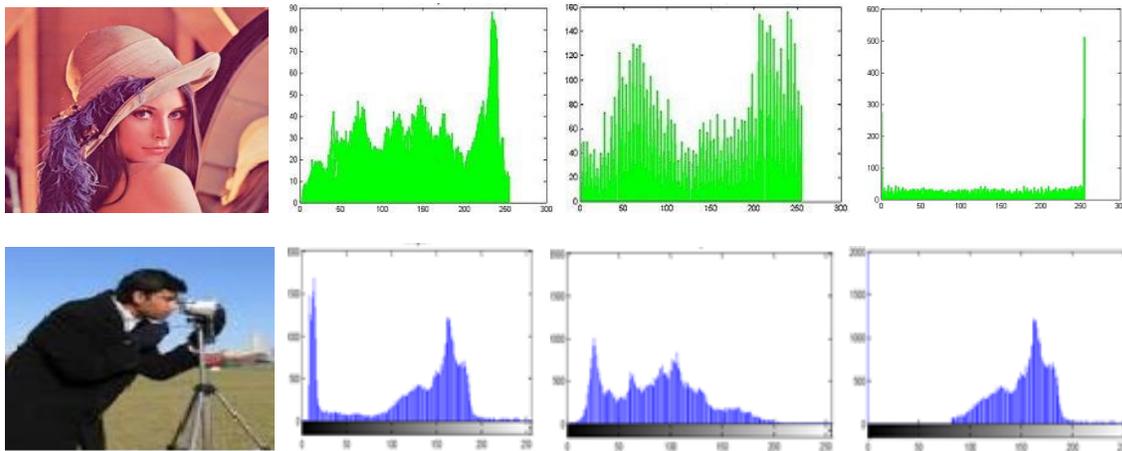
Fig. 9(i) input image; (ii) Histogram original image; (iii) Histogram of enhanced image; (iv) Histogram of fuzzy image.

The following table.1 is showing here different evaluated parameters like PSNR, MSE, and time of execution. These parameters are found after applying a traditional and soft computing technique. In traditional author is considering the histogram equalization and in soft computing have to take the fuzzy technique. In this table, we can easily observe that we got better results as compared to the histogram. We can easily see that the value of PSNR is increasing as compared to the histogram. The value of mean square error is directly proportional to PSNR. So in the result here are the values of MSE that are decreased, when compared to each other. So fuzzy MSE values are better than the histogram. Now we have come to the time taken by the algorithm that is execution time. Execution time in this table is showing the results that the time taken by the histogram technique is high then the time taken by fuzzy. So the conclusion is that when we compare histogram to fuzzy it is clear that fuzzy gives the best results.

Figure 10 is showing here the plot of different parameters. The values of PSNR of an input image, PSNR after applying histogram, and after apply fuzzy logic is showing in a graphical form. Also execution time after histogram, MSE value after apply IEHE and IEFL is also shown in this graph. Execution time when we talk about fuzzy is shown in figure 11. So all the results are evaluated with the help of MATLAB Simulink. For IEFL we have used the fuzzy logic toolbox also in MATLAB and also interfacing with Simulink. When we talk about IEHE we have created a Simulink model of image enhancement using a histogram technique [19-20]. In conclusion, we can easily observe that the fuzzy logic technique for image enhancement gives better results than the histogram technique or we can say that the soft computing technique is better than traditional.

Table: 1 Performance evaluation after applying IEHE & IEFL techniques on different images:

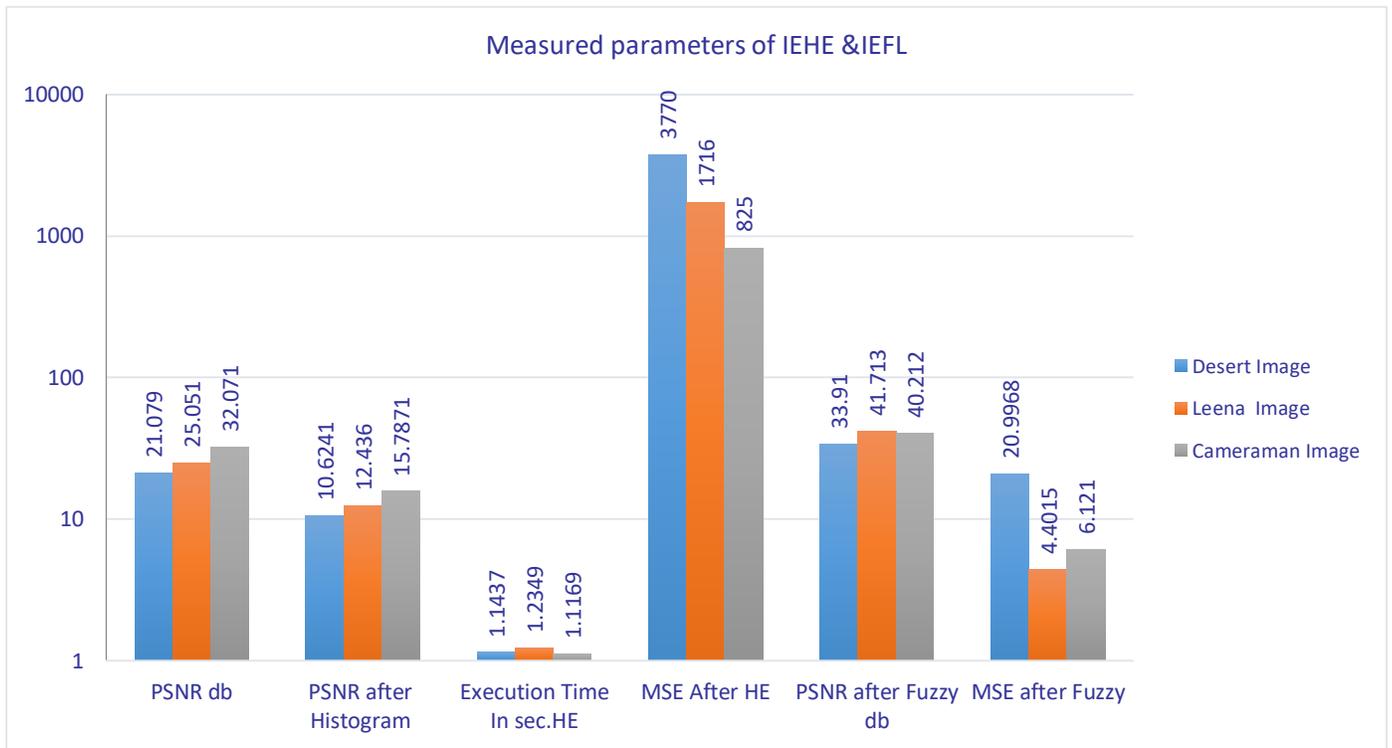| Input Image	Original image	Histogram Equalization			Fuzzy Logic		
	PSNR (db)	PSNR (db)	Execution Time (sec.)	MSE	PSNR(db)	MSE	Execution Time
Desert Image	21.079	10.6241	1.1437	3770	33.910	20.9968	0.0867
Leena Image	25.051	12.4360	1.2349	1716	41.713	4.4015	0.1686
Cameraman Image	32.071	15.7871	1.1169	825	40.212	6.1210	0.5271

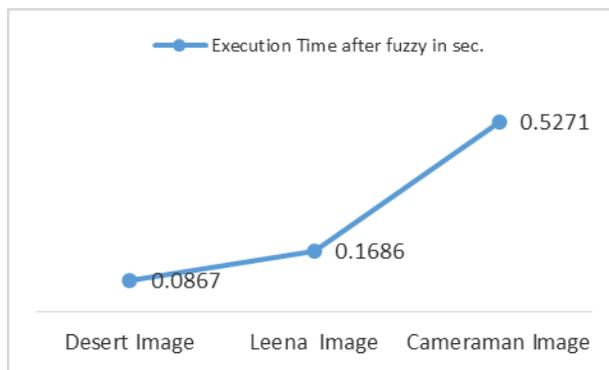Fig.10 Implementation of the proposed method (IEHE & IEFL) using MATLAB

Fig. 11 Execution time taken by fuzzy logic method

VI CONCLUSION AND FUTURE SCOPE

In this research, IEHE and IEFL are implemented for enhancement of images. Both the approaches i.e. histogram and fuzzy are based on MATLAB Simulink. A comparison of both techniques is done. Further the different type of parameters such as speed-up which is taken by an algorithm, find the value of MSE, and also calculate the value of PSNR value by taking a different type of images and also showing the results with the help of the table and in the form of graphical representation. These approaches have the ability to increase the visual appearance of different images. The results have shown the effectiveness of the fuzzy approach having the capability of enhancement of images than the results of histogram equalization. In the near future, we can use more techniques of soft computing also we apply more optimization techniques such as CNN, artificial neural networks, ACO, ABC. We can also think in the direction of in the on real-time world applications.

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