Modified Edge Detection Technique using Fuzzy Inference System

Shaveta Arora
School of Engineering & Technology
EECE Department
ITM University,Gurgaon

Amanpreet Kaur
School of Engineering & Technology
EECE Department
ITM University,Gurgaon

ABSTRACT
Edge detection of real world images is a challenging task. To extract the edges from the images, derivative edge detection operators or gradient operator, such as Sobel operator, Prewitt operator, Roberts operator, and Laplacian operators ,Canny operators are commonly used for which 3x3 mask is used. Different approaches have been used earlier for detecting edges that have some advantages and disadvantages like false edges are detected, some important edges are missed noise around the corners etc. So, in order to reduce these types of effects; special fuzzy inference system are used and the output of fuzzy system will decide whether that particular pixel is a part of edge or not. This paper presents a new edge detection algorithm based on fuzzy inference system. Fuzzy Image Processing is applied in combination with traditional operators used so far. Then fuzzy system will decide for each pixel using different sets of fuzzy rules.

Keywords
Edge Detection, Fuzzy Logic, Fuzzy inference system.

1. INTRODUCTION
Edge is defined as object border, and extracted by features such as gray, color or texture discontinuities [1]. Edge detection is a very important tool widely used in many computer vision and image processing applications. It plays a fundamental role in higher level processing [4]. It provides very useful information for segmentation, registration, and identification of objects in a scene. Most information in an image resides along edges. Therefore, it makes sense to select the features used in image registration along edges. Edges are marked with discontinuities or considerable variations in intensity or gray levels [3]. In general, the following goals must be considered during the process of detecting edges [3]:

1. The edges must be detected carefully. An edge should not be missed or non-edges should not be marked as edges.
2. The edges should be located at the correct positions.

Edge detection can be considered a preprocessing operation that narrows down the search in feature detection and feature correspondence. Over the years, several methods have been proposed for the image edge detection for which different type of methodology have been implemented in various applications like traffic speed estimation, image compression and classification of images. In gradient-based edge detection methods, such as Sobel [2, 7], Prewitt [5, 6], and Roberts [6], a gradient threshold level must be determined, above which a pixel is classified as an edge pixel. The choice of the gradient threshold level depends on the experience or trial-and-error iterations until the best result is obtained. If the selected gradient threshold is not optimal then some of the significant discontinuities may not be detected [3]. Gradient-based edge detectors have a major drawback of being very sensitive to noise. In order to counter noise problems Canny proposed an approach to edge detection in which the image is convolved with the first order derivatives of Gaussian filter for smoothing in the local gradient direction followed by edge detection and thresholding. Russo adopted fuzzy reasoning for edge detection without being deceived by impulsive noise. The results were better than that of both Prewitt and Sobel methods, especially in the presence of noise. Fuzzy logic based signal processing techniques are now used efficiently in many fields of communications, coding and signal processing. Recent examples include edge detectors using fuzzy logic, neural networks or wavelets. Several approaches on fuzzy logic based edge detection have been reported based on fuzzy If-Then rules [23], [24]. 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 [25]. In this paper, fuzzy logic approach is proposed to be applied over different edge detection techniques in digital images.

2. EDGE DETECTION TECHNIQUES
2.1 Sobel Operators
The computation of the partial derivation in gradient may be approximated in digital images by using the Sobel operators which are shown in the masks below:

−1	−2	−1
0	0	0
1	2	1

−1	0	1
−2	0	2
−1	0	1

Fig 1: Sobel Operator

These two masks together with any of the equations are used to obtain the gradient

$$|\nabla f| = \sqrt{G_x^2 + G_y^2}$$

$$|\nabla f| = |G_x| + |G_y|$$

magnitude of the image from the original.

2.2 Roberts Cross Edge Detector
The Roberts Cross operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. It thus highlights regions of high spatial frequency which often correspond to edges. In its most common usage, the input to the operator is a grayscale image, as is the output. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point.

−1	0
0	1

0	−1
1	0

Fig 2: Roberts Cross Operator

2.3 Laplacian Operator

Marr and Hildreth [11] have proposed the Laplacian of Gaussian (LoG) edge detection operator in which Gaussian-shaped smoothing is performed prior to application of the Laplacian. The continuous domain LoG gradient is

$$G(x,y) = -\ \nabla^2 \{F(x,y) \otimes H_X(x,y)\}$$

Where

$$H_S(x,y) = g(x,s)g(y,s)$$

is the impulse response of the Gaussian smoothing function as defined by

$$g(x,s) = \left[2\pi s^2\right]^{-1/2} \exp\{-1/2(x/s^2)\}$$

where s is standard deviation.

As a result of the linearity of the second derivative operation and of the linearity of convolution, it is possible to express the LoG response as

$$G(x,y) = F(x,y) \otimes H(x,y)$$

Where

$$H(x,y) = -\nabla^2\{g(x,s)\}g(y,s)$$

Upon differentiation one obtains

$$H(x,y) = \frac{1}{\pi s^4} g(x,s)\left[1 - \frac{x^2+y^2}{2s^2}\right]\exp\left\{-\frac{x^2+y^2}{2s^2}\right\}$$

This function is commonly referred to as the Laplacian of a Gaussian (LoG). The Laplacian is usually used to establish whether a pixel is on the dark or light side of an edge.

2.4 Prewitt Operator

The prewitt operator uses the same equations as the Sobel operator, except that the constant c = 1. Therefore: Note that unlike the Sobel operator, this operator does not place any emphasis on pixels that are closer to the centre of the masks.

The Prewitt operator measures two components. The vertical edge component is calculated with kernel Gx and the horizontal edge component is calculated with kernel Gy. |Gx| + |Gy| give an indication of the intensity of the gradient in the current pixel.

−1	0	1
−1	0	1
−1	0	1

−1	−1	−1
0	0	0
1	1	1

Fig 3: Prewitt Operator

2.5 Canny Edge Detection Operator

The Canny edge detection operator was developed by John F. Canny [12] in 1986 and uses a multi-stage algorithm to detect a wide range of edges in images. Canny technique is very important method to find edges by isolating noise from the image before find edges of image, without affecting the features of the edges in the image and then applying the tendency to find the edges and the critical value for threshold. The algorithmic steps for canny edge detection technique are follows:

1. Convolve image with a Gaussian function to get smooth image .

2. Apply first difference gradient operator to compute edge strength then edge magnitude and direction are obtain as before.

3. Apply non-maximal or critical suppression to the Gradient magnitude.

4. Apply threshold to the non-maximal suppression image.

3. FUZZY IMAGE PROCESSING

Fuzzy image processing is a combination of fuzzy approach to image processing. Nevertheless, the following definition can be regarded as an attempt to determine the boundaries. It 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. Fuzzy image processing has three main stages: image fuzzification, modification of membership values and image defuzzification. The fuzzification [10] and defuzzification steps are due to the fact that we do not possess fuzzy hardware. Therefore, the coding of image data (fuzzification) and decoding of the results (defuzzification) are steps that make possible to process images with fuzzy techniques. 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. This can be a fuzzy clustering, a fuzzy rule-based approach, a fuzzy integration approach and so on.

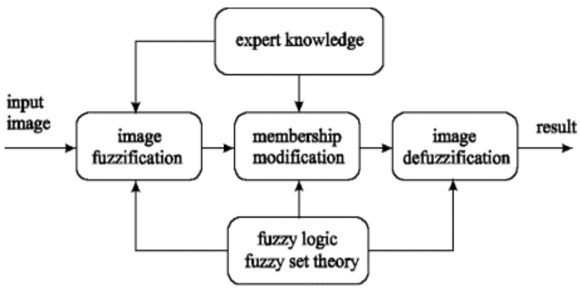

Fig 4: General Structure of Fuzzy Image Processing [9]

In order to compute the output of a given FIS from the inputs, these five steps should be done:

• Fuzzifying Inputs: The first step is determining the degree of membership of each input using membership functions.

• Applying Fuzzy Operators: After inputs have been fuzzified, if the antecedent of a rule has more than one part, the fuzzy operator is applied to obtain the result. The result will then be given to the output function. So the input is two or more membership values from fuzzified inputs and the output is a truth value.

• Applying Implication Method: Implication method is the process of determining the output of each fuzzy rule's consequent. Before applying the implication method, we must take care of the rule's weight which is a number between 0 and 1. Generally this weight is 1 and so it has no effect on the implication process. The input of implication is a single number given by the antecedent, and the output is a fuzzy set.

• Aggregating All Outputs: At this stage, all fuzzy sets that represent the outputs of each rule, are combined into a single fuzzy set. The input is output functions returned by the implication process of each rule and the output is one fuzzy set for each output variable. There are different methods to apply the aggregation such as maximum, probabilistic or, and sum.

• Defuzzifying: Although fuzziness helps during the previous steps, the desired final output is a single number. To do so the output fuzzy set of aggregation process must be converted into a single number. The most common method is the centroid calculation.

4. PROPOSED FUZZY INFERENCE SYSTEM

In this paper we have proposed a new FIS approach over traditional Edge detection Techniques for detecting the edges in digital images without determining the threshold value. This approach begins by segmenting the images into regions using floating 3x3 binary matrixes. A direct fuzzy inference system mapped a range of values distinct from each other in the floating matrix to detect the edge. For this fuzzy image processing is superimposed over most of the traditional edge-detection algorithms in image processing.

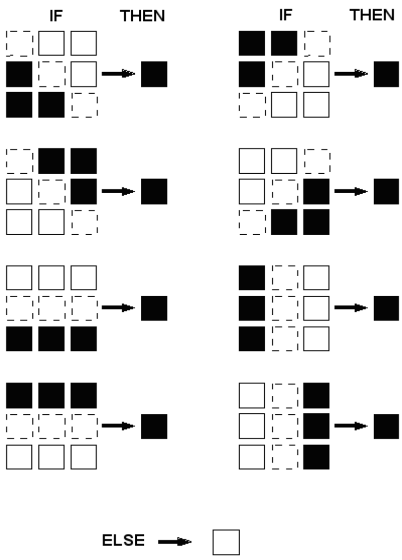

Fig 5: If-Then else rules [9]

4.1 Methodology

•Load the original image and convert it to gray levels. Refer fig 6(a) and (b).

•Apply the following edge detectors using MatLab on the above image

i. Sobel edge detector (fig 6(c))

ii. Canny edge detector (fig 6(d))

iii. Prewitt edge detector (fig 6(e))

iv. Roberts edge detector (fig 6(f))

v. Laplacian of Gaussian edge detector (fig 6(g))

vi. Zero cross edge detector (fig 7(h))

•Apply Fuzzy Inference system to all the techniques.

5. EXPERIMENTS

Firstly, the proposed fuzzy edge detection method is simulated using MATLAB on different images. The original image and the resultant images obtained after applying conventional operators is shown in figure 6.(a)-6.(h). The sample schematic of the proposed fuzzy inference system shown in figure. 7. The fuzzy sets characterized by three triangular membership functions associated to linguistic variable "Low", "Medium" and "High" were created to represent each of the edge strengths. Sequence of eight rules fired for detecting the output as edge pixel. The mamdani inference system using centroid defuzzification method is applied.

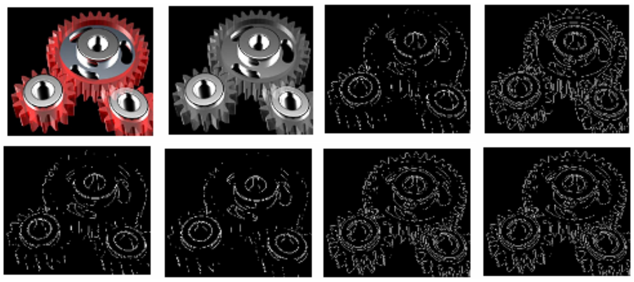

Fig 6.(a) Original Image, (b) Gray Scale Image, (c) Sobel, (d) Canny, (e) Prewitt, (f)Robert, (g) Laplacian, (h) Zero Cross

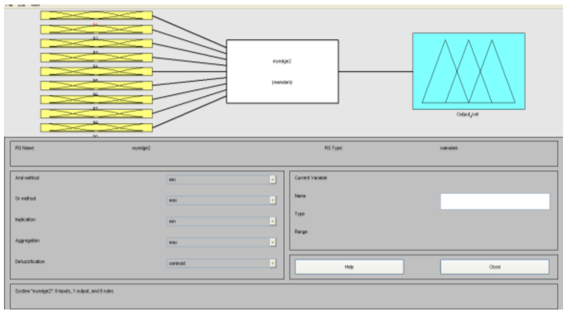

Fig 7: Proposed Fuzzy Inference System

6. CONCLUSION

Fuzzy image processing is a powerful tool to get expert knowledge and the combination of imprecise information from different sources. In this paper we proposed a new technique for edge detection using traditional operators in combination with fuzzy logic. The applications of designed fuzzy rules over the resultant image after applying operator as shown are an attractive solution to improve the quality of edges as much as possible. The approach is easy for implementation and the application of rules is very simple.

The proposed Modified Fuzzy technique will overcome the drawbacks of conventional techniques. Throughout the paper, our analysis has mainly relied on subjective evaluation; however, rigorous objective procedure of evaluation would be pursued in future work.

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