Advances in Fuzzy Mathematics
ISSN 0973-533X Volume 5, Number 1 (2010), pp. 71–76

http://www.ripublication.com/afm.htm

Applications of Advanced Fuzzy Logic Techniques in Fuzzy Image Processing Scheme

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Abstract

In this paper, we propose an alternative scheme to crisp image processing algorithms, especially when subjective or very sensitive parameters or concepts related to the image need to be measured or defined. It involves an image fuzzification function,fuzzy operators and an optional defuzzification function. The Applicability of the scheme is illustrated in three applications,image binarization,edge detection and geometric measurements. This paper also attempts to formulate a mathematical model for a fuzzy image processing approach to provide a guidance to perform fizzy image processing and also applications of fuzzy logic in the development of image processing.

Keywords : Fuzzy logic, Fuzzy operators, Fuzzification, Fuzzy domain, Defuzzification, Fuzzy area, Fuzzy perimeter.

I. Introduction

Image processing changes the nature of an image to make it appear sharper. It uses in applications of medicine, product quality, astronomy, remote sensing, national security autonomus system and industrial applications. [1]Image processing algorithms require modelling of complex systems, which require processing of information with high degree of uncertainty and subjectivity concepts like brightness, edges, uniformity, measurements etc. [2]The concepts related to image analysis contains a certain amount of uncertainty. Due to the uncertainty present on object edges, the decision whether a pixel belong to the background or to the object is non-trivial. Results of crisp based algorithm are not sufficient. So the new development is needed. Fuzzy techniques are very much useful in the development of new algorithms. The fuzzy technique is an operator which is to simulate at a mathematical

level the compensatory behavior in the process of decision making or subjective evaluation. So the incorporation of fuzzy logic in to the development of image processing and analysis opened a research area in the image processing field. [3-5]Fuzzy logic allows one to model uncertainty and subject concepts in a better form than certainty models.

This paper presents a mathematical model to provide a guidance to perform fuzzy image processing and with some applications.

II. Fuzzy Image Processing

Fuzzy image processing is the collection of all approaches that understand, represent and process the images, their segments and feature 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.

1. Image fuzzification
2. Membership modification
3. Image defuzzification

Fuzzy image processing using fuzzy techniques plays a very important role in image processing. Fuzzy techniques are important and powerful tools for knowledge representation and processing, and also managing the subjectivity and uncertainty very efficiently. The three important areas that are not perfect are Grayness ambiguity, Geometrical fuzziness, vague knowledge. Fuzzy Geometry, measures of Fuzziness and image information, fuzzy inference systems, fuzzy clustering, Fuzzy mathematical morphology, fuzzy measure theory, Fuzzy Grammars, neural fuzzy are some of important theoretical components of fuzzy image processing scheme.

III. Steps in Fuzzy image processing scheme.

(a) Mapping the image into the fuzzy domain

The mapping function F is defined such that image characteristics or concepts that are of interest, brightness, contrast, edges, regions, connectivity, image complexity etc, could be better represented in the new image model. The concept of a fuzzy processing scheme is to map the original image into the fuzzy domain, apply a fuzzy operator to the fuzzy image, and defuzzification of the fuzzy image to return to the original domain.

Let I(x,y) is the original image I' (x,y) is the processed image in the original domain. I_F (x,y) is the image in the fuzzy domain. The fuzzy image is processed a fuzzy set of operator $\Im$ yielding a new fuzzy image I_F (x,y)'. Then the fuzzy image is mapped back to the original domain through the defuzzification function D. All of these is represented by the equations.

F: $I(x,y) \Rightarrow I_F(x,y)$

$\Im [I_F(xy)] \Rightarrow I_F'(x,y)$

D: $I_F'(xy) \Rightarrow I'(x,y)$

Fuzzy image processing scheme mainly lies in the modification of membership values by the appropriate fuzzy techniques that are of interest, brightness, contrast,

edges regions, connectivity, image complexity could be represented new image domain.

Some examples of F are

(i) [6]Brightness: The Brightness of pixel 'l' is given by F(l) = ml+b where $l \in L$, L is the set of gray level values of a pixel.

(ii) [7]Edge : The edge of an image is given by

$$F(\nabla) = S(\nabla; a,b,c) = \begin{cases} 0 & \nabla \le a \\ 2\left(\frac{x-a}{c-a}\right)^2 & a < \nabla \le b \\ 1-2\left(\frac{x-c}{c-a}\right)^2 & b < \nabla \le c \\ 1 & \nabla > 0 \end{cases}$$

Where ∇ - gradient value of a neighbour around a pixel.

(b)Operations on the Fuzzy Domain

The fuzzy operators $\Im$ can be expressed through mathematical expression or fuzzy rules. Some of the operators on the Fuzzy domain are given by

(i) Contrast intensification
(ii) Filtering
(iii) Fuzzy entropy

(i) Contrast intensification

It is used to reduce the uncertainty present in the data.

The contrast intensification operator is defined by

$$INT(A) = \begin{cases} 2\mu_A{}^2(1) & 0 \le \mu_A(1) < 0.5 \\ 1-2(1-\mu_A{}^2(1) & 0.5 \le \mu_A(1) \le 1 \end{cases}$$

Where $\mu_A(l)$ is the membership of the gray level l to the fuzzy set A.

(ii) Filtering

Filtering operation allows us to emphasize important information or discard it. [8]The output of a fuzzy filter may be defined by

$$y(i,j) = \frac{\sum_{(r,s)\in d} F[x(i+r, j+s)]\, x(i+r, j+s)}{\sum_{(r,s)\in d} F[x(i+r, j+s)]}$$

Where x(i,j) is the input of the 2D filter,, F [x(i,j))]is a general window function that defines the type of filter, and A is the order of the window. Common filters used in image processing, the median filter, and the moving average filter are defined by the general window functions [7].

$$F_{median}[x(i+r,j+s)] = \begin{cases} 1 \text{ for } x(i+r, j+s) = x_{median}(i,j) \\ 0 \qquad\qquad \text{otherwise} \end{cases}$$

$$F_{mavg}[x(i+r,j+s)] = 1 \text{ for } r,s, \in A$$

(iii) FUZZY ENTROPY

[8]Fuzzy entropy operator is used to measure of information content which is defined by

$$\Sigma_{(A)} = -\sum_{i=1}^{N} \mu_A(l_i)\, P(l_i)\, \text{Log}\, P(l_i)$$

(c) Defuzzification Function

If there is a coding (fuzzification) of image data, then, there will be a decoding [defuzzification] of an image. Defuzzification function consists of the mapping of fuzzy values to the allowed values of the visualization device. For example

D:(0 1) $\Rightarrow$ (0, L-1)

" The membership updates of the pixels are accomplished by

$$\mu ij = \left(\frac{1}{d^2(X_j, V_i)} \right)^{\frac{1}{m-1}} / \sum_{i=1}^{e} \left(\frac{1}{d^2(X_j, V_i)} \right)^{\frac{1}{m-1}}$$

Where

$d^2(X_j, V_i) = (X_j - V_i)^T (X_j - V_i)$

and the objective function is defined by

$$J_m = \sum_{i=1}^{c} \sum_{j=1}^{n} (\mu_{ij})^m d^2(X_j, V_i)$$

Once the goal over the objective function is met, the centroids Vi, are used to classify the pixels into black or white. In this case since membership values are directly related to brightness the defuzzification function was

D: (0,1) $\Rightarrow$ (0,L-1)

IV. Fuzzy edge

The purpose of Edge detection is to try to find objects or region that compose the image. It leads to the segmentation of an edge. Algorithm was developed to determine the edges in an image. The process of edge detection is as follows.

[9]Take an original image 1(x,y), and generate and image I_e with the gradient operator

$\nabla : I(x,y) \rightarrow I_E$

The fuzzification function is accomplished by fuzzy centroids, Ci. This function classifies the pixels $P_{ed} \in I_E$, according to the following rule :

If $|P_{ed} - C_i| < |P_{ed} - C_j|$ for i, j =1,……, 5 $i \neq j$

Then $P_{ed} \in E_{li}$ and mark pixel ped as level i

Where Ei is an edge level. This classification process generates a new image where L_{Ei} where the pixels are marked as edge level 1,2,3, 4 and 5. Thus, images with different edge level information can be generated from I_{El}.

[10]Complexity of an image is computed by fuzzy rules using the edge level information. If the image is A little complex, then the edges are $\int_{i=1,2,3,} I_{Ei(x,y)}$

if the image is A lot complex, then the edges are

$\int_{i=1,2} I_{Ei(x,y)}$

V. Fuzzy Geometry measurement

In image processing measuring the object or attributes of the objects are very important for fuzzy logic schemes.

[11]The fuzzy area is defined as the sum of the membership values of the object pixels.

Fuzzy area = $\sum_{x\in 0} \mu(x)$

Where $\mu(x)$ is the membership value of a pixed, O is the set of pixels corresponding to the object.

The image is fuzzified by the fuzzy binarization algorithm. [12]The fuzzy perimeter is defined by

Fuzzy perimeter = $\sum_{x\in 0} \mu(x)$

Where $\mu(x)$ is the membership value of pixel, PO is the set of pixels corresponding to the perimeter of the object.

VI. Applications of fuzzy techniques in image processing

Fuzzy techniques are applied in image Processing in the areas such as fuzzy contrast Adjustment, image enhancement, fuzzy image segmentation and fuzzy detection. Fuzzy techniques in image processing is applied to various fields such as medicine, agriculture, industry, law enforcement etc. In medicine, images are analysed by using fuzzy techniques for interpretation. [12-14]Fuzzy techniques are used to sharpening or deblurring of speed camera, images, and finger print images, and also to analyse the aerial views of land images for further applications.

VII. Conclusion

In this paper, we presented a scheme of algorithms for subjective or very sensitive parameters or concepts of the needed image, which involves images fuzzification function, fuzzy operators and defuzzification function. The applications of advanced fuzzy techniques in image processing is also explained. In image binarization, the fuzzy scheme is illustrated to resolve uncertainty. The proposed fuzzy scheme

modeled the subjective concept, fuzzy geometry is to measure the content of an image.

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