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An Approach for Accurate Edging using Dynamic Membership Functions

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Abstract

In this paper, by means of fuzzy approaches, an accurate method is introduced for edging of color photographs. The difference between our method with other similar methods is the use of a morphological operation to think or thick the obtained edges. In this proposed method, a 3×3 window is dragged on the photo. For each block, 12 point sets will be defined, each including two non-overlapping point sets. Then, a fuzzy membership function will be designed for each point sets according to data of contrast. At last, the range of membership contrast degree for the points of second point sets will be assessed. A comparison of membership degree of second point sets with a pre-defined threshold indicates whether central point of window is bordered or non-bordered. The method was performed on some reference images and the results were compared with common edging methods. The results show that proposed method has a high capability to edge photographs.

Keywords: Fuzzy Edge Detection, Fuzzy logic, Variant Membership Function.

1. Introduction

Zoning is a process in which some pixels with similar characteristics such as color and contrast are grouped in one zone and are labelled equally [1]. Zoning can be investigated from three viewpoints [2].

a) Edge
b) Zone
c) Border

One method of zoning is according to the edges. The edges include important data about any image and can indicate border of zones. The importance of edges in any image is so great that human visual system refers to a pre-defined stage to distinguish edge of images. Any non-continuity and fast change in color or tissue or contrast of images is called edge [3]. Various algorithms are suggested to identify edges. In classic methods of defining edges, local maximum gradients of images are considered as the edges. Robert, Sobel, Prewitt and canny detectors belong to this group [4]. Various new methods are used besides above-mentioned methods for optimum definition of edges, such as fuzzy-neural based edging systems [5, 6], algorithms of ants [7] and fuzzy system based edging [5].

Fuzzy base principle is used in most of the methods to indicate edges according to fuzzy logic. In these methods, neighbouring points for each point are considered as a group and a fuzzy deduction system is developed using appropriate membership functions for each point sets [5, 8]. For example, we consider 3×3 sets of neighbouring points and describe pre-defined membership functions to detect non-continuity in colors and try to detect the edges of image [9]. This method uses five rules and permanent membership functions to define edges of point. These rules consider non-continuity of colors around the central point.

If such difference is obvious in pre-defined point sets, the central point will be considered as the edge. Although this method has high computational complexity, but the edge detection is relatively low. In another study, neighbour points around central pixel are considered in 6 point sets and each group was given a quantity according to variant membership degree (bridge-shape functions). According to membership degree of each set and by means of fuzzy principles, required decision is taken for existence and direction of edges [10]. Significant point of this algorithm is high computational complexity and large number of fuzzy inference rules in the evaluation stage. It extracts too many false edges. That extracted edges are discontinuous. This paper introduces an edging method based on fuzzy logic and according to variant membership functions defined dynamically for under-process neighbouring.

The rest of this paper is arranged to argue about the proposed method, describe tests and evaluate efficiency of proposed method in section II. Finally, section III concludes the paper.

2. Proposed Method

The proposed method in this paper is designed to edge images with gray scale. Like other classic methods which work based on edging window, this method uses a 3×3 window to classify pixels to bordered and non-bordered. This window is exerted on the image and central pixel of window is defined for any neighbourhood. Neighbourhood of points in a 3×3 window is represented in Fig. 1. As it is seen, pixel p_5 is located at the center of window, so edging operation will be done to classify this pixel to bordered and non-bordered.

P_1	P_2	P_3
P_4	P_5	P_6
P_7	P_8	P_9

Fig.1. Neighbourhood of points in a 3×3 window

In this method, neighbouring points for each pixel are classified in 12 sets. A number between 0 and 1 is defined for each group by means of appropriate membership functions (bridge-shaped functions are used in this method). Fuzzy basic rule is enjoyed to make decision about existence and direction of edges according to membership grade of each group and fuzzy principles. For each group of these 12 which refer to 12 various states for central points, three color parameters (RGB) are allocated to increase accuracy. Model of defined point sets is as follows:

t_1 = [a a a; 0 0 0; b b b]; t_2 = [a a b; a b 0; b 0 0];
t_3 = [b b b; 0 0 0; a a a]; t_4 = [b a a; 0 b a; 0 0 b];
t_5 = [b a 0; b a 0; b a 0]; t_6 = [a 0 b; a 0 b; a 0 b];
t_7 = [0 0 0; b b b; a a a]; t_8 = [0 b a; 0 b a; 0 b a];
t_9 = [a a a; b bb; 0 0 0]; t_{10} = [a b 0; a b 0; a b 0];
t_{11} = [0 0 0; a a a; b b b]; t_{12} = [0 a b; 0 a b; 0 a b];

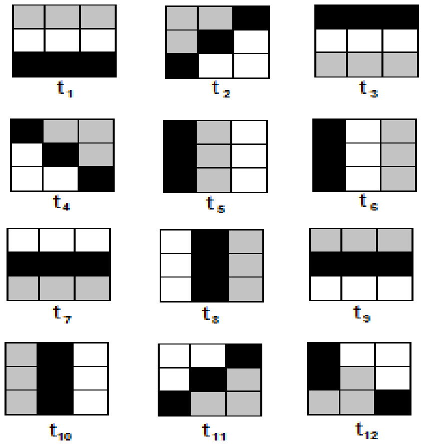

Fig.2. Pixels set points 12 defined in 3×3 window

In this classification, zero refers to highest light in the environment in RGB color mode for any require point. In the proposed method a fuzzy membership function is made for each of these 12 sets by means of contrast data of t_n group points. Then, average contrast for t_n group points are calculated and its dependency on fuzzy function is assessed. To perform this method, bridge-shape functions are used as in Fig. 3. In Equation (1) [10], as mentioned, parameters of made function are extracted by means of contrast data of t_{2n+2} set points.

$$f(I;a,b,c) = \left(1 + \left|\frac{1-c}{a}\right|^{2b}\right)^{-1} \quad (1)$$

In this equation, I= contrast and a, b and c= parameters of function. Variables are calculated dynamically and separately for each point. It should be mentioned that in proposed method, 12 fuzzy membership variables are calculated for each group points. Equation (2) is proposed for calculation amount of sets variable [10]. Here the parameter c is calculated by subtracting. As opposed to classes caused overlapping the edges and not destroying them. This change also causes extracted edges to be continuous and round lines to be curved lines well. In other words, the edges defined sharper images and easily.

$$\begin{aligned} &Max\ M = max\{I(P_x)\} | P_x \epsilon T_n \\ &Min\ M = min\{I(P_x)\} | P_x \epsilon T_n \\ &a = (3/2)\ Min\ M - ((1/2)\ Max\ M) \\ &b = constant \\ &c = (1/4)(Max\ M - Min\ M) \end{aligned} \quad (2)$$

In this equation, $I(P_x)$ refers to contrast of pixel P_x toward the weight of contrast membership function. After defining membership function for each point, allocation of the point to the points set will be assessed according to contrast toward t_{2n+2} sets. If this membership grade is less than threshold, the central point of window will be considered as an edge and will be period parameter for each point in

RGB model. In this model, the color of each image matrix is 3×N; so, contrast for each pixel should be defined according to RGB colors (red, green, blue). This method is due to increased accuracy when the window is dragged on the image to find edges. For red (a) above formulation is used. For green (b) a constant parameter is defined.

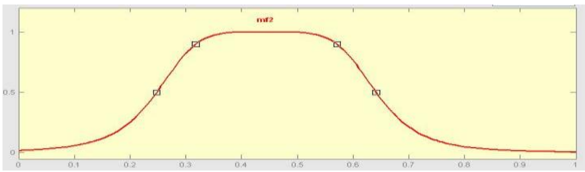

Fig. 3. Bridge-shape membership functions

3. Results

A. Samples of Defined Conditions to Consider Fuzzy Membership Function:

Fig. 4 depicts overall structure of fuzzy image processing algorithms. If the point has a defined range of change (min(x), max(x)) which means maximum and minimum contrasts in our fuzzy range and is according to one of the 12 sets, it will be considered as an edge. It defines a series of "if-then-else" principles for each of 12 sets and considers them for each pixel to distinguish the edges for central membership pixel and lateral points. For example, to consider vertical and horizontal lines around the central point and by means of the window, if gray scales are located on a black line (the least contrast) or on a line with higher contrast and other points are white, the checked point will be an edge. Such situation is defined for directions of 45° and 135°. If gray scales are in direction of black line or on a metaphor range and other points are white, the central point will be an edge, a sample show in Fig 5.

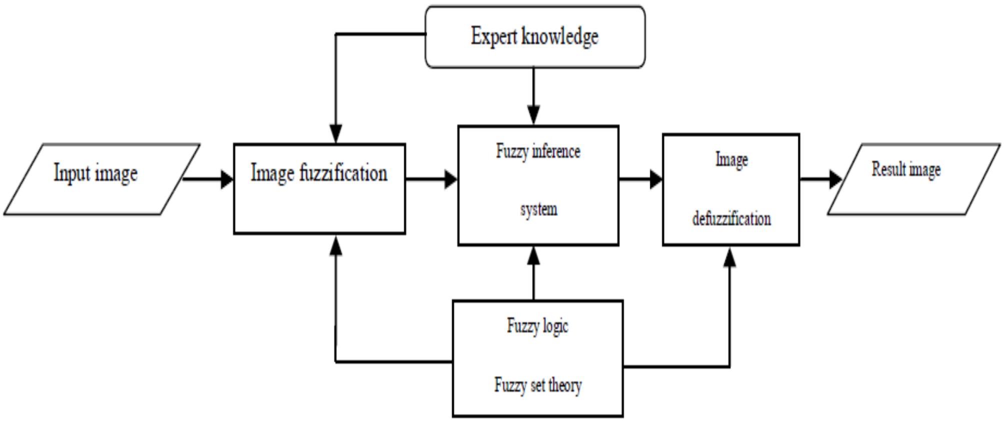

Fig. 4. Fuzzy Image Processing Flowchart

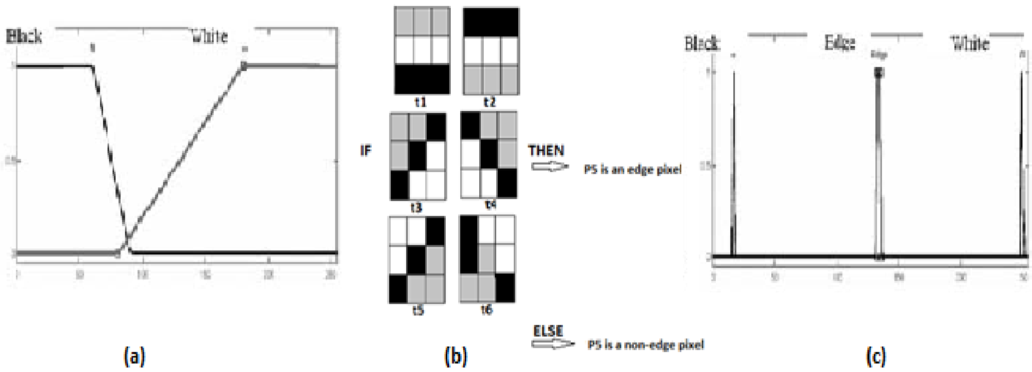

Fig.5. (a) Fuzzy membership functions for the input fuzzy set. (b) Fuzzy If-Then inference rules t1-t6. (c) Fuzzy membership functions for the output fuzzy set

B. Result of Tests:

The proposed fuzzy edge detection presented in this paper performs significantly better than the above-discussed operators. It not only obtains the fine and continuous edges but also removes the false edges in the images. Also, proposed fuzzy method is extracting a clear edge and image which is less sensitive against noises. Fig.9 shown a comparison between the proposed fuzzy edge detection presented in this paper and the above-discussed operators about it.

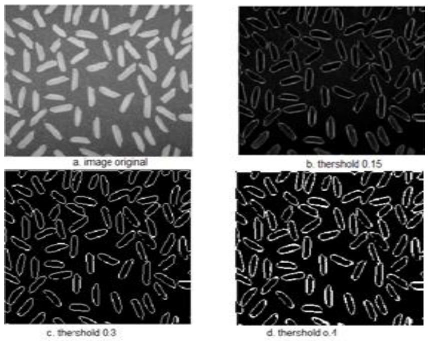

Fig.6. Proposed method with different thersholding

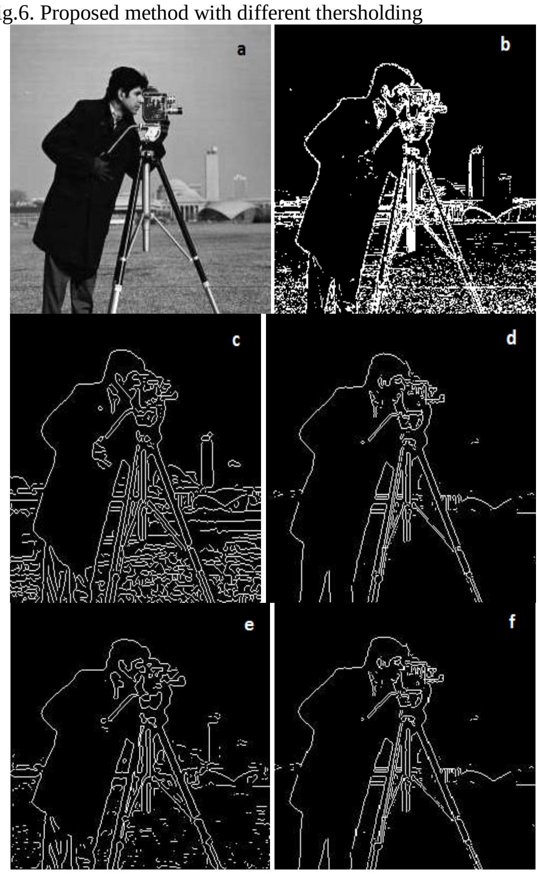

Fig.7. (a) original image,(b) edge detected by proposed method,(c) edge detected by canny,(d) edge detected by Sobel, (e) edge detected by Laplacian, (f) edge detected by Prewitt operator

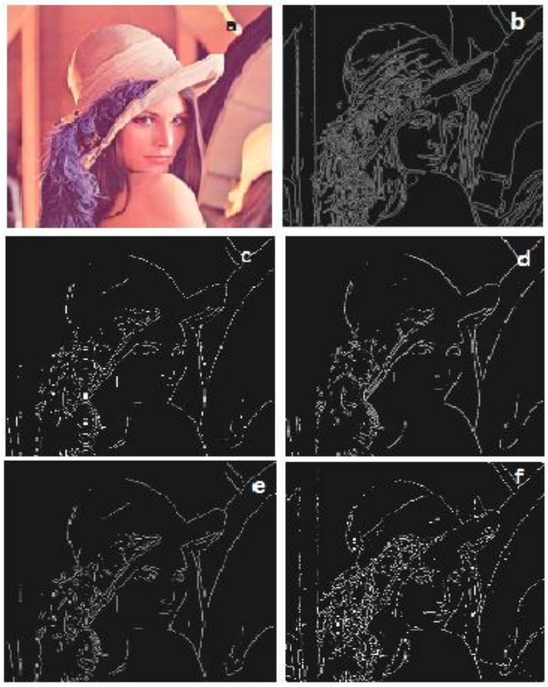

Fig.8. (a) original image,(b) edge detected by proposed method,(c) edge detected by canny,(d) edge detected by Sobel, (e) edge detected by Laplacian, (f) edge detected by Prewitt operator

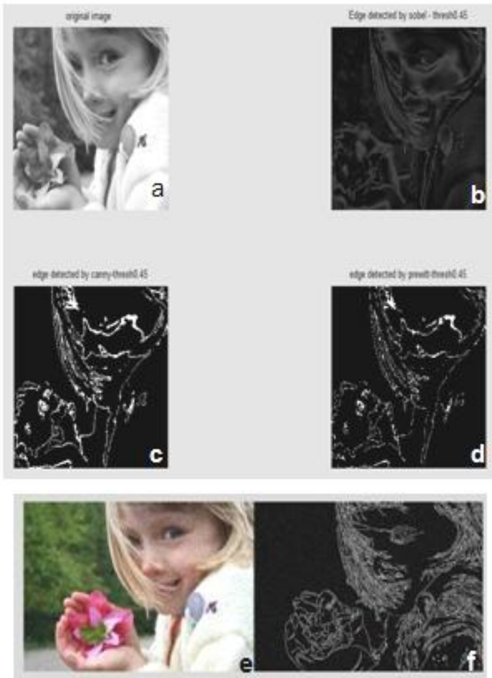

Fig.9. (a) original image (b) edge detected by Sobel(c) edge detected by canny (d) edge detected by Prewitt (e) salt paper noises image (f) edge detected by proposed method

4. Conclusion

Observation and comprehension of images are difficult actions in machine visual patterns. One effective specialty to recognize objects, is to use the information of shapes and their borders. So, using borders and edges in many machine visual applications is common. According to above mentioned details, it can be concluded that designing appropriate edging systems is necessary and important. This paper presents a new method according to concepts of fuzzy set points. In this paper the morphological method is used to adjust the thickness of the edge lines. This will improve the fuzzy edge detection of the proposed method as compared to similar methods.

The results show that the proposed method is simple and has high processing ability. The results also indicate that the method has less sensitivity to noises and presents acceptable and suitable responses. It can hence be concluded that:

1- Proposed method avoids doubling in edges and is more reliable in contrast viewpoint.

2- Curved and sharp edges and lines on the images can be illustrated easily.

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