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Fuzzy Techniques for Enhancement of Low Contrast Images

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Abstract — In the recent years enormous work has been carried out to enhance the contrast of image because of its wide applications in surveillance, medical domain and enhancement of geostationary images. Conventional methods likes histogram equalization and adaptive histogram equalization are either under expose or over expose the contrast of the image which result in bad image quality, to improve on this drawback here we propose a novel fuzzy based contrast enhancement method. In the proposed work variable membership function is used to map input membership function into output memberships which are transformed using different intensity transformation method. At the end fuzzy rule has been adopted to defuzzify the transformed image which results in preeminent contrast enhanced image. To test the performance of the method, comparative analysis have been carried out based on parameters like SSIM, Mean which shows the outperformance of proposed method over the existing.
Keywords—Contrast Enhancement; Intensity Transformation; Fuzzy; Defuzzify.

I. INTRODUCTION

In image enhancement process visual appearance of image is perked up or it is converted in the form that it can be easily understandable to human eyes or machines. Noisy image data is a very difficult to enhance which is necessary in many research and application areas. There are main three categories in image enhancement technique:

Method which works on pixels which known as spatial domain methods.
Method which works on the fourier transform of an image which known as Frequency domain methods.
The method which involves the use of knowledge-base systems known as fuzzy domain methods.

Fuzzy logic gives a good mathematical scaffold to deal with ambiguity of information. Processing of fuzzy image is the collection of all the methods that represent and process the image, segments and features as fuzzy set. In the last decades, fuzzy based nonlinear filters have been made known to be very useful in removing noise without losing the important information contained in the image data. The fuzzy membership functions are used in proposed algorithm. By this algorithm efficiently image can be contrast. If random noise is observed in data then the intensifier worker should convert the image data into the fuzzy domain and that becomes necessary to perform some morphological operations to that noisy data. So apply suggested algorithm then find the good contrasted image compare to the original image, sustaining the all the image data.

A. Spatial domain methods

Spatial domain methods are nothing but the method which function directly on pixels. Spatial domain method pixel values may be adapted according to rules that depend on the original pixel value (local or point processes). on the other hand, pixel values may be pooled with or compared to others in their instant neighborhood in a multiple ways.
Consider input image f(x, y) and processed image g(x, y) then the transformation g(x, y) = T [f(x, y)], Where T is an operator on f defined over some region of (x, y). The operator T is applied at each position (x, y) to capture output g at that position. The process uses pixels in the area of image spanned by vicinity. e.g: Thresholding.

B. Frequency domain methods (DFT)

Fourier transform of an image is used in frequency domain methods.

1) Edges and sharp conversions (e.g., noise) in an image give extensively to high-frequency content of Fourier transform.
2) The general appearance of the image over smooth areas are due to low frequency content in Fourier transform.

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Concept of filtering in frequency domain is easier for study. So enhancement of image f(x, y) we can do it in frequency domain on the basis of DFT. This is useful in complexity. If the spatial extent of the point spread sequence, h(x, y) is large then convolution theory.

$$g(x, y)=h(x, y)*f(x, y) \quad \ldots\ldots \quad 1.1$$

where g(x, y) is enhanced image.

C. Fuzzy Domain Method

Fuzzy set theory is thus useful in managing a variety of uncertainties in computer vision and image processing applications. Fuzzy image processing is a set of different fuzzy approaches to image processing that can recognize characterize, and process the image. It has three main stages, n image fuzzification, modification of membership function values and defuzzification. Fuzzy image enhancement involves gray level mapping into membership function. The aim is to generate an image of higher contrast than the original image. It is done by giving a larger influence to the gray levels that are nearer to the mean gray level of the image that are beyond from the mean.

II. LITERATURE SURVEY

In the field of image enhancement there is a lot of work has been done. For more flexibility if-then rules in Fuzzy Logic will unite with an inference engine. We found from official web page of fuzzy technology that the Fuzzy Logic has very superior results in two main application fields: 1.Industrial applications 2.Business and finance applications. These are categorized under automated control or decision-making support.

A. Survey on Image Enhancement (IE)

In Image Enhancement, Image is converted in the form that it can be clear to human eyes. It is used to increase the contrast in images that are significantly dark or light. Enhancement algorithms always play attention to humans‟ sensitivity to contrast. The prime aim of image enhancement is to process the image so that the result is more appropriate than the original image. Image enhancement techniques such as contrast stretching, map each grey level into another gray level by predestined transformation.

Some of the areas in which IE has wide application are noted below.

Face recognition, [1] For visually impaired people, reading small print, using computers, television and face recognition is difficult. for that purpose IE techniques are used. Lot of work has been done for highlighting the importance of use of IE for visually disabled.

Historic paintings and artifacts [2] are restored using IE technique to reduce stains and crevices. To make the images vibrant Color contrast enhancement, sharpening and brightening are used. IE is a potent tool for restorers who can make informed decisions by screening the results of restoring a painting in advance. It is also use to read historic documents.

In the field of e-learning, IE is used to clarify the contents of chalkboard as viewed on streamed video; it improves the content readability and helps students in focusing on the text Similarly, collaboration [3] through the whiteboard is facilitated by enhancing the shared data and diminishing artifacts like shadows and blemishes .

In Astrophotography IE technique is used to remove the noise pollution and to adjust the brightness [4].It is the most challenged field for the application of IE

□□□□□□ Medical imaging [5] uses IE techniques for minimizing noise and highlighting the details to improve the visual representation of the image. Therefore IE is a necessary tool for screening anatomic areas in MRI, ultrasound and x-rays to name a few.

In forensic sciences [6] IE is used for detection, proof collection and inspection. To identify the culprit Images obtained from fingerprint detection, security videos analysis and crime scene investigations are enhanced for protection of victims. IE is used to diminish the effects of cloud, fog, mist and turbulent weather for meteorological studies in atmospheric sciences [7]. It helps in detecting shape and structure of remote objects in environment sensing. Satellite images undergo image restoration and enhancement to remove noise.

Other fields including law enforcement, microbiology, biomedicine, bacteriology, climatology, meteorology, etc., benefit from various IE techniques.

III. PROPOSED METHOD

The step-by-step methodology to be followed for image enhancement using fuzzy theory:

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a) *Study and analyze various fuzzy techniques and image enhancement techniques.*
b) *Based upon above analysis algorithm is developed for image enhancement.*
c) *Results achieved after the execution of program are compared with the earlier outputs.*

The main purpose of this paper is to enhance the contrast in fuzzy domain electively and adaptively. The first step is to map an image from space domain to fuzzy domain using the S-function as the membership function. Then we propose a more powerful and adaptive fuzzy contrast enhancement method than adaptive contrast enhancement (ACE) method with adaptive power variation and interpolation techniques [8].

The proposed approach employs fuzzy entropy principle and fuzzy set theory. It can automatically determine the related parameters according to the nature of the image. As mentioned before, the performance of fuzzy enhancement depends on the membership function. The selection of parameters *a*, *b* and *c* for S-function becomes an important issue since these parameters decide the shape of the membership function, S-function. The criterion to determine the membership function in this paper is to reduce noise and minimize the information loss. Furthermore, the determination
of the membership function should be based on the characteristics of the image[9].

A. Algorithm

The algorithms designed to implement the proposed work as mentioned in section III is given below:

1) *Specify input membership functions:* Sigma and Triangular functions are used as input membership functions.

Sigma membership: Equation 3.1 shows sigmoidal membership function.

$$sigmf\ (x;a,b,c) = \frac{1}{1+e^{-a(x-c)}} \qquad \text{…..3.1}$$

Equation 3.2 shows triangular membership function.

$$trimf\ (x;a,b,c) = \max\left(\min\left(\frac{x-a}{b-a},\frac{c-x}{c-b}\right),0\right) \qquad \text{…..3.2}$$

2) Specify the output membership functions: Bell membership

Function is used as output membership function which is represented in equation 3.3.

$$gbellmf\ \ (x;a,b,c) = \frac{1}{1+\left|\frac{x-c}{b}\right|^{2b}} \qquad \text{…...3.3}$$

3) Obtain fuzzy system response function: A fuzzy if-then rule (also known as fuzzy rule, fuzzy implication, or fuzzy conditional statement) assumes the form.

If z is A then y is B …..3.4

Where A and B are linguistic values defined by fuzzy sets on universe of discourse X and Y, respectively. Often “x is A” is called the antecedent or premise, while “y is B” is called the consequence or conclusion.

4) Use F to construct an intensity transformation function as shown in equation 3.5:

T=F (z) …..3.5

5) Select the Original Low Contrast Image.

6) Transform the intensities of f using T as:

g(x, y) = T(f(x, y)) …..3.6

where f(x, y) is low contrast image.
g(x, y) is transformed image.

While T is transformation function like Log, Gamma, Stretch and Specified transform.

7) Transformed image shows the contrast enhancement.

IV. RESULTS AND DISCUSSIONS

We have applied the proposed algorithm to a variety of images. As mentioned before, the commonly used techniques for contrast enhancement can be categorized as (1) indirect methods of contrast enhancement and (2) direct methods. Histogram specification

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and histogram equalization are two most popular indirect contrast enhancement methods [9]. The direct contrast enhancement approaches are better than indirect contrast enhancement approaches.

The subjective result obtained for two multimedia and two medical images with poor contrast has been shown in fig.1 to fig.4 respectively, while the Fig.1 shows the plot of Input and Output Membership functions.

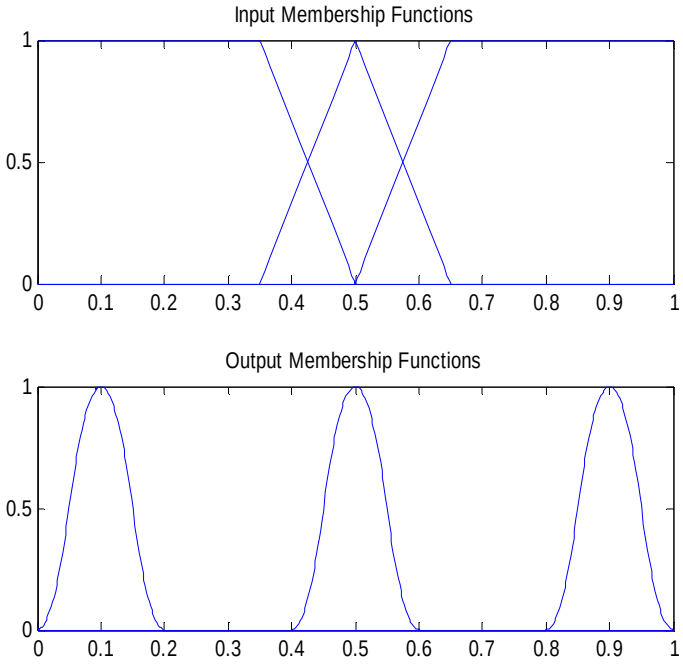


Fig.1: Plot of Input and Output Membership functions.



Fig.2: Original low contrast image “pout.tif” and results obtained using Histogram Equalization, Adaptive Histogram and proposed method.

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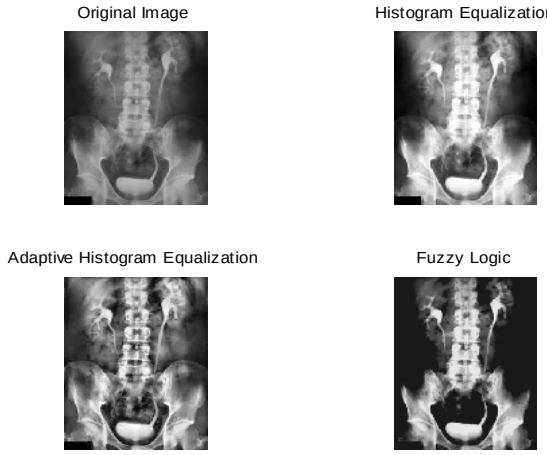


Fig.3: Original low contrast "Vertebra.png" and results obtained using Histogram Equalization, Adaptive Histogram and Proposed Method.

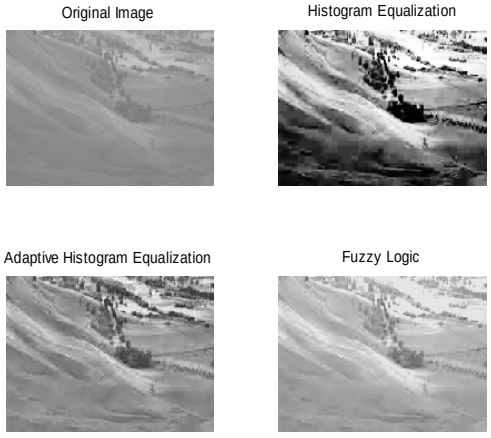


Fig.4: Original low contrast "Ice.png" and results obtained using Histogram Equalization, Adaptive Histogram and Proposed Method.

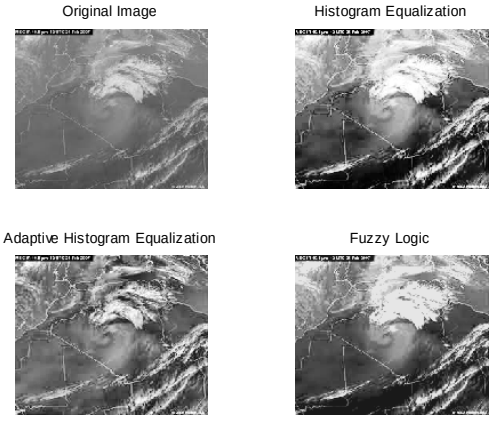


Fig.5: Original low contrast "Climate.png" and results obtained using Histogram Equalization, Adaptive Histogram and Proposed Method.

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TABLE I: SSIM, MEAN, VARIANCE & STD.DEV obtained using Histogram Equalization, Adaptive Histogram and Proposed Method.

Input Image	Parameter	Histogram Equalization	Adaptive Histogram Equalization	Proposed Method
Pout.tiff	SSIM	0.56	0.67	0.79
	MEAN	127.25	116.42	86.54
	VARIANCE	199.83	127.56	78.83
	STD.DEV	13.65	74.90	27.41
Vertebra.png	SSIM	0.67	0.72	0.86
	MEAN	102.36	112.36	114.25
	VARIANCE	228.09	127.10	175.43
	STD.DEV	4.47	74.45	23.80
Ice.png	SSIM	0.41	0.73	0.85
	MEAN	127.38	144.75	179.76
	VARIANCE	172.10	127.50	86.12
	STD.DEV	57.07	74.89	72.16
Climate.png	SSIM	0.67	0.71	0.7293
	MEAN	127.14	122.15	119.23
	VARIANCE	202.77	127.50	133.11
	STD.DEV	42.98	74.71	88.91

V. CONCLUSIONS

Fuzzy technique plays an important role in image segmentation, processing and contrast enhancement. The commonly used techniques for contrast enhancement fall into two categories: (1) indirect methods and (2) direct methods. Direct method of contrast enhancement is more useful because it is considering both global and local information of the image. Fuzzy logic has been found many applications in image processing and pattern recognition, image segmentation etc. With this above information, we propose a novel adaptive direct fuzzy contrast enhancement method based on the fuzzy entropy and fuzzy set theory. The experimental results have demonstrated that the proposed algorithm is more adaptive and effective for contrast enhancement compared to other method. Moreover, it significantly reduces the over enhancement/under-enhancement due to its better adaptive capability.

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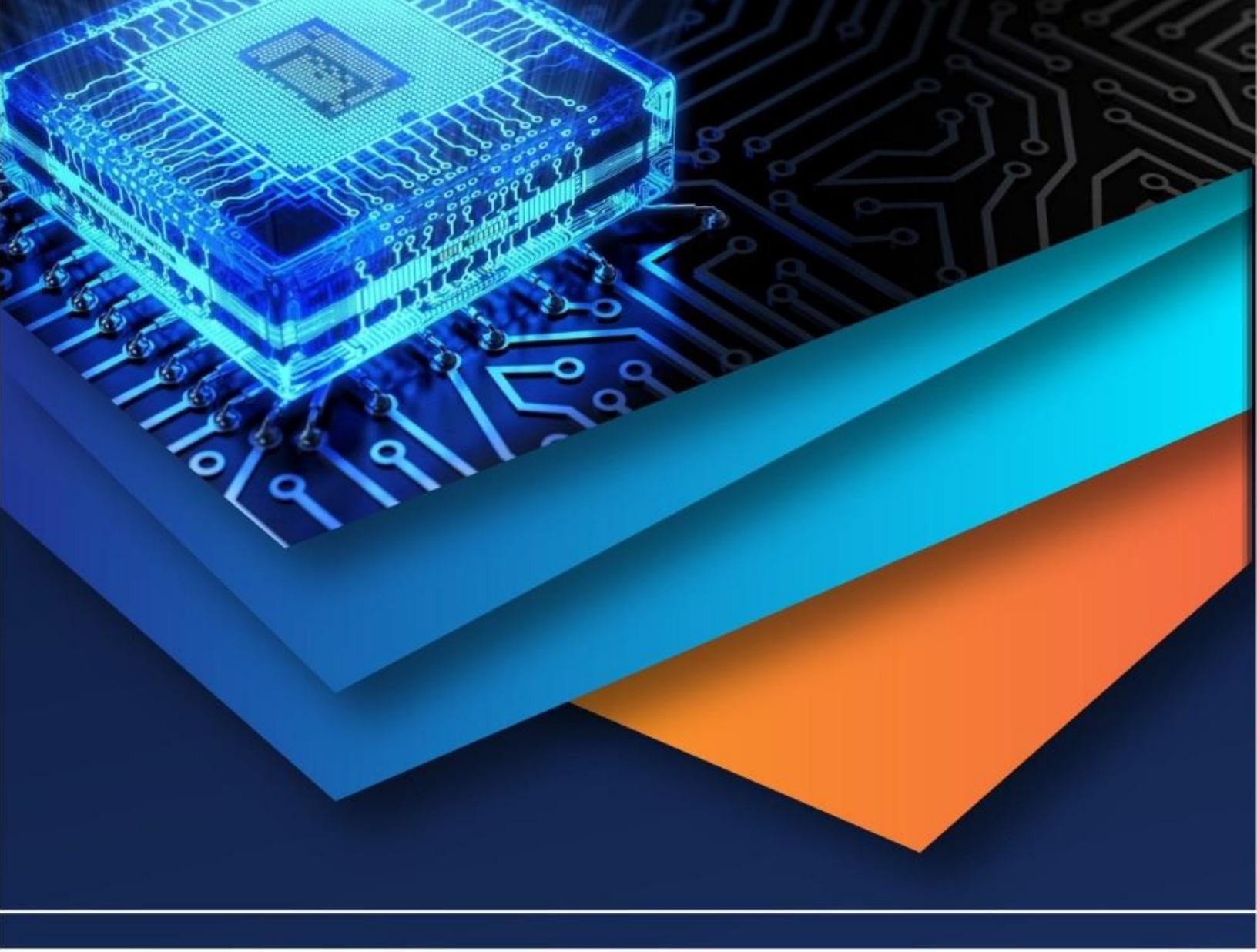
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