ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology
Vol. 2, Issue 7, July 2015

Fuzzy Logic Based Edge Detection in Color Images

Nikitha B S[1], Myna A N[2]

Student, M. Tech (Software Engineering), Dept of Information Science & Engg, M S Ramaiah Institute of Technology (Autonomous Institute Affiliated to VTU) Karnataka, India[1]

Assistant Professor, Department of ISE, M S Ramaiah Institute of Technology, Karnataka, India[2]

Abstract: Edge detection plays an important role in image processing, pattern recognition and in computer vision applications. The amount of data to be processed is reduced in image edge detection while preserving important structural properties in an image. Various edge detection operators such as Sobel operator, Prewitt operator, Robert operator has been proposed in the literature for extracting the edges from the grayscale image. Only 90% of edge information in a color image can be found in the corresponding grayscale image. It implies that 10% of the edges are left over in grayscale images. Since color images give more information than grayscale images, this 10% left over edges may be extracted from color images.

In the proposed algorithm, edge at each pixel of an image is calculated using fuzzy rules around 3 * 3 spatial masks. Fuzzy inference system designed has 8 inputs, which corresponds to 8 neighboring pixels of instantaneous scanning matrix, one output that tells whether the pixel under consideration is an edge or not. Rule base comprises of thirty rules, which classifies the target pixel. The proposed method results for both color images and gray scale images.The fuzzy inference system allows effective utilization and representation of human expertise about the system, thus the edges can be detected efficiently.

Keywords: Edge detection, Color edge detection, Fuzzy logic, Fuzzy inference system.

1.1 INTRODUCTION

Edge detection refers to the process of identifying and locating sharp discontinuities in an image. Edge detection has been very useful low-level image processing tool for image analysis in computer vision and pattern recognition field [1]. Over the last few decades the volume of interest, research, and development of computer vision systems has increased enormously. Due to the substantial increase in digital imagesthat are produced on a daily basis (e.g., from radiographs to images from satellites) there is an increased need for the automatic processing of such images. Thus, there are currently many applications such as computer-aided diagnosis of medical images, segmentation and classification of remote sensing images into land classes (e.g., identification of wheat fields, and illegal marijuana plantations, and estimation ofcrop growth), optical character recognition, closed loop control, content-based retrieval for multimedia applications, image manipulation for the film industry, identification of registration details from car number plates, and a host of industrial inspection tasks (e.g., detecting defects in textiles, rolled steel, plate glass, etc.). Edge detection represents an extremely important step facilitating higher-level image analysis and therefore remains an area of active research, with new approaches continually being developed [2-3].

Color plays a crucial role in image analysis and recognition. A color image will have a vector of three values for every pixel unlike in gray images where a single value representing the intensity of a pixel. Human vision system chooses color rather than shapes and texture as the discriminate attribute. According to statistics 90% of the edges are about the same in gray level and in color images. It implies that 10% of the edges are left over in gray level images. Since color images give more information than gray-level images, this 10% left over edges may be extracted from color images. Edge detection in color images is different from that in gray scale images due to a fundamental difference in their nature. In contrast to a scalar value used to represent a pixel in a gray scale image, a pixel in a color image is represented by a color vector (which generally consists of three components, the tristimulus values). Thus, in color edge detection a vector-valued image function is processed instead of a scalar image function (as in gray scale edge detection)[4-5].

Many edge detection algorithms for the edge detection in gray scale images, such as Sobel operator, Robert and Prewitt operator that performs a 2-D spatial gradient measurement on images[6-9]. But these cross operators were very sensitivity to the noise and did not give sharp edges. The increase in the noise to the image will eventually degrade the magnitude of the edges. The major disadvantage is the inaccuracy, as the gradient magnitude of the edge decreases; the accuracy also decreases [10-11].

Laplacian [12] edge detector was a very popular edge operator before canny proposed his algorithm. It is a gradient based operator which uses the laplacian to take the second derivative of an image and it works on zero crossing method but this operator gets diffracted by some of the existing edges in the noisy image. Canny [13] method was proposed to counter noise problems and minimize the probability of false edges. In his work, image is convolved with the first order derivatives of Gaussian filter for smoothing in the local gradient direction followed by edge detection by thresholding. Canny edge detector has major drawbacks of being computationally complex and does not give a satisfactory result in varying contrast areas. However, improvement in the edge-detection research area has now resulted in the use of some tools such as neural networks, ant colony and fuzzy logic.

Many techniques have been proposed by researchers for fuzzy logic based edge detection. An edge detection technique was proposed by dividing the image into 3-fuzzy partitions (regions) and then finding the maximum entropy to give the best edge and to derive the necessary condition to maximize the entropy function [14-15]. Morphological operation based fuzzy set to detect the edges was proposed [16].Fuzzy rule-based operators built on IF-THEN-ELSE rule-based architecture for edge detection was utilized [17]. The drawback of these algorithms is that they have neglected the global information.

1.2 Fuzzy Inference System

Fuzzifying Inputs: The first step in a fuzzy inference system is the fuzzification of crisp inputs. It transforms the exact logic problem into a fuzzy logic problem. Unlike crisp logic, fuzzy logic deals with linguistic variables instead of numerical variables. The process of converting numerical variables of the problem into grades of membership for linguistic terms of fuzzy sets is called fuzzification. Thus it is a mapping from a certain input space to fuzzy sets in certain input universes of discourse.

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 rules consequent. The rules weight must be taken care before applying the implication method, which is a number between 0 and 1. 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 various defuzzification techniques are:

- Mean of Maximum method
- Center of Gravity method.
- Bisector method
- Smallest of maximum method
- Largest of maximum method

2. PROPOSED METHODOLOGY

In order to detect the edge in the image, a fuzzy inference system has been designed which take different pixel value as inputs, fuzzify these inputs according to different degree of membership function, the fuzzified inputs are combined according to the fuzzy rules to establish a rule strength, and then using this fuzzy rules the considered pixel is marked as edge or background.Bisector method is used as defuzzification method to convert fuzzy output to crisp output.Block diagram of proposed method is shown in Fig.1.

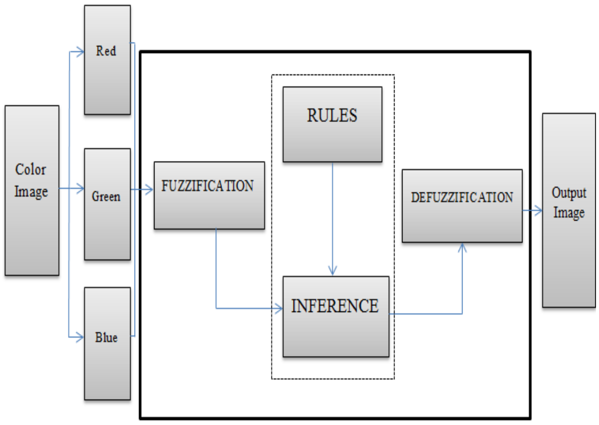


Fig. 1: Fuzzy Inference System for Color Image edge detection

2.1 Algorithm

Step 1: Input the color image.

Step 2: Split the image into red, green and blue component.

Step 3: Apply histogram equalization to enhance the contrast of each component.

Step 4: Repeat steps 5 to 10 for each color component.

Step 5: Input neighboring 8 pixels from the scanned window to FIS system.

Step 6: Then apply Fuzzy t-norms operator (MIN) for calculating firing strength.

Step 7: Fire the fuzzy rules for each fuzzified input.

Step 8: Apply the MAX operator(s-norm) to get the aggregate resultant output.

Step 9: Defuzzification is performed using the Bisector method.

Step 10: Crisp Output P5_out is the pixel value of the output image i.e., one containing the Background and edge regions.

Step 11: Combine the results of each color component using OR operator into one complete edge map.

Step 12: Apply Edge thinning to the obtained edge image to remove spurious or unwanted edge points.

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology
Vol. 2, Issue 7, July 2015

2.2. Window mask

In the proposed approach, edge at each pixel of an image is calculated using fuzzy rules around 3*3 spatial masks. Fuzzy inference system designed has 8 inputs, which corresponds to 8 neighboring pixels P1, P2, P3, P4, P6, P7, P8, P9 of instantaneous scanning matrix and P5_out output pixel tells whether the pixel under consideration is edge or background based on the neighboring pixels as shown in the Fig. 2.

P1	P2	P3
P4	P5	P6
P7	P8	P9

Fig. 2: 3*3 mask for scanning

2.3. Fuzzy Membership Function and Fuzzy Sets

The choice of membership function depends on the problem. In this algorithm Triangular membership functions is used for input as well as for output. The standard Triangular membership function is defined as

$$\text{triangle}(x;a,b,c) = \max\left(\min\left(\frac{x-a}{b-a},\frac{c-x}{c-b}\right),0\right)$$

The input pixels are divided into two fuzzy sets i.e., Black and White.Fuzzy sets for input variables are designed as shown in Fig.3.

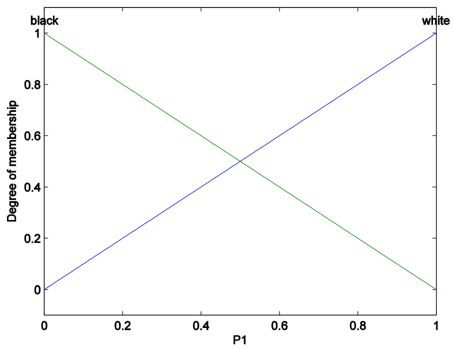


Fig. 3: Membership functions of the fuzzy sets associated to the input

The output pixels are divided into two fuzzy sets i.e., Background and Edge. Fuzzy sets for output variables are designed as shown in Fig.4.

2.4. Fuzzy Rules

Rule base comprises of thirty rules, which classifies the target pixel. The rule base of 30 rules is set for the various fuzzy conditions that can occur.

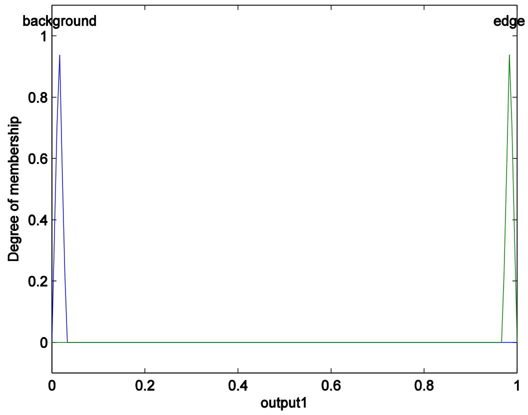


Fig. 4: Membership functions of the fuzzy sets associated tothe output

Single output describes whether the output pixel i.e. P5_out belongs to edge or background.
If the output pixel P5_out is inside the neighboring input pixels of same color then the output pixel P5_ out is considered as Background and if the output pixel P5_out is at the edge of the neighboring input pixels of different color then the output pixel P5_out is considered as Edge. Rules are enlisted in the form of a matrix in Table. 1

Fuzzy Inputs								Fuzzy output
P1	P2	P3	P4	P6	P7	P8	P9	P5_out
W	W	W	W	W	B	B	B	Edge
B	B	B	W	W	W	W	W	Edge
B	W	W	B	W	B	W	W	Edge
W	W	B	W	B	W	W	B	Edge
B	B	W	B	W	B	W	W	Edge
W	W	B	W	B	W	B	B	Edge
B	W	W	B	W	B	B	W	Edge
W	B	B	W	B	W	W	B	Edge
B	B	B	B	W	W	W	W	Edge
W	W	W	B	W	B	B	B	Edge
B	B	B	W	B	W	W	W	Edge
W	W	W	W	B	B	B	B	Edge
W	B	B	W	B	W	W	W	Edge
W	W	W	W	B	W	B	B	Edge
B	B	W	B	W	W	W	W	Edge
W	W	W	B	W	B	B	W	Edge
B	B	W	B	W	B	B	W	Edge
W	W	W	B	B	B	B	B	Edge
B	B	W	W	W	W	W	W	Background
W	B	B	W	W	W	W	W	Background
W	W	B	W	B	W	W	W	Background
W	W	W	W	B	W	W	B	Background
W	W	W	W	W	B	B	W	Background
W	W	W	W	W	W	B	B	Background
B	W	W	B	W	W	W	W	Background
W	W	W	B	W	B	W	W	Background
B	W	B	W	W	W	W	W	Background
W	W	W	B	W	B	W	W	Background
B	B	B	B	B	B	B	B	Background
W	W	W	W	W	W	W	W	Background

DOI 10.17148/IARJSET.2015.2714

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology
Vol. 2, Issue 7, July 2015

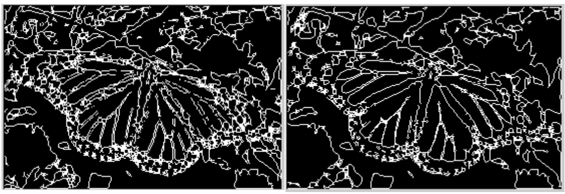
3. EXPERIMENTAL RESULTS

The proposed system was tested with different color images and grayscale images, it was observed that the outputs of this algorithm provide much more distinct marked edges and have better visual appearance. 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. Thus the Fuzzy rule based system provides better edge detection and has an exhaustive set of fuzzy conditions which helps to extract the edges with a very high efficiency.

(a) Original color image (b) Grayscale image

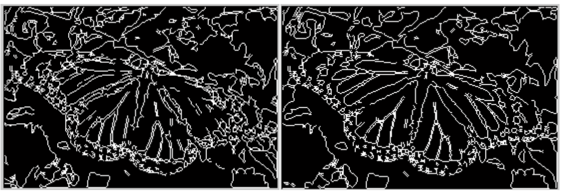
3.1 Results based on different Membership function

3.1.1 Using Triangular membership function:



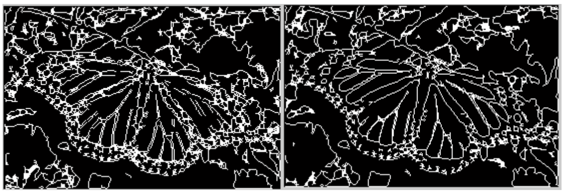
(a) Color edge image (b) Grayscale edge image

3.1.2Using Trapezoidal membership function:



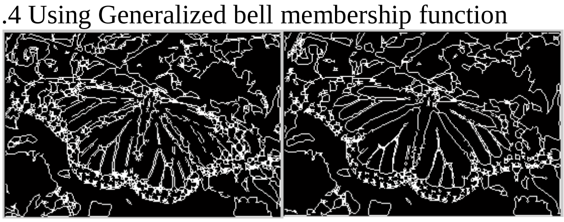
(a) Color edge image (b) Grayscale edge image

3.1.3 Using Gaussian membership function:



(a) Color edge image (b) Grayscale edge image

3.1.4 Using Generalized bell membership function

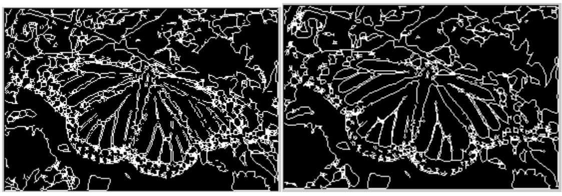


(a) Color edge image (b) Grayscale edge image

It is found that by using triangular membership function better results can be obtained and by using triangular membership function different defuzzification methods are applied.

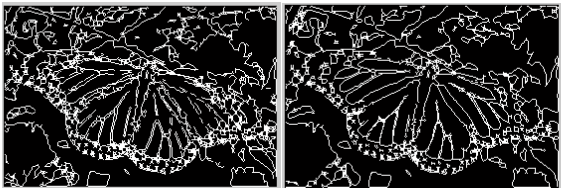
3.2 Results Based On Different Defuzzification

3.2.1 Using Bisector method



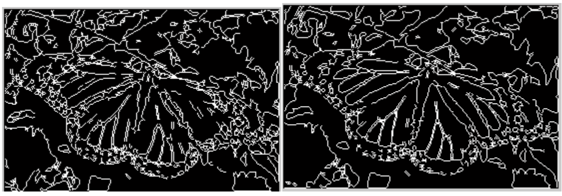
(a) Color edge image (b) Grayscale edge image

3.2.2 Using Mean of Maximum method



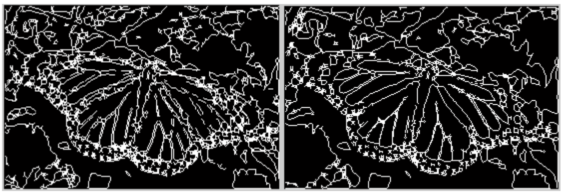
(a) Color edge image (b) Grayscale edge image

3.2.3 Using Smallest of maximum method



(a) Color edge image (b) Grayscale edge image

3.2.4 Using Largest of maximum method



(a) Color edge image (b) Grayscale edge image

It is found that by using Bisector defuzzification method better results can be obtained.

4. CONCLUSION AND FUTURE WORK

As uncertainties exist in many aspects of image processing and computer vision tasks, fuzzy processing is desirable for extracting edges from the image. The proposed method is tested on differentimages. It produced stable and fairly good results. Consistent acceptable outputs over different kinds of real life images have proved robustness of the presented algorithm. Thus, the proposed method may be handy for any computer vision task where extraction of edge maps is required for a large set of images for feature extraction or for any other work. Our next venture will be comparing those algorithms with the proposed one and analyze the performance on the basis of parameters like computing time, execution complexity and accuracy of the system output in presence of noise.

 DOI 10.17148/IARJSET.2015.2714

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology
Vol. 2, Issue 7, July 2015

REFERENCES

[1] Pratt, W.K., Digital Image Processing, New York: Wiley-Interscience, 1978.
[2] Gonzalez, R.C., and Woods, R.E., Digital Image Processing, Addison- Wesley, Reading, M.A., 1992.
[3] Marr, D., and Hildreth, E.C., "Theory of edge detection", Proc. of the Royal Society of London, b207, 1980, 187- 217.
[4] Koschan, A., Abidi, M.: Detection and classification of edges in color images: A review of vector valued techniques. IEEE Signal Processing Magazine, 64-73 Jan (2005)
[5] Chen, X., Chen, H.: A novel color edge detection algorithm in RGB color space. Proc. of IEEE 10th International conference on signal processing, 793-796 (2010)
[6] S. El-Khamy, N. El-Yamany, and M. Lotfy, "A Modified Fuzzy Sobel Edge Detector,"Seventeenth National Radio Science Conference (NRSC'2000), February 22-24, Minufia, Egypt,2000
[7] WenshuoGao and Lei Yang., "An Improved Sobel Edge Detection", 978-1-4244-5540-9/10/©2010 IEEE.
[8] Vojislav Kecman., "Learning and soft computing: support vector machines, neural networks and fuzzy logic models" 2001 Massachusetts Institute of Technology
[9] O. R. Vincent, and O. Folorunso.," A Descriptive Algorithm for Sobel Image Edge Detection", Proceedings of Informing Science & IT Education Conference (InSITE) 2009
[10] Li Bin, Mehdi Samieiyeganeh., "Comparison for Image Edge Detection Algorithms", IOSR Journal of Computer Engineering (IOSRJCE) ISSN: 2278-0661 Volume 2, Issue 6 (July-Aug. 2012), PP 01-04
[11] G.T. Shrivakshan., "A Comparison of various Edge Detection Techniques used in Image Processing", IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 5, No 1, September 2012
[12] H.S. Bhadauria, Annapurna Singh, Anuj Kumar., "Comparison between Various Edge Detection Methods on Satellite Image", International Journal of Emerging Technology and Advanced Engineering ISO 9001:2008 Certified Journal, Volume 3, Issue 6, June 2013
[13] Canny, J.F., "A computational approach to edge detection", IEEE Trans. on Pattern Analysis and Machine Intelligence, 8(6), 1986, pp. 679-698
[14] L. A. Zadeh, "Fuzzy sets," Information and Control, 8: 1965, pp. 338-353.
[15] K. Cheung and W. Chan, "Fuzzy One –Mean Algorithm for Edge Detection," IEEE Inter. Conf. on Fuzzy Systems, 1995, pp. 2039-2044.
[16] Bloch I., "Fuzzy sets in image processing", ACM Symposium on Allied Computing, 1994.
[17] Russo, F., and Ramponi, G., "Edge extraction by FIRE operators", Proc. of the 3rd IEEE Conference on Fuzzy Systems, 1994, 249-253.