Image Edge Detection using Fuzzy Logic

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Abstract

This paper presents a novel algorithm for the image edge detection using the fuzzy logic approach is proposed. Each different edge detection method has its own advantages and disadvantages. For example each method detects part of real edges and also some unreal edges. The contemporary Fuzzy logic, a key concept of artificial intelligence helps to implement the fuzzy relative pixel value algorithms and helps to find and highlight all the edges associated with an image by checking the relative pixel values and thus provides an algorithm to abridge the concepts of digital image processing and artificial intelligence. A set of fuzzy conditions for the comparison of pixel values with adjacent pixels to check the pixel magnitude gradient in the window. After the testing of fuzzy conditions the appropriate values are allocated to the pixels in the window under testing to provide an image highlighted with all the associated edges. The results of the proposed edge detection algorithm were compared with other techniques and it is found that the image obtained using the proposed approach is qualitatively the best.

Keywords: Edge Detection, Fuzzy Logic, Fuzzy Decision System, Gradient and Standard Deviation, China Insurance Industry, Foreign Fund, Challenge

1. Introduction

DGE detection is one of the most important algorithms in image processing. It plays a fundamental role in higher level processing. Edges potentially have important information about image content. Also in human visual system, in a preprocessing stage, image edges are detected. Regarding to importance of edges in image processing lgorithms, such as object detection, capabilities and accuracy of edge detection algorithms are important factors. Edge is defined as object border, and extracted by features such as gray, color or texture discontinuities. Luminance and geometrical features, lightening condition and noise volume has a great impact on shaping the edge. The Edge contains important information of image and provides object's location. Many of edge detection algorithms such as Sobel, Prewitt and Robert are based on gradient value. In these algorithms, the estimated gradient pixel value higher than a threshold is counted as an edge pixel. Because threshold value is often empirically determined, it is possible to lose some edges or over estimation occurs. Most of the traditional edge detection algorithms in image processing typically convolute a filter operator and the input image, and then map overlapping input image regions to output signals which lead to considerable loss in edge detection. Another important gradient based edge

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detection method is canny algorithm which solves an optimization problem to detect the edges. The tradeoff between detection and location of edge pixels make a problematic inaccuracy. By changing threshold values, edge detection rate increases, but the accuracy of edge locating decrease. Because of noise, low contrast, and some other factor edge detection methods that have been mentioned cannot give satisfactory results. For example in some cases over or under edge based segmentation estimation occurs, especially in natural complex image is more obvious. Many researchers have clearly demonstrated that methods involving Gaussian filtering suffer from problems such as edge displacement, vanishing edges and false edges. Another problem faced by few methods like the anisotropic diffusion lies in obtaining the locations of semantically meaningful edges at coarse scales generated by convoluting images with Gaussian kernels. Methods that involve simple scan line approach are not able to detect all the edges due to limitation of the methodology to trace only the horizontal and vertical neighbors of a point. The different types of methodology have been implemented in various applications like.

- Traffic speed estimation [1]
- Image compression [2] and
- Classification of images [3]

Most of the traditional edge-detection algorithms in image processing typically convolute a filter operator and the input image, and then map overlapping input image regions to output signals which lead to considerable loss in edge detection [4]; however there is no such loss in the fuzzy based method described here. Research has clearly demonstrated that methods involving Gaussian filtering suffer from problems such edge displacement, vanishing edges and false edges [5]. Another problem faced by few methods like the anisotropic diffusion lies in obtaining the locations of semantically meaningful edges at coarse scales generated by convoluting images with Gaussian kernels [6]. Methods that involve simple scan line approach are not able to detect all the edges due to limitation of the methodology to trace only the horizontal and vertical neighbors [7] of a point. The method described does not implement any thresholding unlike few published methods [8] which helps to detect each and every edge associated with the image but introduces fuzzy logic which derives its origin from approximate reasoning for highlighting all the edges associated with an image. The fuzzy relative pixel value algorithm has been developed with the knowledge of vision analysis with low or no illumination [9, 13, 14] thus making this method optimized for application requiring such methods. The method helps us to detect edges in an image in all cases due to subjection of pixel values to an algorithm involving host of fuzzy conditions for edges associated with an image. The purpose of this paper is to present a new methodology for image edge detection which is undoubtedly one of the most important operations related to low level computer vision, in particular within area of feature extraction with plethora of techniques, each based on a new methodology, having been published. The method described here uses a fuzzy based logic model with the help of which high performance is achieved along with simplicity in resulting model [10, 15], [16, 17]. Fuzzy logic helps to deal with problems with imprecise and vague information and thus helps to create a model for image edge detection as presented here [11, 18] displaying the accuracy of fuzzy methods in digital image processing [12, 19]. The proposed fuzzy logic method, which derives its origin from approximate reasoning for highlighting all the edges associated with an image. The fuzzy relative pixel value algorithm has been developed with the knowledge of vision analysis with low or no illumination, thus making this method optimized for application requiring such methods. The method helps us to detect edges in an image in all cases due to subjection of pixel values to an algorithm involving host of fuzzy conditions for edges associated with an image. The purpose of this paper is to present a new methodology for image edge detection which is undoubtedly one of the most important operations related to low level computer vision. The Fuzzy logic helps to deal with problems with imprecise and vague information and thus helps to create a model for image edge detection as presented here displaying the accuracy of fuzzy methods in digital image processing. The paper is organized as follows. A brief literature review about the work presented in this paper along with related work was presented in the previous paragraphs in the introductory section. In section 2, a brief introduction about the fuzzy sets is given. The inference rules are presented next. Further, the concept of fuzzy image processing is presented along with the algo. The conclusions are finally presented in the last section with the simulation results followed by the references.

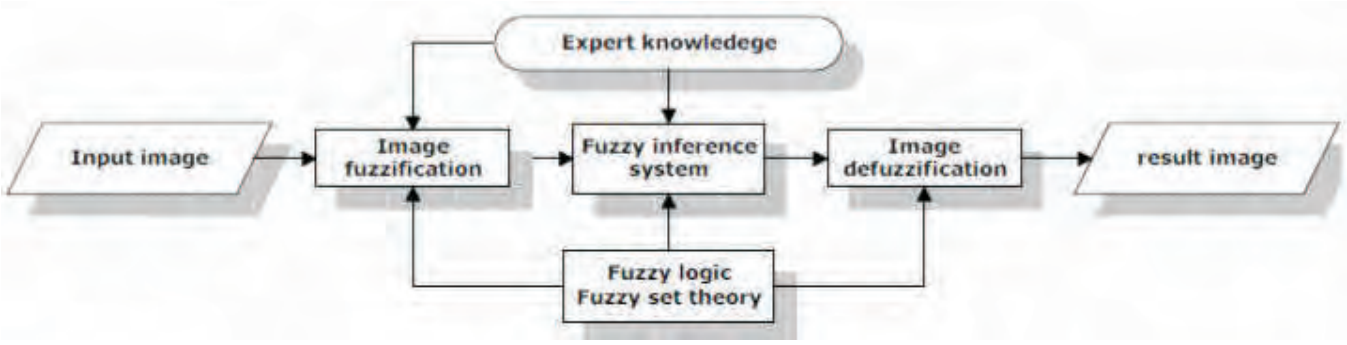

Fig. 1: The general Block diagram of fuzzy image processing

2. Fuzzy Sets in Classical

In classical or crisp set theory, the boundaries of the set are precise, thus membership is determined with complete certainty [12, 19]. An object is either definitely a member of the set or not a member of it. However, in reality most sets and propositions are not so neatly characterized. For example, concepts such as experience, tallness, richness, brightness etc cannot be represented by classical set theory. Fuzzy sets, in turn, are capable to represent imprecise concepts. In Fuzzy sets, the membership is a matter of a degree, i.e., degree of membership of an object in a fuzzy set expresses the degree of compatibility of the object with the concept represented by the fuzzy set. Each fuzzy set, A is defined in terms of a relevant universal set X by a membership function. Membership function assigns each element x of X a number, A(x), in the closed unit interval (0, 1) that characterizes the degree of membership of x in A. In defining a membership function, the universal set X is always assumed to be a classical set.

3. Fuzzy Image Processing

Fuzzy image processing has three main stages, image fuzzification, modification of membership values and finally image defuzzification. The fuzzification and defuzzification steps are coding of image data (fuzzification) and decoding of the results (defuzzification). These steps make possible to process images with fuzzy technique. 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 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 [12, 19]. 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 membership function. The values of the three membership function of the output are designed to separate the values of the blacks, whites and edges of the image.

4. Inference Rules Definitions

The inference rules is depends on the weights of the eight neighbors gray level pixels, if the neighbor's weights are degree of blacks or degree of whites. The powerful of these rules is the ability of extract all edges in the processed image directly [12, 19]. This study is assaying all the pixels of the processed image by studying the situation of each neighbor of each pixel. The condition of each pixel is decided by using the floating 3x3 mask which can be scanning the all grays. In this location, some of the desired rules are explained. 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. The second four rules are dealing with the 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. The introduced rules and another group of rules are detecting the edges, the white and the black pixels.

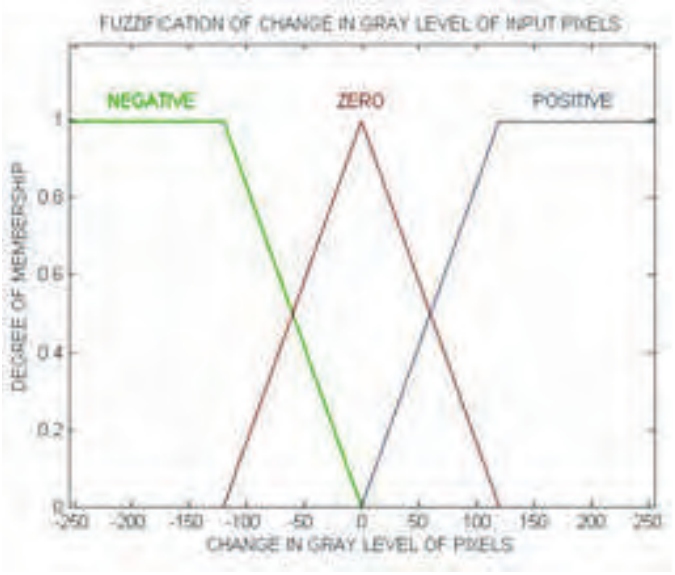

Fig. 2: Fuzzification of change in the gray level of input levels

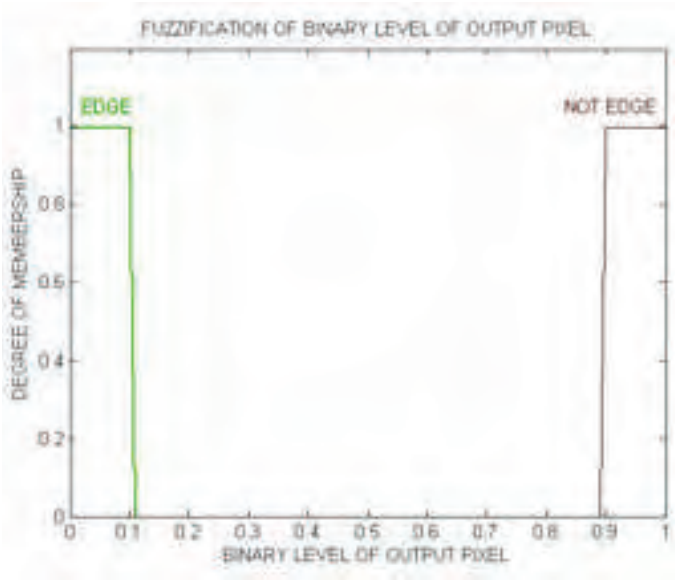

Fig. 3: Fuzzification of binary level of output levels

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. The output of the FIS according to the defuzzification is presented again to the values from 0- 25 & then the black, white and edge are detected.


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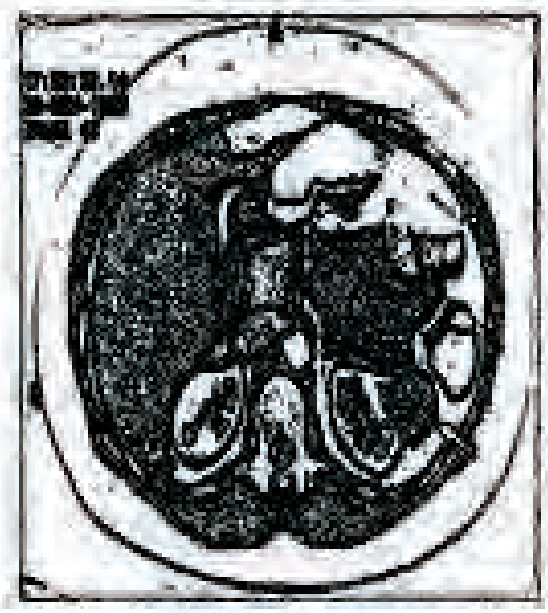

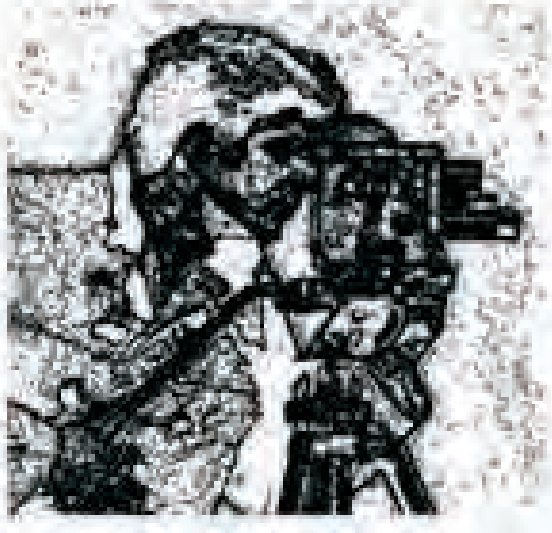

Fig. 4: Simulation results

5. Conclusion

In this paper, novel algorithms designed specifically for image processing using the fuzzy logic approach have been explored. All image information with filtering and edge detection can be represented by linguistic statements in natural language and the processing is performed by very practical and powerful fuzzy approximate reasoning. The processing performance relies on the fuzzy inference engine which has been demonstrated to be able to give better results than the traditional approaches.

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