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A Research on Fingerprint Image Enhancement: A New Application of Fuzzy Technique

Deepak kumar[1], Deepak Sherawat[2], Naveen Kumar[3], Kumar Shivendu[4], Deepak Deshwal[5]

1. Dronacharya college of Engineering Gurgaon, India, E-mail: deepaksoni.dce@gmail.com
2. Dronacharya college of Engineering Gurgaon, India, E-mail: deepaksherawat1990@gmail.com
3. Dronacharya college of Engineering Gurgaon, India, E-mail: nktobaria90@gmail.com
4. Dronacharya college of Engineering Gurgaon, India, E-mail: kumarshivendu.20790@gmail.com
5. Dronacharya college of Engineering Gurgaon, India, E-mail: deepak.deshwal07@gmail.com

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ABSTRACT

Fingerprints are the oldest and mainly used form of biometric identification. The aim of image enhancement is to improve the interpretability or perception of information in images for human viewers, or to provide 'better' input for other automated image processing techniques. Fuzzy techniques can manage the vagueness and ambiguity efficiently (an image can be represented as fuzzy set). Fuzzy logic is a powerful tool to represent and process human knowledge in form of fuzzy if-then rules. The manipulation of these concepts leads to theory of approximation using fuzzy systems in image processing. If the observed data are disturbed by random noise then the fuzzification operator should convert the probabilistic data into fuzzy numbers or fuzzy data. Some images are not available to good quality. In this paper a fuzzy techniques based method to enhance the image is discussed and then implemented in MATLAB7.0.

Keywords: Image, Fuzzy Techniques, Fuzzy Image Processing, Fuzzy Inference System, Linguistic variable.

1. INTRODUCTION

A image contain the high contrast and ridges and brightness is called good quality image while a poor quality image is marked by low contrast and ill defined boundaries between the ridges .Image enhancement can be treated as transforming one image to another so that the look and feel of an image can be improved for machine analysis or visual perception of human beings. Image Enhancement alters an image to makes its meaning clearer to human observers. It is often used to increase the contrast in images that are substantially dark or light. In Fig.1 show the fingerprint image. Implement the image enhancement with fuzzy techniques and enhance the image. In this paper presents the research enhance the image using fuzzy techniques. Image enhancement techniques are used to improve the appearance of the image or to extract the finer details in the degraded images.

Figure1
Fingerprint image

2. EXPLANATION

Fuzzy set theory proposed in 1965 by lotfi. a Zadeh . A fuzzy set theory is a generalization of classical set in which the characteristic function is permitted to have any values between 0 and 1. A fuzzy set A defined as a set A= {(x, $\mu_A(x)$) | x € X }. Where $\mu_A(x)$ is called membership function for a fuzzy set A. In classical set theory an element either belongs to or does not belong to a set and hence such sets are termed crisp sets. The membership function $\mu_A(x)$ is associated with a fuzzy set. A function mapping all the elements in a crisp set into real numbers in [0; 1] is called a membership function. The larger value of the membership function represents the higher degree of the membership. It means how closely an element resembles an ideal element. Membership functions can represent the uncertainty using some particular functions. Example of membership functions triangular, trapezoidal, Generalize bell and curved (Gaussian) can be seen in Fig.2 and described with the following formulas:

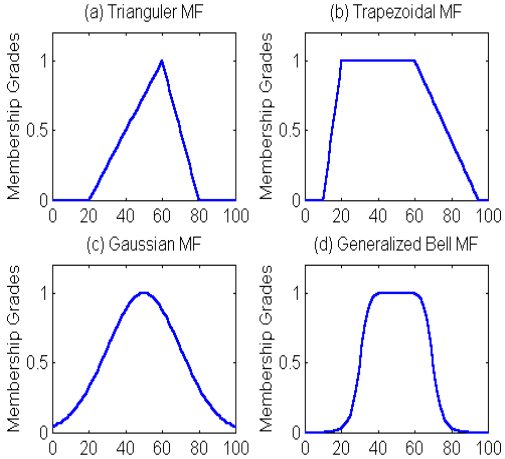

Figure 2
Membership function

2.1. Linguistic variable

The concept of linguistic variable was introduced by Zadeh to provide a basic for approximate reasoning. A linguistic variable was defined as a variable whose values are words or sentences. For instance, Age can be linguistic variable if its values are linguistic rather than numerical, i.e., young, very young, old, very old, etc., rather than 20, 21, 53, 55, etc.

2.2. Fuzzy if-then rules

A fuzzy if-then rule (fuzzy rule, fuzzy implication, or fuzzy conditional statement) is expressed as follow:

If x is A then y is B

Where A and B are linguistic values defined by fuzzy sets. "x is A" is called "antecedent" or "premise", while " y is B" is called the "consequence" or "conclusion". Some of the if-then rule examples can be given below:

- If age is 25, then person is young.

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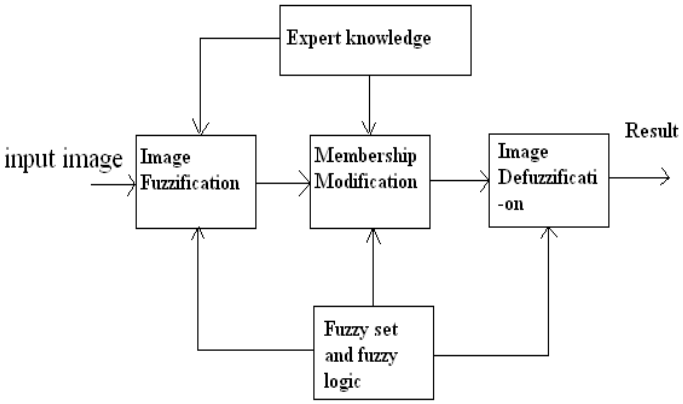

Figure 3
Fuzzy Image Processing

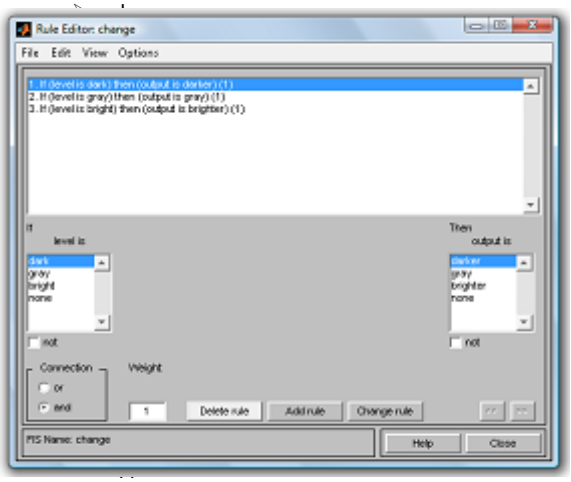

Figure 4 N
D
FIS rule for image enhancement

the distance is small, then the force on brake should be small.

- If height is 180 cm then person is tall.

2.3. Fuzzy Image Processing

Fuzzy image processing is not a unique theory. It is a collection of different fuzzy approaches to image processing. 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. Fuzzy image processing has three main stages: image fuzzification, modification of membership values, and if necessary, image defuzzification (Fig.3). The fuzzification and defuzzification steps are due to the fact that we do not posses 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 are 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.

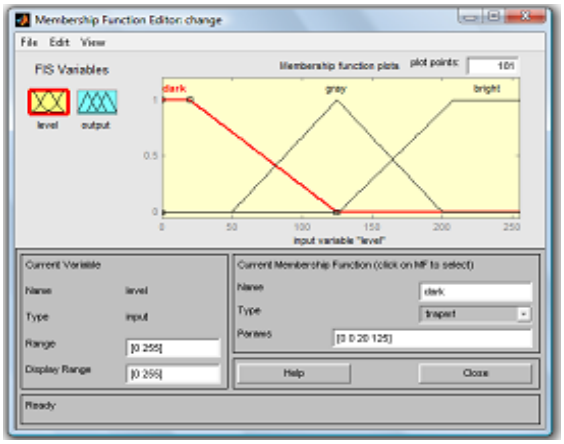

Figure 5
FIS Membership Function

2.4. Different image enhancement methods

Many kinds of enhancement methods of the fingerprint image have been proposed. Most are based on image binarisation, while others enhance the image directly from gray-scale images. In the gray-scale images approach, the enhancement algorithm includes the following steps: (i) Normalization, (ii) local orientation estimation, (iii) local frequency estimation, and (iv) Filtering by a bank of the designed filters. In the normalization step, an input fingerprint image is normalized to decrease the dynamic range of the gray scale between ridges and valleys of the image estimation and the tuning of the filter parameters.
Following are some of the methods used for enhancement of fingerprint images, (i) Enhancement algorithm based on image normalization and Gabor filter. (ii) Fourier domain filtering of fingerprint images [5]. (iii) Fingerprint image enhancement using CNN Gabor-type filters [6]. (v) Enhancement of fingerprint image using M-lattice [1].

3. IMPLEMENTATION

Fuzzy logic is not just new method for image enhancement. Many researchers have been done on the fuzzy logic and image enhancement. Some of fuzzy rule for image enhancement are such as

- If pixel level is dark then output is darker.
- If pixel level is gray then output is gray.
- If pixel level is bright then output is brighter.

Fig.4 and Fig.5 shows implementation of these rules in fuzzy inference system:-
On the basis of these rule, a new algorithm based on fuzzy methods on image enhancement have been implemented which have following steps:

- Taking image and set membership function for each gray level as:

$$\mu(x, y)=e^{-\left(\frac{\left(L-\frac{f(x,y)}{s}\right)}{s}\right)^2}$$

Where L=max gray level
F(x, y)= any gray level.

S=variance between gray values

- Get new membership function by putting:

$V(x, y)=2*((\mu(x,y))^2$ if $\mu(x, y)<=0.5$

$V(x, y)=1-2*(1-\mu(x,y))^2$ if $0.5<=\mu(x, y)<=1$

- Get new image by setting the method as:

$g(x , y)=L-s(\sqrt{-2\log(\mu(x,y))})$

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4. RESULTS AND CONCLUSION

First a code was written on the basis of our proposed algorithm and then saves in the workspace of MATLAB as an M-file. Experiment was done on about 10 poor quality images. One of the result is as below (Fig.6 & Fig.7): This paper presents a fuzzy method for the fingerprint image enhancement. The results indicate that application of this algorithm is more promising in further work on fingerprint minutiae point's extraction.

Figure 6
Finger1

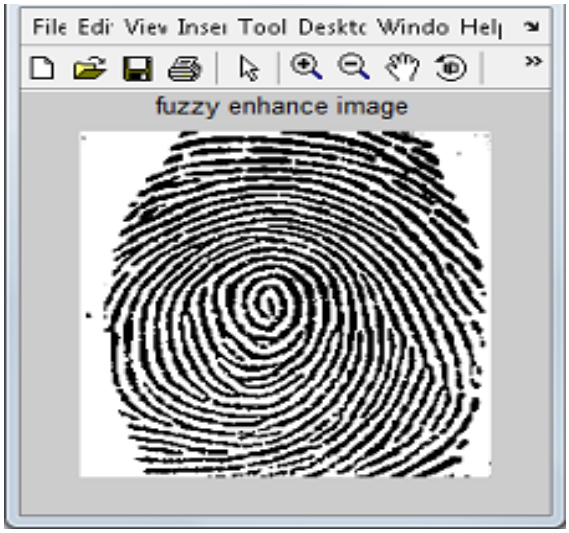

Figure 7
Enhancement of finger1 by Fuzzy logic

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