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Fuzzy Logic Approach to Edge Detection for Dental X-ray Image Segmentation

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***Abstract*— Fuzzy image processing is a powerful tool formulation of expert knowledge edge and the combination of imprecise information from different sources. The fuzzy technique is an operator in order to simulate at a mathematical level the compensatory behavior in process of decision making or subjective evaluation. Edge is a basic feature of image. The image edges include rich information that is very significant for obtaining the image characteristic by object recognition. Edge detection is the most commonly used technique in image processing. In this paper, the main aim is to study the theory of edge detection for dental x-ray image segmentation using fuzzy logic approach.**

***Keywords*— fuzzy logic, edge detection, dental x-ray image, image segmentation.**

I. Introduction

Fuzzy image processing is the collection of all approaches that understand, represent and process the images, their segments and features as fuzzy sets[1][5]. The representation and processing depend on the selected fuzzy technique and on the problem to be solved[2]. Fuzzy image processing has three main stages, image fuzzification, modification of membership values, and, if necessary, image defuzzification[3][4]. Therefore, the coding of image data (fuzzification) and decoding of the results (defuzzification) are steps that make possible to process images with fuzzy techniques[5][8]. 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[5][9]. This can be a fuzzy clustering, a fuzzy rule-based approach, a fuzzy integration approach and so on, [4][9].

Digital image processing is a subset of the electronic domain wherein the image is converted to an array of small integers, called pixels, representing a physical quantity such as scene radiance, stored in a digital memory, and processed by computer or other digital hardware[6][10]. Edges characterize boundaries and Edge detection is one of the most difficult tasks in image processing hence it is a problem of fundamental importance image processing[5][7]. Edges in images are areas with strong intensity contrasts and a jump in intensity from one pixel to the next can create major variation in the picture quality[1].

Edge detection of an image significantly reduces the amount of data and filters out useless information, while preserving the important structural properties in an image[6]. Digital image processing allows one to enhance image features of interest while attenuating detail irrelevant to a given application, and then extract useful information about the scene from the enhanced image[1][5].

II. Fuzzy Inference System – An Overview

Fuzzy systems are made of a knowledge base and reasoning mechanism called fuzzy inference system. A fuzzy inference system (FIS) consists of four functional blocks[2][4][5].

Fuzzification: Transforms the crisp inputs into degrees of match with linguistic values. Reverse process of defuzzification[1][4].

***Knowledge Base*:** Consists of a rule base and a database. A rule base contains a number of fuzzy if-then rules. A database defines the membership function of the fuzzy sets used in the fuzzy rules[2][3].

Fuzzy Inference Engine: Fuzzy Inference engine performs the inference operations on the rules[4][5].

Defuzzification: This conversion of fuzzy set to single crisp value is called defuzzification[3][6].

There are many reasons to do this. First, Fuzzy is powerful tool to knowledge representation and process human knowledge in form of fuzzy if then rules[4]. Second, Fuzzy techniques can manage the ambiguity efficiently and vagueness[5].

III. Fuzzy Logic Approach

The inference rules is depends on the weights of the eight neighbors gray level pixels, if the neighbors weights are degree of blacks or degree of whites[2][4]. The powerful of these rules is the ability of extract all edges in the processed image directly[3][7]. This study is assaying all the pixels of the processed image by studying the situation of each neighbor of each pixel[2][5].

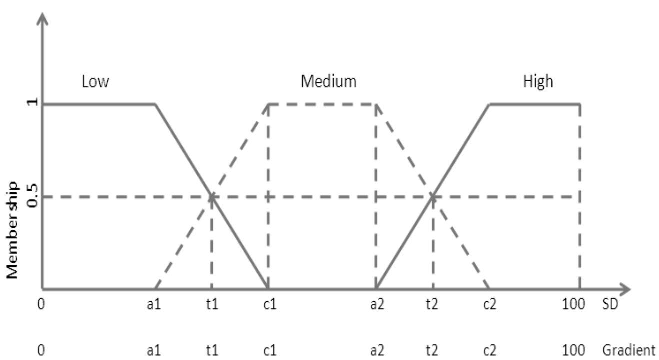


Fig.1. Example for classes and membership functions

Here the value for c-low is 0.25, c-medium is 0.5 and c high is 0.75[3]. Then the final edge pixel will be calculated as

Edgefinal=(sl*gl*cl)+(sl*gm*cl)+(sl*gh*cm)+(sm*gl*cl)+
(s m*gm*cm)+(sm*gh*ch)+(sh*gl*cm)+(sh*gm*ch)
+(sh*g*ch)[2][4][5].

Finally compared to the threshold equal to 0.26, pixel is classified as edge[1].

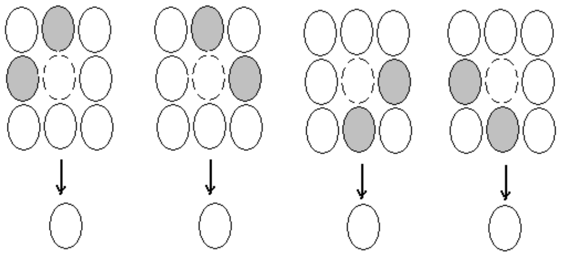


Fig.2. Example for modified Fuzzy System rules

Modified Fuzzy System rules[4]

If {(i, j-1)& (i+1, j)} are blacks
If{(i-1)&(j-1) &(i-1,j) &(i-1,j+1) &(i,j+1)&(i+1,j+1)} are whites
If{(i+1,j+1)} are whites
Checked pixel is white – edge[3];
If {(i, j-1) &(i-1, j)}are blacks
If{(i-1,j+1)&(I,j+1)&(i+1,j+1)&(i+1,j)&(i+1,j-1)} are whites
If {(i-1,j-1)} are whites
Checked pixel is white – edge[3][5];
If {(i-1,j) & (i,j+1)} are blacks
If {(i-1,j-1)&(i,j-1) & (i+1,j-1) &(i+j, j) &(i+1,j+1)} are whites
If {(i-1,j+1)} are whites
Checked pixel is white –edge[3][5];
If{(i,j+1) &(i+1,j)} are blacks
If{(i-1,j-1) &(i-1,j) &(i-1,j+1) &(i,j-1) &(i+1,j-1)} are whites
If{(i+1,j+1)} are whites
Checked pixel is white –edge[4];

The condition of each pixel is decided by using the floating 3x3 mask which can be scanning the all grays[5]. In this location, some of the desired rules are explained[2]. The first four rules are dealing with the vertical and horizontal direction lines gray level values around the checked or centered pixel of the mask, if the grays represented in one line are black and the remains grays are white then the checked pixel is edge[1]. The second four rules are dealing with the eight eight neighbors also depending on the values of the gray level weights, if the weights of the four sequential pixels are degree of blacks and the weights of the remain fours neighbors are the degree of whites, then the center pixel represents the edge[3][4]. The introduced rules and another group of rules are detecting the edges, the white and the black pixels[5]. The result images contribute the contours, the black and the white areas. From the side of the fuzzy construction, the input grays is ranged from 0-255 gray intensity, and according to the desired rules the gray level is converted to the values of the membership functions[3][4]. The output of the FIS according to the defuzzification is presented again to the values from 0- 255 and then the black, white and edge are detected[2][4]. From the experience of the tested images in this study, it is found that the best result to be achieved at the range black from zero to 80 gray values and from 80 to 255 meaning that the weight is white[3][6].

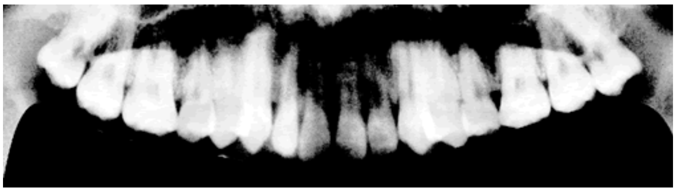


Fig. 3. Example of an unacceptable low-resolution image

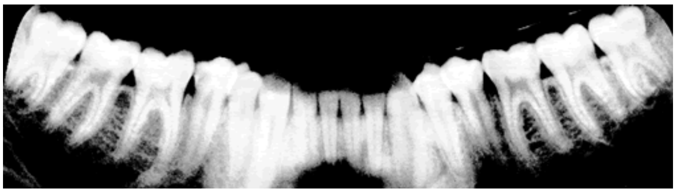


Fig. 4. Example of an image with acceptable resolution

A region usually describes contents, or interior points, which are surrounded by a boundary which is often called the region's contour, or the region's boundary[2][4][5]. The contour form is in generally referred as the object shape. A point can be defined to be on the contour (boundary) if it is part of the region and in the same time there is at least one pixel in its neighborhood that is not part of the region[1]. The boundary itself is usually found by iterative contour following, i.e., based on one first point on the boundary the iterative process is to extract the other boundary points based on the progress in the clockwise direction or anti-clockwise direction[3][6]. The relationships are described by means of connectivity rules[2]. There are two common ways of defining connectivity, 4-way (or 4-neighborhood) where only immediate neighbors are analyzed for connectivity or 8-way (or 8-neighborhood) where all the eight pixels surrounding a chosen pixel are analyzed for connectivity[4]. These two types of connectivity are illustrated in fig. 5[3][5]. In this figure 5, the pixel is shown in light grey and its neighbors in dark grey with arrow marks[2]. In 4-way connectivity a pixel has four neighbors in the directions north, east, south and west, its immediate neighbors[5]. The four extra neighbors in 8-way connectivity, are those in the directions north east, south east, south west and north west, the points at the corners [3][6].

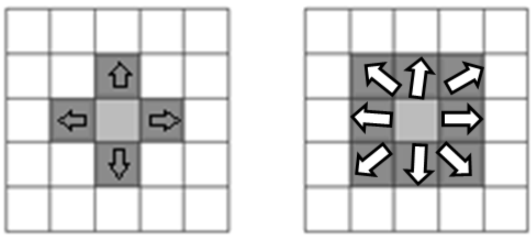
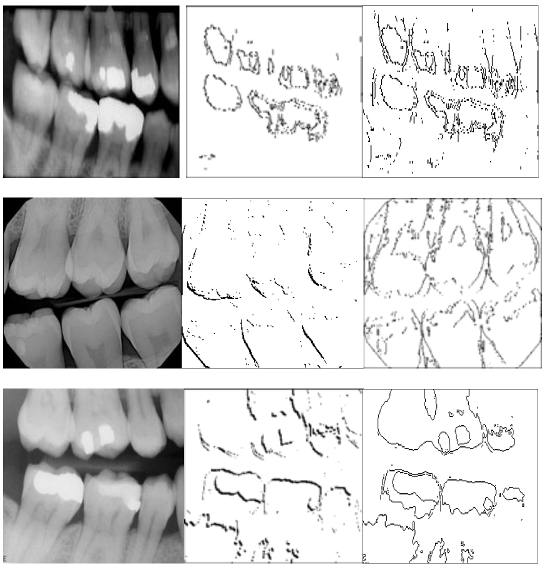


Fig. 5. The main types of connectivity analysis, image extracted[].

There exists a variety of boundary representation algorithm, one of the oldest is the Chain Codes[6]. The basics is the representation of the relative position between consecutive pixels[2][4]. This is perform by the use of the different main types of connectivity as shown in figure 5. But in this case its necessary to define extra rules, consisting in the order of the pixel visits[3][6]. The chain code is formed by concatenating the number that designates the direction of the next pixel[2]. That is, given a pixel the successive direction from one pixel to the next pixel becomes an element in the final code[1]. This is repeated for each point until the start point is reached when the (closed) shape is completely analyzed[5]. But this process is very dependent on the initial point because different starting points originates different chain codes, so the goal is to make this chain code invariant to the initial point[2]. The process consists in actually look to the chain code as an integer, and make the shift position operation[4]. Although our chain code with this step became invariant to the initial point, but it's not invariant to the rotation of the object[1][5].

IV. Experimental Results



(a) (b) (c)

Fig. 6. Dental X-ray image edge detection, (a) original images, (b) using Roberts Technique, (c) using Fuzzy Logic approach.

V. Conclusion

Fuzzy logic represents a good mathematical framework to deal with uncertainty of information. 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.

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