International Journal of Control Theory and Applications

ISSN : 0974-5572

Volume 9 • Number 46 • 2016

Different Scenario for MRI Image, Dark Image, Low Contrast Image and Noisy Image Contrast Enhancement Using Fuzzy and Edge Detection

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Abstract: Contrast enhancement is the most challenging area in the research work. Contrast enhancement is used to enhance the perception of the image. We have discussed four scenarios in this paper such as improved fuzzy rule based edge detection, contrast enhancement of MRI images based on fuzzy type II, image enhancement of noisy and low contrast images using fuzzy logic and contrast enhancement scheme for dark images. These scenarios are used to enhance the contrast of different-different images. In the first scenario, firstly input image is fission into two parts such as without edge image and edge detection. By using fuzzy type I and fuzzy type II enhance the both of the images. Then final image have produced by fusion of the images. Contrast enhancement is a way to enrich the quality of images.

Keywords: Contrast enhancement, fuzzy logic, edge detection, un-sharp masking.

1. INTRODUCTION

Contrast enhancement is one of the most important visual evidences in image processing. Edge detection is imperative part of image processing. Edge detection is a great interest in the image processing. It is a crucial issue in object recognition, locate object in satellite images, automatic driving, medical imaging, computer guided surgery diagnosis, automatic traffic controlling systems, etc. Many edge detection approaches have been proposed till now. The classical approaches include Kirsch, Sobel, Prewitt and Robert's cross. These are simple to compute and are capable to detect the edges and also they have sensitivity to noise and results are less accurate. The Laplacian of Gaussian (LoG) gives sharp edge. The Canny algorithm has better performance than the above operators. This algorithm reduces probability of false edge detection. A variety of new edge detection techniques have been explored based upon fuzzy logic, wavelet transforms and neural networks etc. Fuzzy logic represents a powerful approach for decision making. In this paper rule based fuzzy logic technique is proposed. Firstly for each input image three edge values are calculated. These values are calculated by using three 3*3 linear filters. After calculations, fuzzy sets are characterized by Gaussian membership functions associated to linguistic variables "low", "medium" and "high" are created to represent the edge strength. Secondly, fuzzy inference rules are used to get the better output. Fuzzy inference rules are defined that the fuzzy output would be low, medium or high. The results are compared on the basis of 4 comparison parameters that are Root Mean Squared Error (RMSE), Edge Density, Edge Intensity and Peak Signal to Noise Ratio (PSNR)[10].

MRI is an excellent at imaging the augmented breast. Breast MRI is useful for determining the most appropriate treatment, staging breast cancer and for patient follow-up after breast cancer treatment. In this paper, we utilize the use of type-II fuzzy sets to enhance the contrast of the MRI image. We are applied fuzzy type-II technique on different MRI breast images and get a much better output. This technique shows that the overall high accuracy. There are different sources of uncertainties in type-I fuzzy sets. Type-II fuzzy sets are an extension of type-I fuzzy sets. Membership functions are usually defined by expert. These membership functions are based on his knowledge. Type-II fuzzy sets are able to remove the uncertainties because their membership functions are themselves fuzzy. This technique is used for to determine the exact membership function for a fuzzy set. Figure (1) shows the architecture of the type-II fuzzy logic. Firstly, crisp input is fuzzified. This input is fuzzified into either singleton fuzzifier or non-singleton fuzzifier. After that the inference engine is activated. The rule base is to generate a fuzzy type-II output. The type-II fuzzy has entered in the type reducer. The type reducer is produced a type-I fuzzy reduced set. In the end, defuzzifier gives a crisp output by defuzzifies the type-reduced set[3].

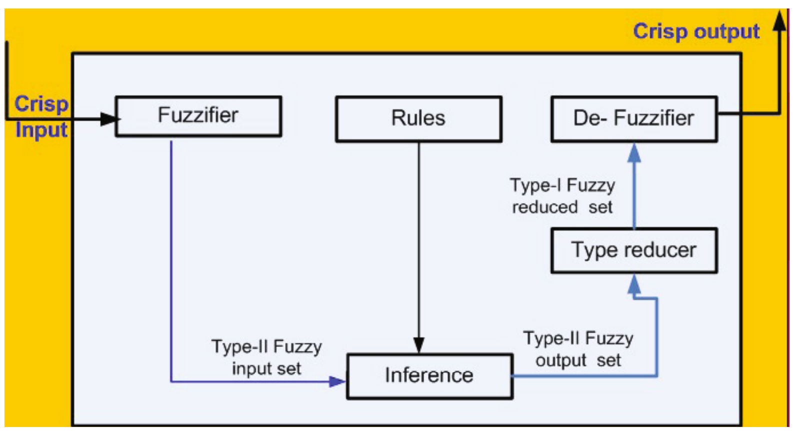


Figure 1: Type II fuzzy Logic System

Removing impulse noise is very active research area in image processing. Images can be deal with many different types of noise. Because of the different circumstances, noise can be occurring. The circumstances include may be storage, recording, transmission, copying, scanning etc. Impulse noise is most commonly found. It is a great challenge to remove noise from the image without disturbing its content. An image is converted from one form to another form. These forms are produced a better output. The output image has to undergo a process called image enhancement. In this paper, fuzzy logic control approach is introduced which will remove the noise and improve the contrast of the image[2].

Contrast Enhancement is used to enhance the contrast of the images and improve the visibility of the image. The objects are represented in the real world which is filled with images. Images are represented by an array of pixels. There are many aspects of images that are not properly defined. Sometimes an image may be too dark contains blurriness. These images are difficult to recognize the different objects. Image enhancement techniques are widely used in many fields, where the subjective quality of images is important. In this paper, sigmoid function is used for achieving contrast enhancement. Slider window was used on the image if the neighbourhood pixel will be remapped or not in contrast enhancement. The new value of remapped pixel based on a sigmoid map function[1].

2. LITERATURE SURVEY

Mr. Harish Kundra et. al. proposed an image enhancement of based on fuzzy logic is to remove the noise and improve the contrast of the image. Removing and reducing impulse noise is very active research area in image processing. Images can be deal with many different types of noise. Because of the different circumstances, noise can be occurring. The circumstances include may be storage, recording, transmission, copying, scanning etc. Impulse noise is most commonly found. It is a great challenge to remove noise from the image without disturbing its content. An image is converted from one form to another form. These forms are produced a better output. The output image has to undergo a process called image enhancement. In this paper, fuzzy logic control approach is introduced which will remove the noise and improve the contrast of the image[1].

Aboul Ella Hassanien et. al. proposed a contrast enhancement of breast MRI images based on fuzzy type-II. In this paper, we utilize the use of type-II fuzzy sets to enhance the contrast of the MRI image. We are applied fuzzy type-II technique on different MRI breast images and get a much better output. This technique shows that the overall high accuracy. There are different sources of uncertainties in type-I fuzzy sets. Type-II fuzzy sets are an extension of type-I fuzzy sets. Membership functions are usually defined by expert. These membership functions are based on his knowledge[2].

Harleen Kaur et. al. proposed an improved fuzzy rule based edge detection technique. Fuzzy logic represents a powerful approach for decision making. Edge detection is imperative part of image processing. In this paper rule based fuzzy logic technique is proposed. Firstly for each input image three edge values are calculated. These values are calculated by using three 3*3 linear filters. After calculations, fuzzy sets are characterized by Gaussian membership functions associated to linguistic variables “low”, “medium” and “high” are created to represent the edge strength. Secondly, fuzzy inference rules are used to get the better output. Fuzzy inference rules are defined that the fuzzy output would be low, medium or high. The results are compared on the basis of 4 comparison parameters that are Root Mean Squared Error (RMSE), Edge Density, Edge Intensity and Peak Signal to Noise Ratio (PSNR)[3].

Anubha Prajapati et. al. proposed a review on various contrast enhancement scheme for dark images. Sometimes contrast enhancement techniques are offered by various researchers for the improvement of the quality of images. Most probably common problem have generated with image enhancement is difficult to achieve such images. Sometimes noise has creating problems in the system. Then we are using the scaling to remove unwanted and internal noise of dark images. This is done by using DCT technique. Here in this paper we are presenting some techniques used for enhance the contrast of the image[4].

Amit Kamra et. al. proposed an improved method for image enhancement using fuzzy approach. An image enhancement is used for betterment the quality of the image. The viewers can easily view the image when images are stored and manipulating the pixel value. This is possible with the help of software. Fuzzy is better technique of image enhancement which is used for enhanced the images. Fuzzy image enhancement is based on a mapping of gray levels. This gray level mapping is possible by using a membership function. Otherwise there are many techniques are used for betterment the quality of the image by using pixel values. These pixel values are defined with the number of inputs[5].

Gonzalez et. al. proposed an edge detection method based on interval type-II fuzzy systems for color images. The proposed method shows that the use of interval type-2 fuzzy inference systems can improve the performance in edge detection with respect to type-1 fuzzy systems. In the proposed method, the morphological gradient filter is used on the original images first. After that the IT2FSs edge detector is applied in each channel of the RGB color space. The proposed method is applied over many images such as synthetic and real images. The performance of the proposed method is compared with the edge detection algorithms based on type-1 fuzzy systems (T1FSs). The results of our technique based on IT2FSs are observed to be better and more noise-robust than the T1FSs edge detector[6].

Naglaa Yehya Hassan et. al. proposed a contrast enhancement technique for dark blurred image. Contrast Enhancement is used to enhance the contrast of the images and improve the visibility of the image. The objects are represented in the real world which is filled with images. Images are represented by an array of pixels. There are many aspects of images that are not properly defined. Sometimes an image may be too dark contains blurriness. These images are difficult to recognize the different objects. Image enhancement techniques are widely used in many fields, where the subjective quality of images is important. In this paper, sigmoid function is used for achieving contrast enhancement. Slider window was used on the image if the neighbourhood pixel will be remapped or not in contrast enhancement. The new value of remapped pixel based on a sigmoid map function [7].

3. DIFFERENT SCENARIOS

3.1. Scenario 1

1. Edge Detection Algorithm

Firstly input image is fission into two parts such as without edge image and edge detection. Fuzzy type-I and type-II is applied on without edge image. Similarly type-I and type-II fuzzy is applied for edge detection. The inference rules have applied on both of the images. Then fusion is applied on both of the images. In the end, we have to get an enhanced image. That all have possible through convolution process. We are used three linear filters such as a low pass, edge enhanced filter and high pass. We are defined 9 convolution coefficients called convolution mask[10].

$[i-1, j-1]$	$[i-1, j]$	$[i-1, j+1]$
$[i, j-1]$	$[i, j]$	$[i, j+1]$
$[i+1, j-1]$	$[i+1, j]$	$[i+1, j+1]$

Figure 2: 3*3 Convolution Mask

Prewitt (edge enhanced filter) operators are used to find the first derivative of Image in horizontal and vertical directions. The following masks are used.

+1	+1	+1
0	0	0
–1	–1	–1

–1	0	+1
–1	0	+1
–1	0	+1

Figure 3: Prewitt Masks

Then the convolution operation is applied on the filtered images.

$$\mathrm{Ch} = \mathrm{Ph} \times \mathrm{I}$$

$$\mathrm{Cv} = \mathrm{Pv} \times \mathrm{I}$$

The result of the two Prewitt kernels is combined to get the final value.

$$\mathrm{Val} = \sqrt{(\mathrm{C}h^2 + \mathrm{C}v^2)}$$

A high-pass filter is defined as:

$H_{hf}=$

0	–1/4	0
–1/4	2	–1/4
–1/4	0	–1/4

The filtered image is calculated through a bidimensional convolution operation.

$$HF = H_{hf} \times \text{Original Image}$$

The median filter is calculated as shown below by using the 3×3 mask.

$$mf = \text{median}\{x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9\}$$

The filtered image is also calculated through a bidimensional convolution operation.

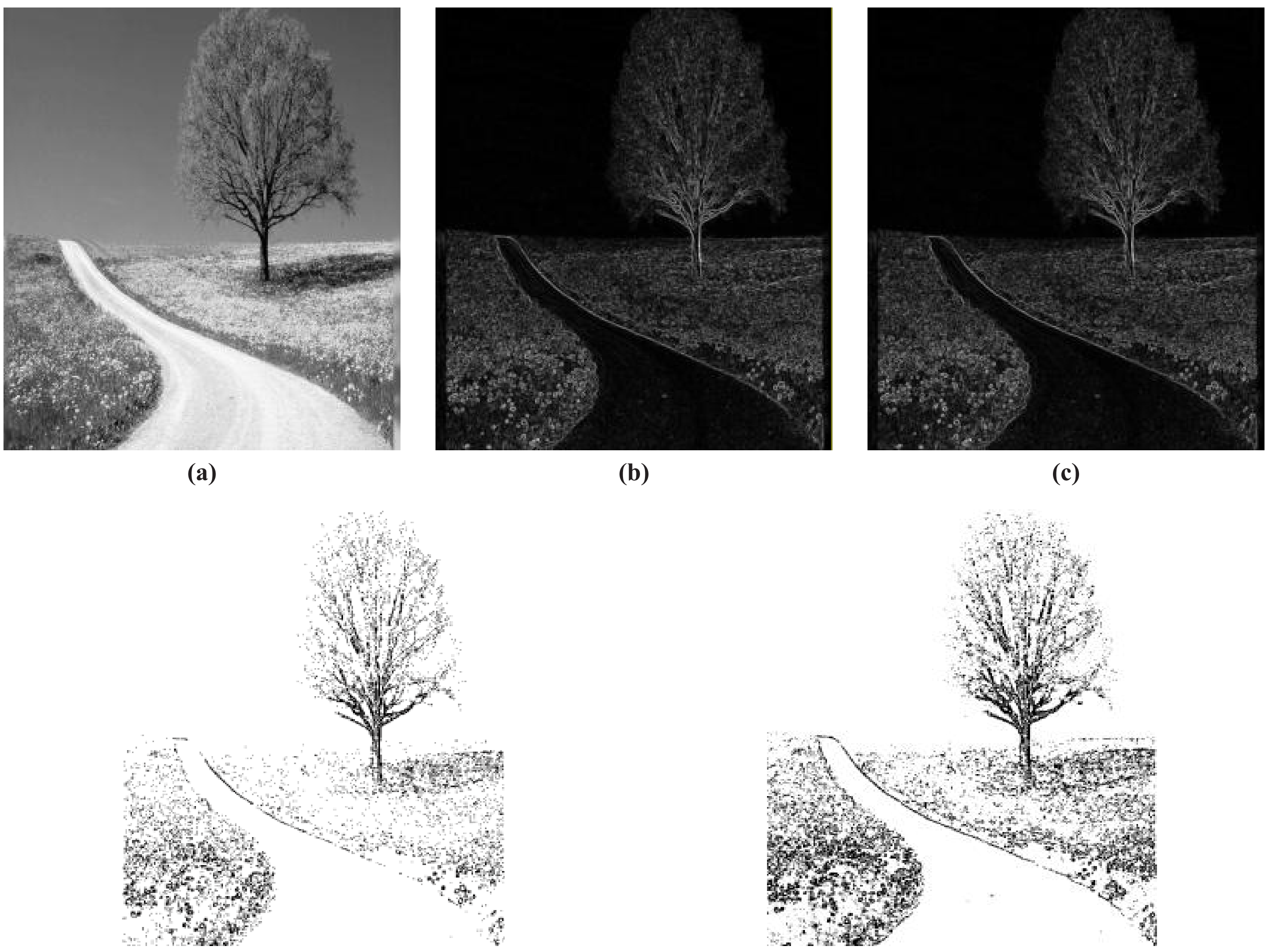
$$\text{MF} = mf \times \text{Original Image}$$

2. Fuzzy Inference Rules

The fuzzy inference rules are defined as shown below:

1. If (MF is low) and (Val is low) and (HF is low) THEN (“Edge is low”).
2. If (MF is low) and (Val is low) and (HF is medium) THEN (“Edge is low”).
3. If (MF is low) and (Val is low) and (HF is high) THEN (“Edge is low”).
4. If (MF is low) and (Val is medium) and (HF is low) THEN (“Edge is low”).
5. If (MF is low) and (Val is medium) and (HF is medium) THEN (“Edge is low”).
6. If (MF is low) and (Val is medium) and (HF is high) THEN (“Edge is medium”).
7. If (MF is low) and (Val is high) and (HF is low) THEN (“Edge is low”).
8. If (MF is low) and (Val is high) and (HF is medium) THEN (“Edge is high”).
9. If (MF is low) and (Val is high) and (HF is high) THEN (“Edge is high”).
10. If (MF is medium) and (Val is low) and (HF is low) THEN (“Edge is low”).
11. If (MF is medium) and (Val is low) and (HF is medium) THEN (“Edge is low”).
12. If (MF is medium) and (Val is low) and (HF is high) THEN (“Edge is medium”).
13. If (MF is medium) and (Val is medium) and (HF is low) THEN (“Edge is medium”).
14. If (MF is medium) and (Val is medium) and (HF is medium) THEN (“Edge is medium”).
15. If (MF is medium) and (Val is medium) and (HF is high) THEN (“Edge is high”).
16. If (MF is medium) and (Val is high) and (HF is low) THEN (“Edge is medium”).
17. If (MF is medium) and (Val is high) and (HF is medium) THEN (“Edge is high”).
18. If (MF is medium) and (Val is high) and (HF is high) THEN (“Edge is high”).
19. If (MF is high) and (Val is low) and (HF is low) THEN (“Edge is low”).

20. If (MF is high) and (Val is low) and (HF is medium) THEN ("Edge is medium").
21. If (MF is high) and (Val is low) and (HF is high) THEN ("Edge is medium").
22. If (MF is high) and (Val is medium) and (HF is low) THEN ("Edge is medium").
23. If (MF is high) and (Val is medium) and (HF is medium) THEN ("Edge is medium").
24. If (MF is high) and (Val is medium) and (HF is high) THEN ("Edge is high").
25. If (MF is high) and (Val is high) and (HF is low) THEN ("Edge is medium").
26. If (MF is high) and (Val is high) and (HF is medium) THEN ("Edge is high").
27. If (MF is high) and (Val is high) and (HF is high) THEN ("Edge is high").



(a) (b) (c)

(d) (e)

Figure 4: (a) Original Image (b) Sobel (c) Prewitt (d) Old Fuzzy (e) New Fuzzy

3.2. Scenario 2

Type 2 Fuzzy Set Image Enhancement

Input: MRI breast image

Output: Type-I and Type-II fuzzy enhancement images of the input image

Processing:

Step 1: Fuzzy Hyperbolization

for each grey level **do**

compute the fuzzy type-I membership value using the following equation:

$$\mu(g_{mn}) = \frac{g_{mn} - g_{\min}}{g_{\max} - g_{mn}} \tag{1}$$

where, $g_{\min}$ and $g_{\max}$ are the image minimum and maximum grey level.

end for

Step 2: Type-I Fuzzy Enhanced Image Calculation

Compute the new grey levels of the enhanced image using

$$\tilde{g}_{mn} = \frac{L-1}{e^{-1}-1} \times \left[e^{-\mu(g_{mn})^{\beta}} - 1\right]$$

Where the parameter β as a fuzzifier is set to 1.7 and the number of grey levels L is set to 256.

Step 3: Calculation of Type-II Fuzzy Membership Function

Compute lower and upper membership values

$$\mu_{\mathrm{LOWER}}(x) = \mu(x)^{2}$$

and

$$\mu_{\mathrm{UPPER}}(x) = \mu(x)^{0.5}$$

Divide the image into sub-images.

for every grey level value **do**

Calculate a window of size 21×21.

Compute type-II fuzzy membership function using

$$\mu_{\mathrm{T_{II}}}(g_{mn}) = (\mu_{\mathrm{LOWER}} \times \alpha) + (\mu_{\mathrm{UPPER}} \times (\alpha - 1))$$

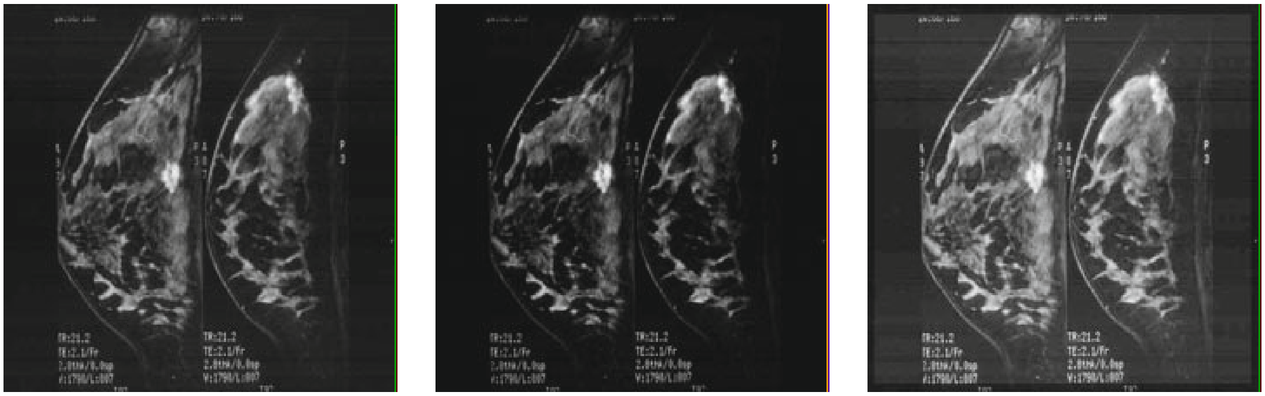
where, $\alpha = \frac{g_{\mathrm{mean}}}{L}$.

end for

Step 4: Fuzzy Type-2 Enhanced Image Calculation: Compute the new grey levels of the enhanced image using Equation[1]

Table 1
Fuzzy type-I and type-II

Image	*Type*	*Total of Pixels*	*Ratio*	*Accuracy*
Image 1	Type-I	238400	–299760	7.67718
Image 2	Type-II	214120	2102354	–0.0927



(a) MRI Original **(b) Fuzzy Type-I** **(c) Fuzzy Type-II**

Figure 5: MRI Breast Enhanced Result

Accuracy of type-II fuzzy is much better than type-I fuzzy. We are defined the accuracy by using this equation:

$$\text{Accuracy} = \frac{R}{T}$$

where, R = Pixel of original-Pixel of fuzzy

where, *T* is the total number of pixels and *R* is ratio of the pixels in the original and the enhanced one. We observe that the experimental results indicate the promising possibilities of type-II fuzzy proposed approach give a good better quality compared with the commonly used type-I fuzzy approach[3].

3.3. Scenario 3

Removing and reducing impulse noise and improve contrast of the image:

1. Removal of Impulse Noise

Let the grayscale image be represented by a matrix F of size $N_1 \times N_2$, F ={F(*i*, *j*) € {0, ..., 255}, $i = 1, 2, ..., N_1$, $j = 1, 2, ..., N_2$}. Our construction starts with the introduction of the similarity function μ: [0; ∞) → R. We will need the following assumptions for μ:

1. μ is decreasing in [0, ∞),
2. μ is convex in [0, ∞),
3. μ(0) = 1, μ(∞) = 0.

The membership function used are LARGE (for the fuzzy set large), SMALL (for the fuzzy set small), BIG POSITIVE (for the fuzzy set big positive) and BIG NEGATIVE (for the fuzzy set big negative)[2].

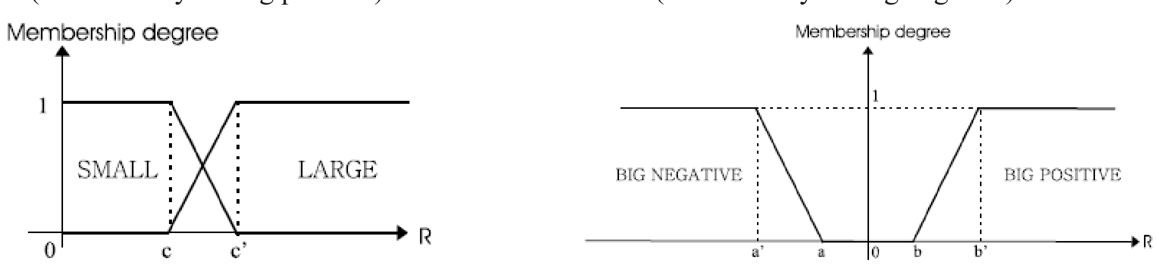
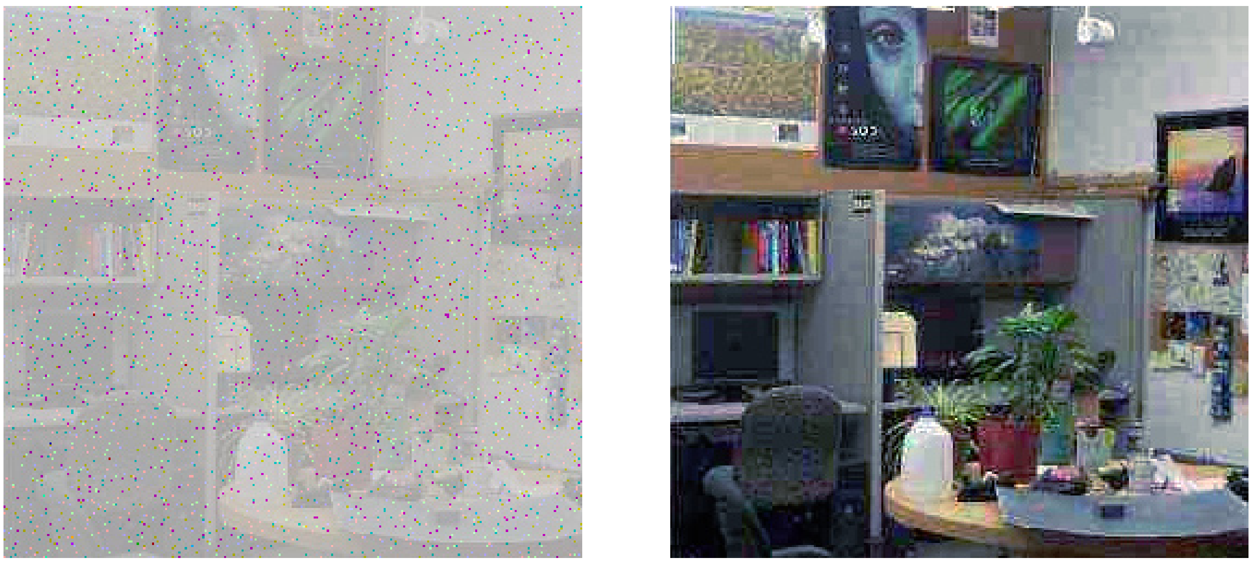


Figure 6: Membership Functions

2. Improving Contrast of the Image

For improving the contrast of the image following steps are done:

1. Setting the shape of membership function (regarding to the actual image)
2. Setting the value of fuzzifier Beta
3. Calculation of membership values
4. Modification of the membership values by linguistic hedge
5. Generation of new gray-levels



(a) (b)

Figure 7: (a) Noisy & Low Contrast Image (b) Fuzzy Enhanced Image

3.4. Scenario 4

Algorithm for Dark Blurred Image:

Step 1: Un-sharp Masking Step: Un-sharp masking performed by generating a blurred copy of the original image by using laplacian filter, subtracting it from the original image.

$$I(i, j) = I_0(i, j) - I_b(i, j)$$

where,

$I(i, j)$ Un-sharp masking image

$I_0(i, j)$ Original image

$I_b(i, j)$ Blurred copy

In this step, the small features are enhanced but large ones are not changed. The result is a sharper, more detailed image.

$$g(i, j) = I_0(i, j) + kI(i, j)$$

where, $g(i, j)$ is output image, k is scaling constant. Logical values for k vary between 0.2 and 0.7.

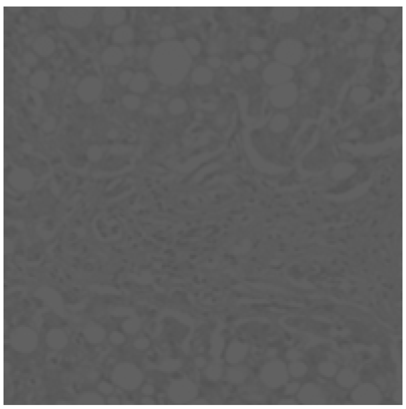
Step 2: Contrast Enhancement Step: The process can be described with the mapping function $O = M(i)$, where O and i are the new and old pixel values, respectively. The form of the mapping function M that determines the effect of the operation is:

$$\mathrm{M} = i \times \frac{c}{1 + e^{-1}}$$

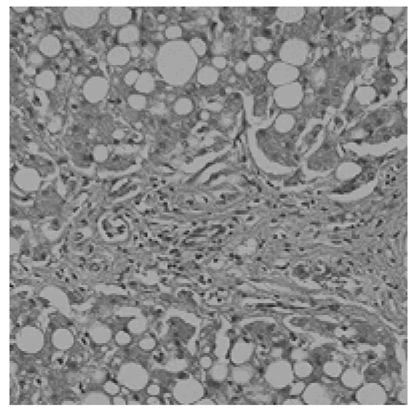
According to above mapping function the new value of corresponding pixel will be:

$$\mathrm{O} = \begin{cases} i & \text{if } i > t \\ i + \left(i \times \left(\dfrac{c}{1 + e^{-1}} \right) \right) & \text{if } i < t \end{cases}$$

where, c is a contrast factor determines the degree of the needed contrast. After map window reaches the right side, it returns to the left side and moves down a step. The process is repeated until the sliding window reaches the right-bottom corner of the image.



(a)



(b)

Figure 8: (a) Original dark blurred image (b) Output image

The results from applying our approach on grey scale; color and medical images show that the technique is robust and able to recover even too dark images from blurring and darkness[1].

4. CONCLUSION

We have discussed four scenarios in this paper. These all of scenarios have produced better results. In the first scenario, image is divided into two parts such as without edge image and edge detection. Fuzzy type-I and fuzzy type-II method have applied on both of the images. In the end, final image is produced by combining the both of those images. In the second scenario, fuzzy type-I and fuzzy type-II techniques are applied on MRI images. In the third scenario, fuzzy logic control approach is used for removing impulse noise and improves the contrast of the image. In the fourth scenario, we are sigmoid function for contrast enhancement of dark blurred image.

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