Edge Detection Technique Based on Fuzzy Logic

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***Abstract* —An edge is sharp change in intensity of an image. Now, since the overall goal is to locate edges in the real world via an image, the term edge detection is commonly used. If the edges in an image are identified accurately, all the objects are located and their basic properties such as area, perimeter and shape can be measured. Therefore edges are used for boundary estimation and segmentation in the scene. Uncertainty of image processing is handeled within the frame work of fuzzy logic.**

In this paper a novel method based on fuzzy logic reasoning strategy is proposed for edge detection in digital images without determining the threshold value. The proposed approach begins by segmenting the images into regions using floating 2x2 mask. The edge pixels are mapped to a range of values distinct from each other.

***Keywords:* Image Processing, Edge detection, Fuzzy Logic.**

I. INTRODUCTION

Modern time is an era of technology in which we now believe in the vision based intelligence. Penetration of computers into each area of the market and living has forced the designers to add the capability to see and analyze and to innovate more and more into the area of electronic vision or image processing. At the level of computational intelligence for electronic vision, many of the algorithms have been developed to extract different types of features from the image such as edges, segments and lot many other types of image features.

Edge detection is a terminology in electronic vision, particularly in the areas of feature extraction, to refer to algorithms which aim at identifying points in a digital image at which the image brightness changes sharply or more formally has discontinuities. The goal of edge detection is to locate the pixels in the image that correspond to the edges of the objects seen in the image. This 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. The purpose of detecting sharp changes in image brightness is to capture important events and changes in properties of the world. Discontinuities in image brightness are likely to correspond to discontinuities in depth, discontinuities in surface orientation, and changes in material properties or variations in scene illumination.

Shashank Mathur and Anil Ahlawat, presented a fuzzy relative pixel value algorithm for edge detection by checking the relative pixel values in 3*3 pixels mask for scanning of image using the windowing technique, which is subjected to a set of fuzzy conditions for the comparison of pixel values with adjacent pixels to check the pixel magnitude gradient in the window. However their technique was not rule based [2]. Yinghua Li et. al. [3] presented Fuzzy technology as a newly rising technology used in many fields, especially in the image domain[3]. Yasar Becerikli1 and Tayfun of Kocaeli University,Computer Engineering Department, Izmit, Turkey proposed that an edge detection is one of the most important tasks in image processing. They studied that image segmentation; registration and identification are based on edge detection. They proposed that fuzzy rules based algorithm is more flexible in handling thickness of edges in the final image [4].

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 [7-11]. Recently there has been much revived interest in feature points determined by "corner" operators such as the Plessey, and interesting point operators such as that introduced by Moravec. Classical operators identify a pixel as a particular class of feature point by carrying out some series of operations within a window centred on the pixel under scrutiny. The classic operators work well in circumstances where the area of the image under study is of high contrast. In fact, classic operators work very well within regions of an image that can be simply converted into a binary image by simple thresholding.

Recent research has concerned Fuzzy Logic to develop edge detectors. The work of this paper is concerned with the development of a fuzzy logic rules based algorithm for the detection of image edges. Scanning mask used is smallest possible i.e. 2*2 pixels window. Fuzzy Inference based system in MATLAB environment has been developed, which is capable of detecting edges of an image. The rule-base of 16 rules has been designed to mark the pixel under consideration as Black, White or Edge. The noise removal algorithm has been implemented at intermediate and final levels of processing. The result has been compared with the standard algorithms.

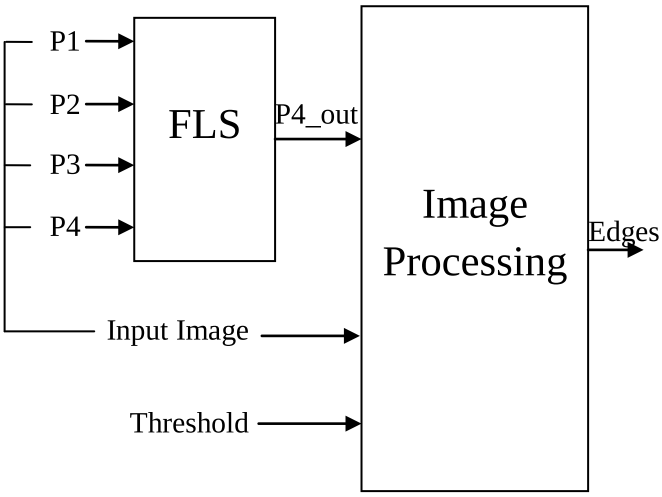

Fig. 1. Basic Block Diagram

II. Fuzzy Inference System

The Fuzzy Logic tool was introduced in 1965, also by Lotfi Zadeh, and is a mathematical tool for dealing with uncertainty. It offers to a soft computing partnership the important concept of computing with words'. It provides a technique to deal with imprecision and information granularity. The fuzzy theory provides a mechanism for representing linguistic constructs such as "many," "low," "medium," "often," "few." In general, the fuzzy logic provides an inference structure that enables appropriate human reasoning capabilities.

On the contrary, the traditional binary set theory describes crisp events, events that either do or do not occur. It uses probability theory to explain if an event will occur, measuring the chance with which a given event is expected to occur. The theory of fuzzy logic is based upon the notion of relative graded membership and so are the functions of mentation and cognitive processes. The utility of fuzzy sets lies in their ability to model uncertain or ambiguous data, Fig. 2, so often encountered in real life.

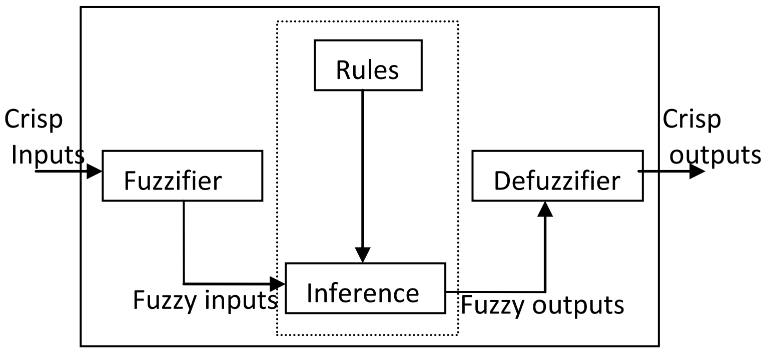

Fig. 2. Fuzzy Logic System

In this paper, the designed fuzzy inference system is given four inputs and one output. The four inputs are the four pixel values of the window mask used. The triangular membership functions are used both for the inputs and the output. Two fuzzy sets are used for the input Black and White and three fuzzy sets are used for the output. Fuzzy sets for input and output variables are designed as shown in the table below:

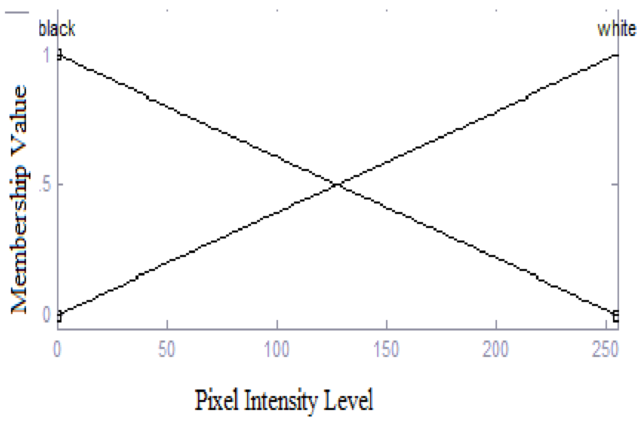

Fig. 3. Fuzzy Sets of Input Pixels (P1-P4)

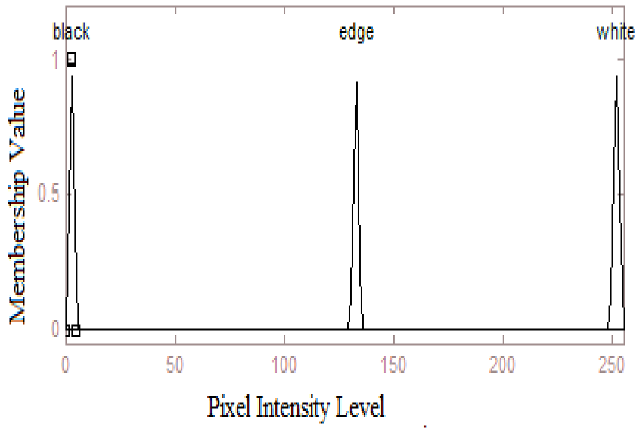

Fig. 4. Fuzzy Sets of output pixel P4_out

Table I and Table II show the fuzzy sets for I/O variables and fuzzy rule matrix respectively. A rule base of 16 rules is set for the various fuzzy conditions that can occur. Singe output describes whether the output pixel i.e. P4 belongs to White fuzzy set, Black fuzzy set or Edge fuzzy set. Rules are enlisted in the form of a matrix in Table. II

TABLE I

FUZZY SETS FOR I/O VARIABLES

Fuzzy input no. 1, Pixel P1		
Name	**Range**	**MF Type**
Black	[0 0 255]	Triangular
White	[0 255 255]	Triangular
Fuzzy input no. 2, Pixel P2		
Black	[0 0 255]	Triangular
White	[0 255 255]	Triangular
Fuzzy input no. 3, Pixel P3		
Black	[0 0 255]	Triangular
White	[0 255 255]	Triangular
Fuzzy input no. 4, Pixel P4		
Black	[0 0 255]	Triangular
White	[0 255 255]	Triangular
Fuzzy output no. 1, Pixel P4_out		
Black	[0 3 5]	Triangular
Edge	[130 133 135]	Triangular
White	[249 252 255]	Triangular

TABLE II

FUZZY RULE BASE

Fuzzy Inputs				**Fuzzy Outputs**
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

III EXPERIMENTS

The algorithm is based on the subjection of a set of four pixels, part of a 2×2 window of an image to a set of fuzzy conditions which help to highlight all the edges that are associated with an image. . The fuzzy conditions help to test the relative values of pixels which can be present in case of presence on an edge. So the relative pixel values are instrumental in extracting all the edges associated to an image. The image is said to have an edge if the intensity variation in between the adjacent pixels is large. This task is accomplished with the help of sixteen rules. Result of this proposed method is then designed in order to compare the results with the existing techniques. The mask used for scanning image is shown below and an example is shown when P1, P2, P3, are white and P4 is Black then output is Black.

P1	P2
P3	P4

Fig. 5. 2×2 mask used for scanning

The mask is slid over an area of the input image, changes that P4 pixel's value and then shifts one pixel to the right and continues to the right until it reaches the end of a row. It then starts at the beginning of the next row and process continues till the whole image is scanned. When this mask is made to slid over the image, the output is generated by the fuzzy inference system based upon the rules and the value of the pixels P1, P2, P3 and P4.

IV RESULTS

The proposed system was tested with different images, its performance being compared to that of the Sobel operator in MATLAB environment. The firing order associated with each fuzzy rule were tuned to obtain good results while extracting edges of the image where we used this image as comparative model for the classical Sobel operator and the FIS method. Results of different images are shown below. Fig. (a) shows the original image in grayscale form. Fig. (b) shows the edges using the classical Sobel operator and Fig. (c) shows the output of our designed FIS.

From Fig. (b) and Fig. (c), it is 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. For example, in Fig. 8, FIS output has lesser edges as compared to the Sobel operator output. Observe the original image, it has a sharp transition from high intensity level to low intensity level (i.e from black to gray) in the lower area of the image. The Sobel operator output does not show that distinct image in the lower area. But FIS ouput shows all the distinct images. 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.

Fig. 6(a). Original image

Fig. 6(b). Edges using Sobel operator

Fig. 6(c). Edges using FIS

Fig. 7(a). Original image

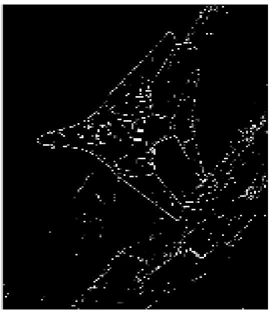

Fig. 7(b). Edges using Sobel operator

Fig. 7(c). Edges using FIS

Fig. 8(a). Original image

Fig. 8(b). Edges using Sobel operator

Fig. 8(c). Edges using FIS

V Conclusion

In this paper, emphasis has been to develop a very simple and small but a very efficient, fuzzy rule based edge detection algorithm to abridge the concepts of artificial intelligence and digital image processing. We have used the smallest possible mask 2×2.The algorithm 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.

VI Future Work

a) In our technique, the image is first to be converted into gray image. This limitation can be eliminated and algorithm can be applied directly to color images, and the detection would then become significantly more complex.
b) Further the size of mask can be increased from 2x2 to 3x3 or 4x4 and accordingly more rules can be set and results can be compared w.r.t. mask size.
c) In our method, we have used Mamdani Fuzzy Inference System. But we can also use Sugeno FIS and compare both the results

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