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A Novel Method for Image Segmentation Using Fuzzy Threshold Selection

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Abstract: The fuzzy technique is an operator introduced in order to simulate at a mathematical level the compensatory behavior in process of decision making or subjective evaluation. The following paper introduces such operators on hand of computer vision application. The areas of this work are in electronics and telecommunication engineering, which are very wide fields. This work is intended to implement the edge detection for digital image, so that it may be carried out to a big contour (face) identification of an object (an image). In this paper a novel method based on fuzzy logic reasoning strategy is proposed for edge detection in digital images using 16 fuzzy edge templates that show the possible direction of the edge in the image and then calculating the divergence between the origins image and the 16 fuzzy templates. Calculation of the maximum of the divergence value between the 16 templates and the original image of the same size. Set a threshold and applying the morphological operators. After emerging the fuzzy logic concept, a lot of Researcher of image processing shifted their attention towards the fuzzy logic concept and its applicability in the field of image processing.

Keywords: fuzzy logic, Edge detection, fuzzy sets, Threshold, Morphological operator.

I. Introduction

Last few decades the volume of interest, research, and development of computer vision systems has increased enormously. Nowadays they appear to be present in almost every sphere of life, from surveillance systems in car parks, streets, and shopping centers, to sorting and quality control systems in the majority of food production. Thus, introducing automated visual inspection and measurement systems are necessary, especially for the two dimensional mechanical objects, [1:8]. Sankura and Sezgin list over 40 different thresholding techniques [9].

In the past few years, fuzzy logic emerged as a different yet powerful tool to decision making [10], [11], [12]. In 1965 Zadeh proposed the concept of fuzzy logic and soon fuzzy concept gained popularity in the image processing field. Many technique have been proposed by researcher for fuzzy logic based edge detection [13], [14], and [15]. Zhao [16], proposed an edge detection technique by dividing the image into 3-fuzzy partitions (regions) and then finding the maximum entropy to give the best edge. He also derived the necessary condition to maximize the entropy function. Based on these condition three-level thresholding is obtained.

A very important role is played in image analysis by what are termed feature points, pixels that are identified as having a special property. Feature points include edge pixels as determined by the well-known classic edge detectors of PreWitt, Sobel, Marr, and Canny [17:21]. Recently there has been much revived interest [22, 23] in feature points determined by "corner" operators such as the Plessey, and interesting point operators such as that introduced by Moravec. [24, 25] Classical operators identify a pixel as a particular class of feature point by carrying out some series of operations within a window centered on the pixel under scrutiny.

In the proposed work an algorithm based on fuzzy logic rules are developed for detecting edges from an image. In order to avoid the complexity, Selection of the 16 fuzzy templates, converting into the fuzzy domain from the original image, Increasing the border line of the image of existing rows and columns respectively, finding Hesitation degree or intuitionistic fuzzy index, Calculation of the maximum of the divergence value between the 16 templates and the original image of the same size let the original image denoted by this formed by taking the 3x3 matrix in the border matrix, Selecting the minimum divergence among the 16 divergence values, so we have to transforming back in the image pixel domain i.e in the interval [1 255] domain and set a threshold.

II. Fuzzy logic technique

A. Fuzzy 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. The fuzzification and defuzzification steps are due to the fact that we do not possess 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,

B. Fuzzy Sets and Fuzzy Membership Functions

The system implementation was carried out considering that the input image and the output image obtained after defuzzification are both 8-bit quantized; this way, their gray levels are always between 0 and 255. The fuzzy sets were created to represent each variable's intensities; these sets were associated to the linguistic variables "Black", Edge and "white". The adopted membership functions for the fuzzy sets associated to the input and to the output were triangles, as shown in Fig. 1.

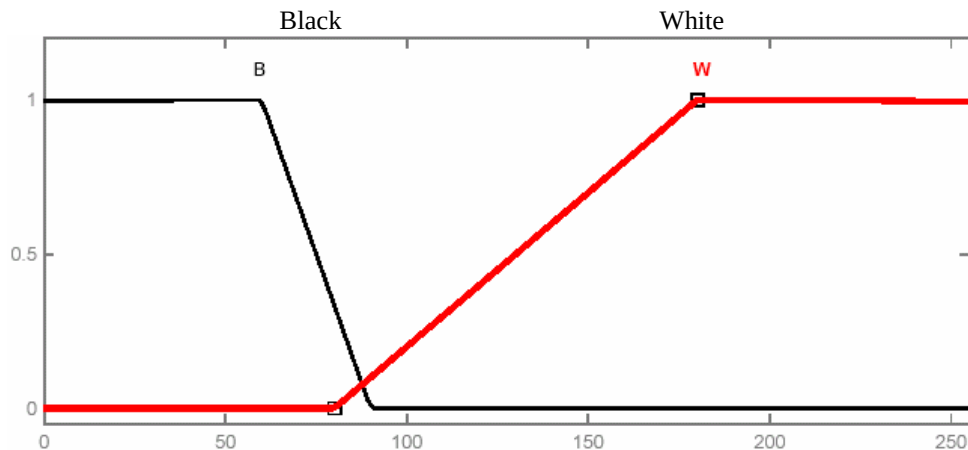


Figure 1 (a) Membership functions of the fuzzy sets associated to the input and to the output

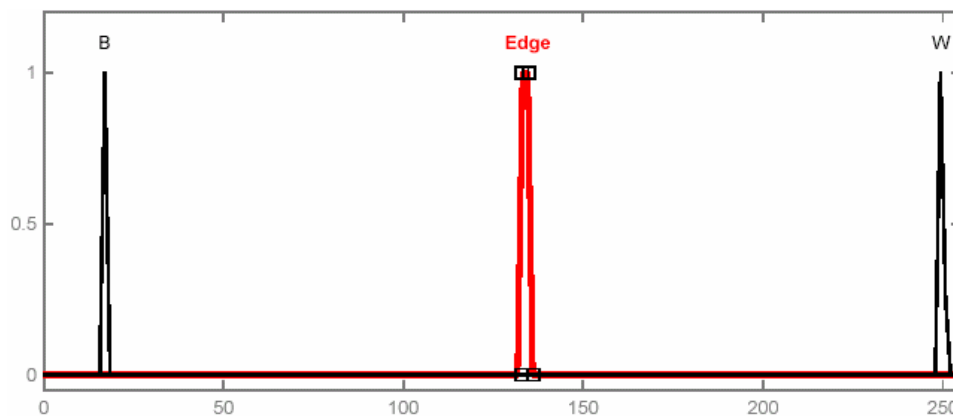


Figure 1 (b) Membership functions of the fuzzy sets associated to the input and to the output

The functions adopted to implement the "and" and "or" operations were the minimum and maximum functions, respectively. The Mamdani method was chosen as the defuzzification procedure, which means that the fuzzy sets obtained by applying each inference rule to the input data were joined through the add function; the output of the system was then computed as the loom of the resulting membership function. The values of the three memberships function of the output are designed to separate the values of the blacks, whites and edges of the image.

III. Algorithm Description

The general algorithm for image thresholding based on measure proposed above can be formulated as follows:

- (1) Reading the pixel of the image.
- (2) Number of row(n) and column(r) of an image is taken.
- (3) Selection of the 16 fuzzy templates.
 $a=0.3$; $b=0.8$;
 $t1 = [a \ a; \ 0 \ 0; \ b \ b]$; etc., (distinct templates)

- (4) Converting into the fuzzy domain from the original image.
All value in the interval of [0 1] (ie maximum pixel/element of the image)
- (5) Finding Hesitation degree or intuitionistic fuzzy index 0.2 (assume)
 $H_{pimage} \text{ for each templates} = c * (1 - p_{image} \text{ for each templates})$
- (6) Calculation of the maximum of the divergence value between the 16 templates and the original image of the same size let the original image denoted by this formed by taking the 3x3 matrix in the border matrix.
- (7) Finite iteration by Selecting the minimum divergence among the 16 divergence values and is positioned at the center of the templates position for the edge image.
 $\text{Fuzzy domain image}(i,j) = \max_n [\min_r H_{pimage}(i,j)]$
- (8) Edge image in the fuzzy domain matrix is transformed back in the image pixel domain i.e in the interval [1 255] domain (multiply by 255)
- (9) Set a threshold, and applying the morphological operators of matlab.

IV. Experiment

The proposed system was tested with different Images, its performance being compared the existing edge detection algorithms and it was observed that the outputs of this algorithm provide much more distinct marked edges and thus have better visual appearance than that of the standard existing one. Five 350 X 350 pictures are taken into consideration. The result of various pictures in Berkley dataset are shown below in Figure 2, 3 & 4.

Figure 2. Rice.tif

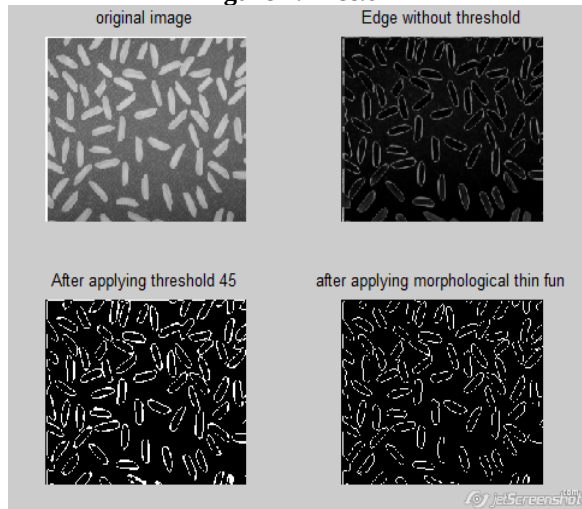


Figure 3.

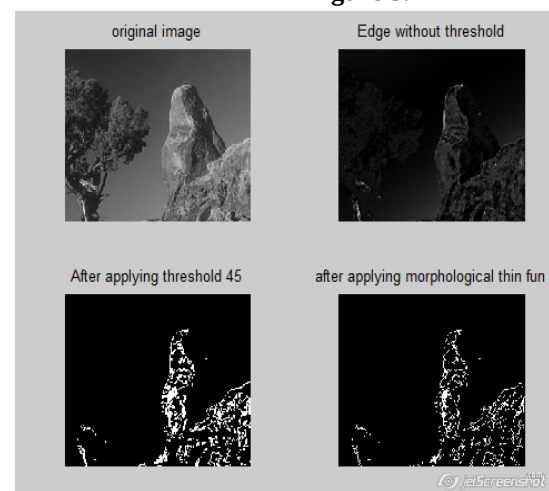


Figure 4



For various threshold value the pixels ranges are displayed in the figure 5. It can be observed that the output that has been generated by the fuzzy method has found out the edges of the image more distinctly as compared to the ones that have been found out by the “threshold” edge detection algorithm. Thus the Fuzzy rule based System

provides better edge detection and has an exhaustive set of fuzzy conditions which helps to extract the edges with a very high efficiency.

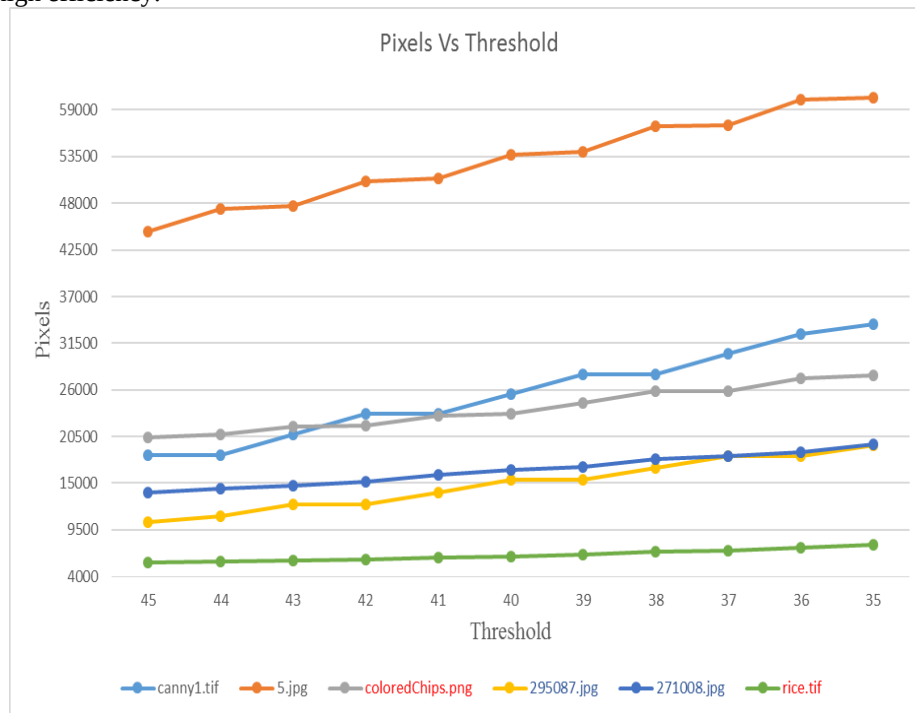


Figure 5. Threshold Value and Pixel Ranges

V. Conclusion

In this paper, we have proposed a very simple and small but a very efficient, fuzzy rule based edge detection algorithm which infuse the concepts of artificial intelligence and digital image processing. Comparisons were made without threshold edge detection method. Displayed results have shown the accuracy of the edge detection using the fuzzy rule based algorithm over the other threshold method.

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