Fuzzy Logic Based Image Edge Detection Algorithm in MATLAB

Musbah Ali Alhanis
Higher Institute of Science & Technology
Alkums – Libya
musbhsali@gmail.com

Hesham Ahmed Almgarbj
Higher Institute of Science & Technology
Alkums – Libya
hhhgarbigee38@gmail.com

Abstract:

This paper presents a new fuzzy based edge detection algorithm. 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. To reduce this effect we have used two different source of information and a fuzzy system to decide about whether each pixel is edge or not.

First both gradient and standard deviation values are computed, form two set of edges, utilized as inputs for our fuzzy system. Then fuzzy system decides on each pixel according to fuzzy rules. Finally we have compared results of the proposed algorithm with other algorithms such as Sobel, Robert, and Prewitt. Experimental results show the ability and high performance of proposed algorithm.

Introduction:

Images have always been very important in human life. Soft Computing is an emerging field that consists of major seminal theories which include fuzzy logic, genetic algorithms, evolutionary computation, and neural networks In the last few years there is an increasing interest on using soft computing (SC) techniques to solve image processing real-world problems covering a wide range of domains. Edge detection refers to the process of identifying and locating sharp discontinuities in an image. The discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a scene**.** Edge detection i is usually done with a first and/or second derivative measurement following by a comparison with threshold which marks the pixel as either belonging to an edge or not. The result is a binary image which contains only the detected edge pixels. Usage of specific linear time-invariant (LTI) filter is the most common procedure applied to the edge detection problem, and the one which results in the least computational effort. In the case of first-order filters, an edge is interpreted as an abrupt variation in gray level between two neighbor pixels. 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 Recent research has concerned using neural Fuzzy Feature to develop edge detectors, after training on a relatively small set of proto-type edges, in sample images classifiable by Classic edge detectors. This work was pioneered by Bezdek et. al, who trained a neural net to give the same fuzzy output as a normalized Sobel Operator.

In the system described in, all inputs to the fuzzy inference systems (FIS) system are obtained by applying to the original image a high-pass filter, a first-order edge detector filter (Sobel operator) and a low-pass (mean) filter. The whole structure is then tuned to function as a contrast enhancing filter and, in another problem, to segment images in a specified number of input classes. The adopted fuzzy rules and the fuzzy membership functions are specified according to the kind of filtering to be executed. The work of this paper is concerned with the development of a Fuzzy logic rules based algorithm for the detection of image edges. By

scanning the images using floating 3x3 pixel window mask .Fuzzy Inference based system in MATLAB Environment has been developed, which is capable of detecting edges of an image. The rule-base of 28 rules has been designed to mark the pixel under consideration as Black, White or Edge. The result has been compared with the standard algorithms.

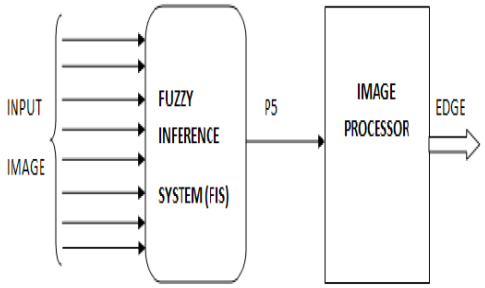

Figure 1. Basic Block Diagram

P1	P2	P2
P4	P5	P6
P7	P6	P9

Figure 2. Floating 3x3 pixel window mask

Fuzzy Logic Application In Edge Detection:

Considering the capability of neural network and fuzzy logic based processing, in recent years, many researches have been done on their application at image processing and as a result edge detection algorithm.

Different algorithms for fuzzy based edge detection have been proposed. In the work proposed by Zhao, et al, image is segmented by a three level threshold. By applying the two different ways between probability region and three fuzzy regions and also minimum entropy rule, a technique to determine the parameters of best three fuzzy regions is proposed. The necessary condition for maximizing entropy function is also expressed. Based on this condition an effective algorithm for three level thresholding is obtained. Fuzzy based rules method in most of fuzzy based edge detection algorithms are used. In most of these methods, adjacent points of pixels are assumed in some classes and then fuzzy system inference are implemented using appropriate membership function, defined for each class.

For example in, adjacent points are assumed as 3×3 sets around the concerned point. By predefining membership function to detect edges. In these rules discontinuity in the color of different 3×3 sets, edges are extracted. It uses 5 fuzzy rules and predefined membership function to detect edges. In these rules discontinuity of adjacent point around the concerned point are investigated. If this difference is similar to one of predefined sets, the pixel is assumed as edge.

A similar work is proposed by Mansoori, et al. In this work adjacent points of each pixel, are grouped in six different set. Then by using of appropriate bell shape membership

function, the value from zero to one is determined for each group. Based on the membership values, and fuzzy rules, decision about existing/not existing and direction of edge pixels are obtained.

Proposed Algorithm:

Primary Edge Detection and Fuzzy Rules In this paper, at first by two different methods, gradient and standard deviation of pixels value, edges are separately extracted and then based on fuzzy logic, final decision about whether each pixel is edge or not is made. Problematic results could be gained if each of the methods be used solely. It may causes on identifying of edge pixels as non edge pixels and vice versa. Although different methods have been used for edge detection, many of them are gradient based. Therefore in the first method, the gradient values are computed by the Sobel operator and then pixels with gradient value bigger than a threshold are edge candidate. The second used method for edge detection is based on gray level standard deviation (SD). In this method, for each pixel SD is computed by 3×3 mask, shown in Fig. 2, over adjacent neighborhood pixels. Similarly pixels with SD grater than a threshold value are edge candidate.

Applied mask to compute standard deviation By considering two mentioned methods and a fuzzy idea, two computed values are used as fuzzy system inputs. The final decision about edge candidate pixels is based on the output of this fuzzy system. Appropriate membership functions are defined for fuzzy system inputs. To apply these functions, first both SD and gradient values are mapped to the range of [0 100]. Then both of the mapped values are classified to one of the low, medium, or high classes. The SD classes are shown by SD L , SD M , and SD H symbols. To separate different SD

Fuzzy Inputs				Fuzzy Output
P1	P2	P3	P4	P4_out
B	B	B	B	B
B	B	B	W	E
B	B	W	B	E
B	B	W	W	E
B	W	B	B	E
B	W	B	W	E
B	W	W	B	E
B	W	W	W	W
W	B	B	B	E
W	B	B	W	E
W	B	W	B	E
W	B	W	W	E
W	W	B	B	E
W	W	B	W	E
W	W	W	B	E
W	W	W	W	W

Figure 3. Fuzzy sets & Rule Base

classes four different thresholds a 1 , c 1 , a 2 , and c 2 are used. So that if SD value is in the range of [0 c 1], then, the corresponding pixel is classified to SD L , for the range of [a 1 c 2], the pixel is classified to SD M, and finally for the range of [a 2 100], pixel is classified to SD H . The similar function and classes are defined for gradient value. In Fig 2 the defined classes and membership functions are shown.

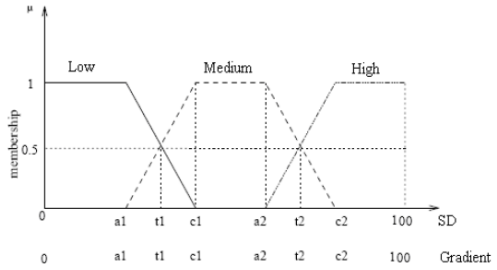

Figure 4. The defined classes & membership functions

The defined classes and membership functions The output of fuzzy system explains to how extent a pixel could be edge. By the defined fuzzy rules, the output of this fuzzy system is classified to one of three classes. The first class, E L , correspond to pixels with low probability value to belong to edge pixels set. In the same way, E M corresponds to medium probability and E H corresponds to high probability.

Output membership functions If SD value of a pixel being equal to k 1 , and gradient be equal to k 2 , the fuzzy rules are defined as the following: 1- If k 1 in SD L and k 2 in G L then P Edge classified to E L 2- If k 1 in SD L and k 2 in G M then P Edge classified to E L 3- If k 1 in SD L and k 2 in G H then P Edge classified to E M 4- If k 1 in SD M and k 2 in G L then P Edge classified to E L 5- If k 1 in SD M and k 2 in G M then P Edge classified to E M 6- If k 1 in SD M and k 2 in G H then P Edge classified to E H 7- If k 1 in SD H and k 2 in G L then P Edge classified to E M 8- If k 1 in SD H and k 2 in G M then P Edge classified to E H 9- If k 1 in SD H and k 2 in G H then P Edge classified to E H. These rules are summarized in Figure 4.

Grad / SD	Low	Medium	High
Low	E_L	E_L	E_M
Medium	E_L	E_M	E_H
High	E_M	E_H	E_H

Figure 5. Fuzzy system rules

Simulation Results:

GUI designed for this application is shown in Figure. 6. & Figure. 7. Any of the standard edge detection algorithms (Sobel, Canny, Prewit & Roberts) can be selected for comparison from the List Box on GUI. Threshold level setting is done through the slider control of GUI. More the value of the slider, more of the edges will be traced, however, noise will also be increased. The developed fuzzy algorithm for image edge detection was tested for various images and the outputs were compared to 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 the standard existing. The sample output shown below in

Fig. compares the "Sobel" Edge detection algorithm and our fuzzy edge detection algorithm. 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 "Sobel" edge detection algorithm. Thus the Fuzzy rule based algorithm provides better edge detection and has an exhaustive set of fuzzy conditions which helps to extract the edges with a very high efficiency.

Figure 6.a. Original Image

Figure 6.b. Edge detection using Fuzzy logic

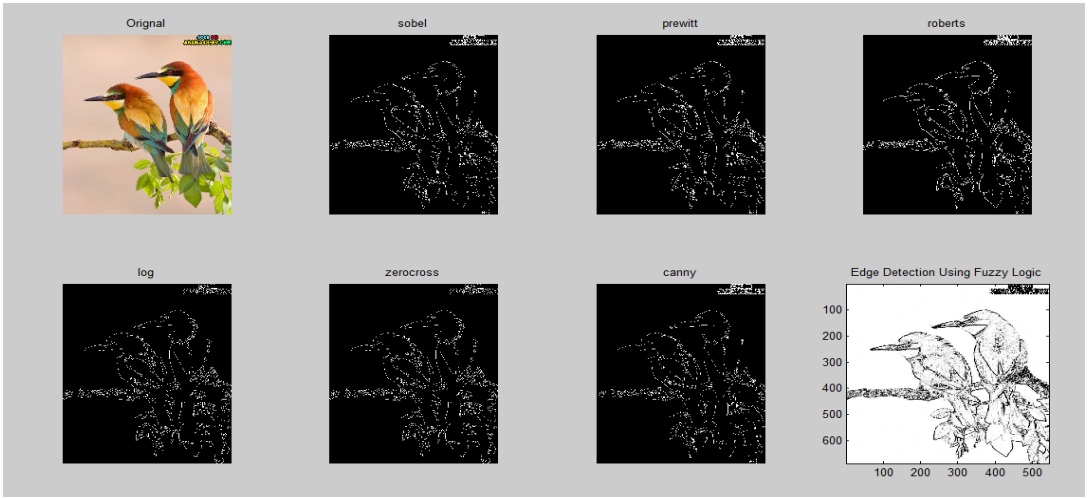

Figure 7. Comparison between standard edge detection algorithms & Fuzzy logic algorithm

Conclusions:

In this paper, emphasis has been to develop a very simple & small but a very efficient, fuzzy rule based edge detection algorithm to abridge the concepts of artificial intelligence and digital image processing. The algorithm and associated GUI has been developed in MATLAB environment. Comparisons were made with the various other edge detection algorithms that have already been developed. Displayed results have shown the accuracy of the edge detection using the fuzzy rule based algorithm over the other algorithms. The fuzzy rule based algorithm has been successful in obtaining the edges that are present in an image after the its implementation and execution with various sets of images. Sample outputs have been shown to make the readers understand the accuracy of the algorithm. Thus developed algorithm exhibits tremendous scope of application in various areas of digital image processing.

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