# Automatic contrast enhancement using fuzzy logic for real time object recognition system

Pradeep Jain[1], Meenu[2]
1. Department of Mechanical Engineering , NIT Kurukshetra
2. Department of Mechanical Engineering , NIT Kurukshetra

**Abstract**— *Low contrast images occur often due to poor or non- uniform lighting conditions and sometimes due to the non-linearity or small dynamic range of the imaging system. The quality of an image should be improved to support the real-time object recognition system. The aim of the automatic contrast enhancement is to process a given image in real time so that the result is more suitable for analysis and object recognition. In this paper, a method for contrast enhancement based on the contrast intensification operator and automatic selection of the value of the exponential fuzzifier has been proposed.*

**Index Terms**— *fuzzy set theory, fuzzy intensifier operator, contrast enhancement, histogram equalization, standard deviation,membership function, RMS contrast,.*

## 1 Introduction

Contrast enhancement is one of the most important issues of image processing and analysis. It is believed that contrast enhancement is a fundamental step in image segmentation. Image enhancement is employed to transform an image on the basis of the psychophysical characteristics of the human visual system. In computer vision and pattern recognition, edge detection is a useful low-level image processing tool for Image analysis and interpretation. It is also a segmentation tool for various recognition applications. Edges and contours are often useful features as they represent an image by its object boundaries and separation of dissimilar regions in terms of pixel intensities. Furthermore, edges are considered important elements in a picture, as they present essential information of an object of interest in a picture. Contrast plays an important role in the process of segmenting an image into sub-regions. As the degree of color separation is increased in an image, the contrast is improved; hence an improved segmentation. The focus of this study is to propose a technique to improve the image contrast so that the segmentation process via contour or edge detection is also improved.

In this work, a totally automatic image enhancement algorithm is developed for real-time object recognition and classification system.

## 2 SURVEY OF IMAGE ENHANCEMENT TECHNIQUES

The enhancement methods can broadly be divided into the following two categories, Spatial Domain Method, and Frequency Domain Methods. In spatial domain techniques we directly deal with the image pixels. The pixel values are manipulated to achieve desired enhancement. In frequency domain methods, the image is first transferred to frequency domain. It means that, the Fourier Transform of the image is computed first. All the enhancement operations are performed on the Fourier transform of the image and then the Inverse Fourier transform is performed to get the resultant image. These enhancement operations are performed in order to modify the image brightness, contrast or the distribution of the gray levels. As a consequence, the pixel value (intensities) of the output image will be modified according to the transformation function applied to the input values.
The greatest difficulty in image enhancement is quantifying the criterion for enhancement and a large number of image enhancement techniques are empirical [1].

Rajesh Garg proposed Adaptive histogram equalization method extension to the traditional histogram equalization technique. It enhances the contrast of images by transforming the values in the intensity image [2].

Brahmadesam Sateesh proposed a novel approach for image enhancement by median based brightness, improving filter based on standard histogram equalization (SHE) [3].

Sing Bing Kang addressed the problem of incorporating user preference in automatic image enhancement. Unlike generic tools for automatically enhancing images, Methods were developed that can first observe user preferences on a training set, and then learn a model of these preferences to personalize enhancement of unseen images[4].

Saeid iranmanesh proposed a hybrid method for improving the contrast in an image. It describes the application of fuzzy measure to the maximization of fuzzy entropy in the combined fuzzy contrast (CFC), resulting in a much improved contrast [5].

Harish Kundra developed a fuzzy-logic-control based filter which removes the noise and improves the contrast of the image [6].

Parvathi Rangasamy developed a method for image enhancement based on the contrast intensification operator on the first and second type Intuitionistic Fuzzy Sets (IFSs)[7].

Sathit Intajag et al suggested a model for Automatic, Gray-tone image enhancement employing the fuzzy rules for contrast stretch in his work automatic image enhancement using fuzzy rules [8].

S. K. Pal developed a algorithm based on minimization of compactness and fuzzyness [9].

Dah-Chung Chang et al developed adaptive contrast enhancement algorithm, which uses contrast gains(CGs) to adjust the high frequency components of images in the paper Image Contrast Enhancement Based on a Histogram Transformation of Local Standard Deviation[10].

R. Malladi et al presented a unified approach to noise removal, Image Enhancement, and shape recovery in images the underlying approach relies on the level set formulation of curve and surface motion[11].

Bei Tang et al proposed a novel approach for color image enhancement.The algorithm is based on separating the color data into chromaticity and brightness and then processing each one of these components with partial differential equations or diffusion flows[12].

V.V. Starovoitov et al presented an idea to enhance contrast locally analyzing local gaey differences taking into account mean gray level[13].

Jean-Luc Starck et al presented a new method for contrast enhancement based on the curvelet transform. The curvelet transform represents edges better than wavelets, and is therefore well-suited for multiscale edge enhancement [14].

Dipti Deodhare et al discussed the form image registration technique and the image masking and image improvement techniques implemented in the system as part of the character image extraction process. These simple yet effective techniques help in preparing the input character image for the neural networks-based classifiers and go a long way in improving overall system accuracy[15].

H.D. Cheng developed a novel fuzzy logic approach to contrast enhancement [16].

Ehsan Nadernejad suggested methods assume the intensity of illumination on edges varies like geometric heat flow in which heat transforms from a warm environment to a cooler one until the temperature of the two environments reaches a balanced point[17].

Amit karma developed an Improved Method for Image Enhancement Using Fuzzy Approach [18].

Marius Tico presented an image enhancement algorithm based on fusing the visual information present in two images of the same scene, captured with different exposure times[19].

P Kannan Compared two approaches histogram equalization and fuzzy rules to enhance the sports images [20].

## 3. FUZZY ENHANCEMENT TECHNIQUES

Fuzzy image processing is the collection of all approaches that understand, represent and process the images, Their segments and features are fuzzy sets. Fuzzy set theory is thus useful in handling various uncertainties in computer vision and image processing applications . The representation and processing depend on the selected fuzzy technique and on the problem to be solved. It has three main stages that are image fuzzification, modification of membership function values, and defuzzification. Fuzzy image enhancement is based on gray level mapping into membership function with fuzzy intensification factors. The aim is to generate an image of higher contrast than the original image by giving a larger weight to the gray levels that are closer to the mean gray level of the image that is farther from the mean. Fig. 1 shows the general structure of fuzzy image enhancement[3].

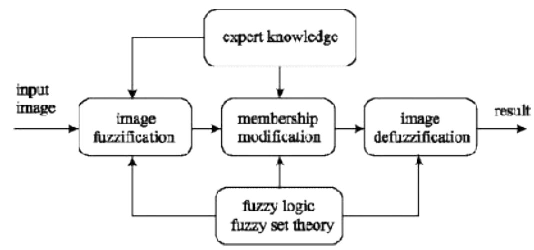


Fig. 1 General structure of fuzzy image enhancement

The fuzzification and defuzzification steps are due to the fact that we do not posse's fuzzy hardware. The fuzzy image processing is the collection of different areas of fuzzy set theory, fuzzy logic and fuzzy measure theory. The most important theoretical components of fuzzy image processing are fuzzy geometry, measure of fuzziness and image information, fuzzy inference system, fuzzy clustering and fuzzy mathematical morphology. The aim is to generate an image of better quality as compare to other techniques.The fuzzy image enhancement technique is based on fuzzy set theory to improve the contrast of an image. The fuzzy image enhancement process identifies the all fuzzy sets and the variables which are used with the membership functions. The fuzzy intensification factors are used to modify the membership values which are applied on the images so that the gray scale images can be enhanced These enhanced images identify the quality.

## 4. PROPOSED ENHANCEMENT ALGORITHM

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 by giving a larger weight to the gray levels that are closer to the mean gray level of the image than to those that are farther from the mean. Pal and King used fuzzy sets for image enhancement [10]. The result of this method has been satisfactory, but the processing is very complex and requires user predefined parameters, such as the number of the contrast intensification, and the fuzzifiers that are very difficult to specify and time consuming .In this paper the value of fuzzifier is established heuristically using the standard deviation of the image to simplify and automate the scheme for image enhancement are proposed.

## 4.1 Image Representation

An image $G$ of size $M$ x $N$ and L gray levels can be considered as an array of fuzzy singletons, each having a value of membership denoting its degree of brightness relative to some brightness levels. For an image $G$, we can write in the notation of fuzzy sets as given by equation 1

$$G = \bigcup_{m=1}^{m} \bigcup_{n=1}^{n} \frac{\mu_{mn}}{x_{mn}} \qquad (1)$$

Where $\mu_{mn}$ is its membership value of $x_{mn}$ th pixel.

### 4.2 RMS contrast

Root mean square (RMS) contrast, does not depend on the spatial frequency content or the spatial distribution of contrast in the image. RMS contrast is defined as the standard deviation of the pixel intensities as given by equation -02

$$\sqrt{1/MN \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} \left( xij - \bar{x} \right)} \qquad (2)$$

Where intensities $x_{ij}$ are the i-th and j-th element of the two dimensional image of size M by N. $\bar{x}$ is the average intensity of all pixel values in the image. The image is assumed to have its pixel intensities normalized in the range [0 1].

### 4.3 Contrast Improvement using Intensification Operator

Find the maximum value $x_{max}$ and minimum value $x_{min}$ of the given image and value of parameters Fe automatically selected for the maximum value of standard deviation achieved .The value of Fe and the corresponding maximum standard deviation for 20 images is shown in the Table 1

**Table - 1**

| Image No. | Standard Deviation Original Image | Fe | Maximum Standard Deviation |
|---|---|---|---|
| 1 | 34 | 2 | 71 |
| 2 | 10 | 1 | 52 |
| 3 | 42 | 1.2 | 74 |
| 4 | 11.28 | 1.2 | 45.75 |
| 5 | 14 | .6 | 49 |
| 6 | 22.18 | 1.5 | 72 |
| 7 | 11 | .7 | 61 |
| 8 | 9 | .7 | 48 |
| 9 | 35 | 1.7 | 82 |
| 10 | 31 | .6 | 82.5 |
| 11 | 20 | .8 | 63 |
| 12 | 58.52 | 1.1 | 96 |
| 13 | 20 | .7 | 78.79 |
| 14 | 27 | .9 | 92.93 |
| 15 | 22 | 1.1 | 69 |
| 16 | 51.48 | 1.2 | 87.11 |
| 17 | 5.64 | .6 | 16 |
| 18 | 38.37 | 1.9 | 76.42 |
| 19 | 23.72 | .7 | 68.32 |
| 20 | 21.21 | .7 | 67.67 |

**The value of Defuzzifier $F_d$ calculated using following relation-**

$$F_d = \chi_{max} - \chi_{min} / (.5)^{-1/Fe} - 1 \qquad (3)$$

**Membership Function Defined as**

$$\mu_{mn} = G(\chi_{mn}) = \left[1 + (x_{max} - x_{mn}) / F_d\right]^{-Fe} \qquad (4)$$

**Modify the membership values using contrast intensification operator on fuzzy sets**

$$\mu'_{mn} = \begin{cases} 2[\mu_{mn}]^2, 0 <= \mu_{mn} x <= .5 \\ 1 - 2[1 - \mu_{mn}]^2 .5 <= \mu_{mn} x <= 1 \end{cases} \qquad (5)$$

**Generate new gray levels (Defuzzification)**

$$\hat{g}_{mn} = G^{-1}(\mu'_{mn}) = X_{max} - F_d * ((\mu'_{mn})^{-1/Fe}) + F_d \qquad (6)$$

## 5. Results and Discussion

The proposed algorithm and histogram equalization algorithm is applied to the given image and the output generated as shown in Fig. 2


(a) (b) (c)

Fig. 2 (a) Original Image(b) Histogram Equalization (c) Proposed algorithm

In order to demonstrate the performance of the proposed method the experimental results of the proposed approach and the histogram equalization method are compared the above are the test images as well as the output generated by applying the histogram equalization algorithm and the proposed algorithm. The output generated by proposed algorithm is an enhanced image with improved contrast without ruined the image and the output generated by applying the histogram equalization algorithm enhanced the image but ruined the image. Thus, the above mentioned method proves the best approach for enhancing the corrupted images.

## 5 Conclusion

In this paper , an automatic image contrast enhancement algorithm is proposed. The technique is based on employing automatic selection of the suitable value of exponential fuzzifier to enhance the images. From experiments, the presented algorithm can be used over a wide variety of images with good quality results without user intervention. In addition , the results of the proposed method in enhancement will provide more consistency in data distribution with smooth images than other classical image enhancement techniques.

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