EDGE DETECTION USING ADVANCED THRESHOULDING AND FUZZY LOGIC WITH 3X3 MASK

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ABSTRACT

Digital image processing having applications in various fields like Medical, consumer Electronics, Defense. Digital images are a set of values stored in a array which are equal to the intensity level in a real scene which can easily stored and processed using digital hard- ware. In robotics and artificial vision system it is important to find out the objects in an image and differentiating different objects in an image. Edges in an image are high frequency components and these will give considerable information compared to color. Edges and boundaries of an image are used to find out the shapes of an object in the image for shape which is important for human interpretation and also for autonomous machine vision. Edge detection reduces the amount of data to be processed and filters out useless information. In this paper implemented an improved Otsu thresholding method and fuzzy logic for edge detection in an image.

Keywords: Edge Detection, Fuzzy Logic, Otsu Method

I. INTRODUCTION

Edge detection is a very important process in image processing and analysis [1-2]. Edges are high frequency components and 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. Edges carry important information. There are different types of edge detection tools are there Sobel, Canny, Prewitt and Laplacian and 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.

Fuzzy logic is also used to develop the algorithms for the image processing. Yinghua Li, Bingqi Liu, and Bin Zhou of Ordnance Engineering College (China), presented Fuzzy technology as a newly rising technology used in many fields, especially in the image domain, and fuzzy enhancing technique as one important portion of the fuzzy technology. Based on this technology, they firstly set the image fuzzy characteristic plane of original image, secondly preceded the fuzzy enhancement, and then detected the edge by Sobel differential arithmetic [3]. The work of this paper is to develop a improved Otsu's thresholding method and fuzzy logic rule base for edge detection by sliding a 3X3 pixel mask over the binary image which is segmented by improved Otsu's method. Improved Otsu's segmentation method uses a weight, this weight ensures that the selected threshold value will always be a value resides at the valley or bottom rim of the gray level distribution [4].

II. IMPROVED OTSU METHOD

Otsu's thresholding technique is based on partitions of the image into two classes C0 and C1 at a gray level t such that $C_0 = \{0,1,2,.....,t\}$ and $C_1 = \{t+1, t+2,....., L-1\}$, where L is the total number of gray levels of the image Let the number of pixels at i th gray level n_i, and n be the total number of pixels in a given image. The probability occurrence of gray level i is defined as:

$$p_i = \frac{n_i}{n}$$

C_0 and C_1 are normally corresponding to the object of interested and the background, probabilities of two classes are ω_0 and ω_1:

$$\omega_0 = \sum_{i=0}^{t} p_i \qquad \omega_1 = \sum_{i=t+1}^{L-1} p_i$$

Means of two classes can be computed as:

$$\mu_0(\mathrm{t}) = \sum_{i=0}^{t} ip_i / \omega_0(\mathrm{t})\mu_1(\mathrm{t}) \qquad \mu_1(\mathrm{t}) = \sum_{i=t+1}^{L-1} ip_i / \omega_1(\mathrm{t}) \qquad \mu_T = \sum_{i=0}^{L-1} ip_i$$

Formula for obtaining optimal threshold t^* is

$$t^* = Arg \underset{0<t<L}{Max}[\omega_0(\mu_0 - \mu_T)^2 + \omega_1(\mu_1 - \mu_T)^2]$$

The formula for improved Otsu improved method is

$$t^* = Arg \underset{0<t<m-1}{Max}[\omega_0(\sigma_0^2(\mathrm{t}) - \sigma_T^2)^2 + \omega_1(\sigma_1^2(\mathrm{t}) - \sigma_T^2)^2](1 - \mathrm{p(t)}/2)$$

Where

$$\sigma_0^2(\mathrm{t}) = \frac{1}{\omega_0(\mathrm{t})} \sum_{0<i<t} (\mathrm{i} - \mu_0(\mathrm{t}))^2 p(\mathrm{i})$$

$$\sigma_1^2(\mathrm{t}) = \frac{1}{\omega_1(\mathrm{t})} \sum_{t<i<m-1} (\mathrm{i} - \mu_1(\mathrm{t}))^2 p(\mathrm{i})$$

$$\sigma_T^2 = \sum_{0<i<m-1} (\mathrm{i} - \mu_T)^2 p(\mathrm{i})$$

Improved Otsu method applies a weight $[1 - \mathrm{p(t)}/2]$ to Otsu method

After applying Otsu's improved method on a gray scale image we get a threshold value t and i image gets segmented based on this threshold value.

III. FUZZY LOGIC CONTROLLER

Fuzzy logic is based on IF and THEN conditions, designed fuzzy logic controller will take eight inputs; these inputs are the surrounding pixel values of the processing pixel. There are 32 rules for the given 8 inputs and each input will consists of two membership functions, one is for black pixel and one is for white pixel. There is one output from the fuzzy rule base which contains two member ship functions; those are edge and non-edge pixels.

3.1 Floating Mask

The floating mask is a 3x3 array which slides over the image row by row, figure 3.1 shows the structure of floating mask, where p5 be the processing pixel, which is surrounded by eight pixels, which are inputs for the fuzzy logic controller

P1	P2	P3
P4	P5	P6
P7	P8	P9

Figure 3.1: 3x3 Floating Mask

The fuzzy logic controller is shown below eight inputs are feed into the rule base, which contains total of 32 rules which are implemented using the figure 3.3

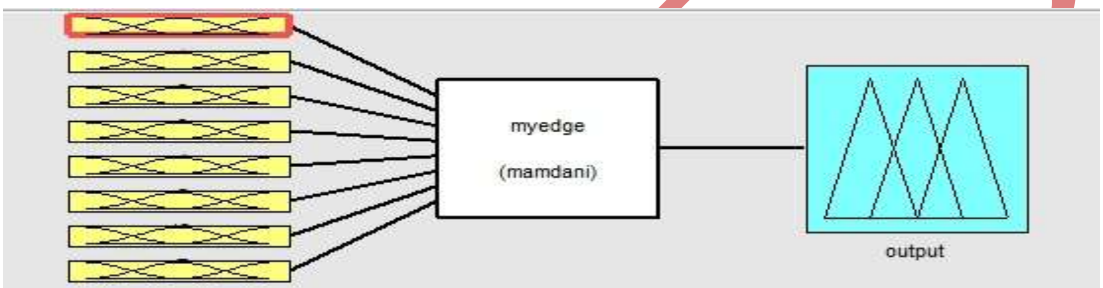


Figure 3.2: Fuzzy Input and Output

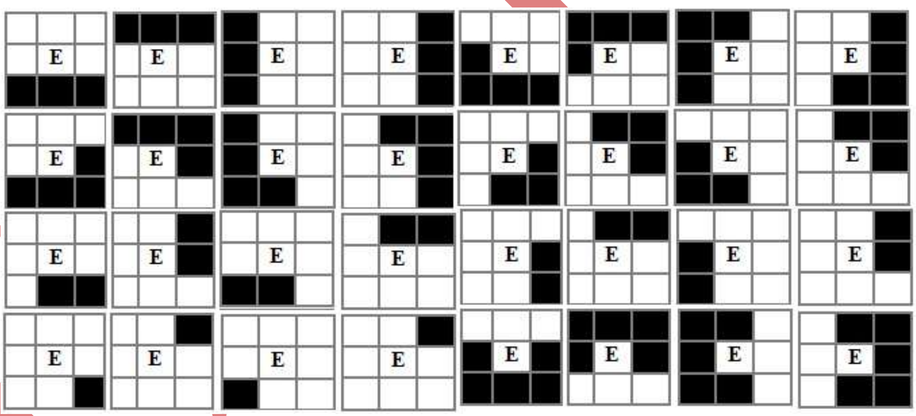


Figure 3.3: Occurrence of Edge Pixel

Table 3.1 Shows the Rule Base of the Fuzzy Logic Controller

	P1	P2	P3	P4	P6	P7	P8	P9	OUTPUT
1	H	H	H	H	H	L	L	L	E
2	L	L	L	H	H	H	H	H	E
3	L	H	H	L	H	L	H	H	E
4	H	H	L	H	L	H	H	L	E

5	**L**	**L**	**H**	**L**	**H**	**L**	**H**	**H**	**E**
6	**H**	**H**	**L**	**H**	**L**	**H**	**L**	**L**	**E**
7	**L**	**H**	**H**	**L**	**H**	**L**	**L**	**H**	**E**
8	**H**	**L**	**L**	**H**	**L**	**H**	**H**	**L**	**E**
9	**L**	**L**	**L**	**L**	**H**	**H**	**H**	**H**	**E**
10	**H**	**H**	**H**	**L**	**H**	**L**	**L**	**L**	**E**
11	**L**	**L**	**L**	**H**	**L**	**H**	**H**	**H**	**E**
12	**H**	**H**	**H**	**H**	**L**	**L**	**L**	**L**	**E**
13	**H**	**L**	**L**	**H**	**L**	**H**	**H**	**H**	**E**
14	**H**	**H**	**H**	**H**	**L**	**H**	**L**	**L**	**E**
15	**L**	**L**	**H**	**L**	**H**	**H**	**H**	**H**	**E**
16	**H**	**H**	**H**	**L**	**H**	**L**	**L**	**H**	**E**
17	**L**	**H**	**H**	**L**	**H**	**H**	**H**	**H**	**E**
18	**H**	**H**	**H**	**L**	**H**	**L**	**H**	**H**	**E**
19	**H**	**H**	**H**	**H**	**H**	**L**	**L**	**H**	**E**
20	**L**	**L**	**H**	**H**	**H**	**H**	**H**	**H**	**E**
21	**H**	**H**	**H**	**H**	**H**	**H**	**L**	**L**	**E**
22	**H**	**H**	**H**	**H**	**L**	**H**	**H**	**L**	**E**
23	**H**	**H**	**L**	**H**	**L**	**H**	**H**	**H**	**E**
24	**H**	**L**	**L**	**H**	**H**	**H**	**H**	**H**	**E**
25	**L**	**L**	**L**	**L**	**L**	**H**	**H**	**H**	**E**
26	**L**	**L**	**H**	**L**	**H**	**L**	**L**	**H**	**E**
27	**H**	**H**	**H**	**L**	**L**	**L**	**L**	**L**	**E**
28	**H**	**L**	**L**	**H**	**L**	**H**	**L**	**L**	**E**
29	**L**	**H**	**H**	**H**	**H**	**H**	**H**	**H**	**E**

30	**H**	**H**	**H**	**H**	**H**	**L**	**H**	**H**	**E**
31	**H**	**H**	**H**	**H**	**H**	**H**	**H**	**L**	**E**
32	**H**	**H**	**L**	**H**	**H**	**H**	**H**	**H**	**E**

Table 3.1: Fuzzy Rules

IV. ALGORITHM

Step 1: select input image.

Step 2: convert color image into gray scale image.

Step 3: apply Improved Otsu's segmentation.

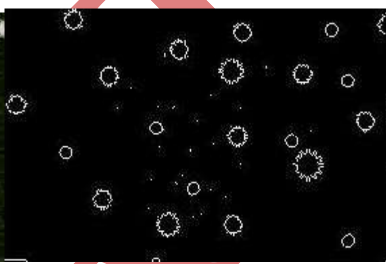
Step 4: Segment the image using the threshold value t, obtained from step3

Step 5: load the Fuzzy rule base, and feed eight inputs to it

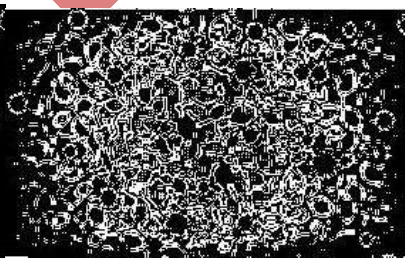
Step 6: Finally compare the experimental results with existing Sobel edge detector

V. OUTPUT IMAGES

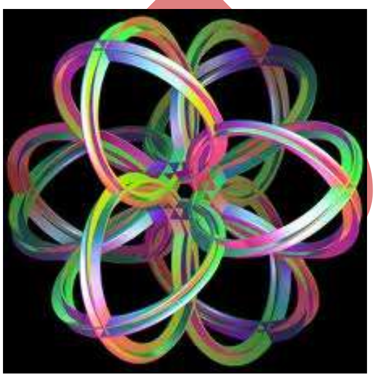
(a)



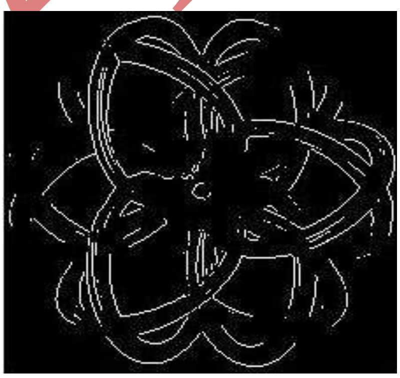
(b)



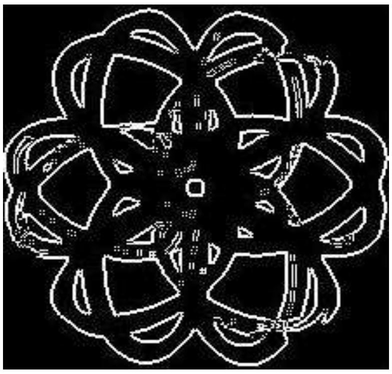
(c)



(a)

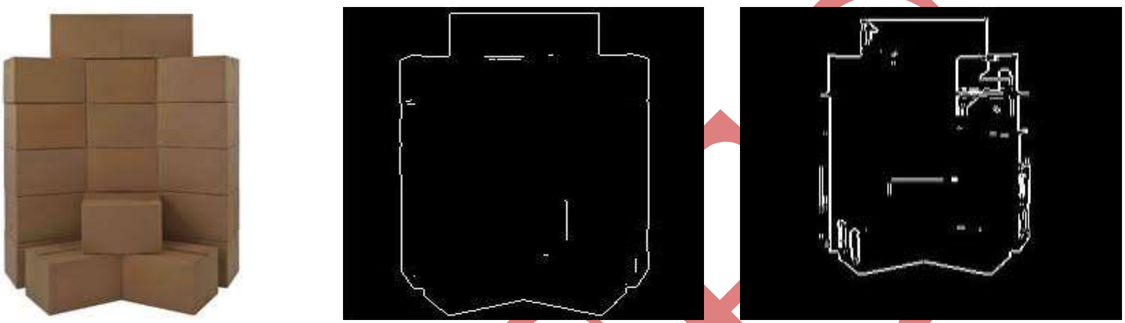


(b)

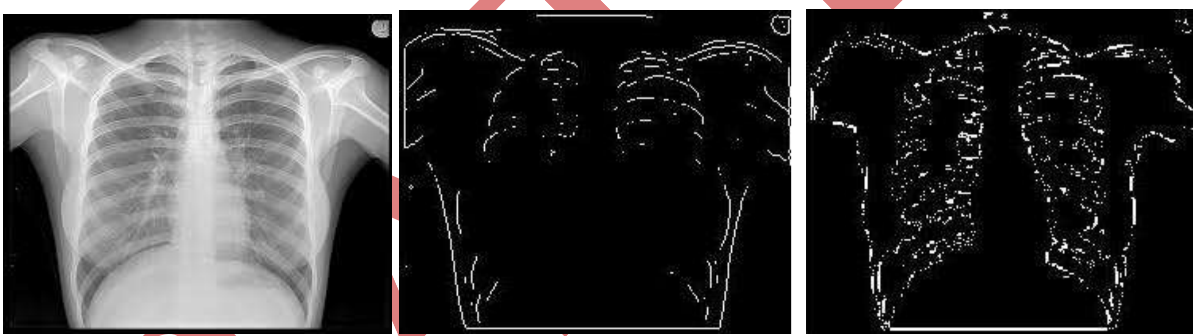


(c)

(a) (b) (c)



(a) (b) (c)



(a) (b) (c)

Figure 4.1: (A) Original Image (B) Sobel Edge Detection (C) Proposed Method

VI. CONCLUSION

In this paper we used improved image segmentation algorithm based on Otsu's method and fuzzy rule base for edge detection which works well and good for images which are having bimodal and unimodal type histograms. Sample outputs have been shown to make readers understand. This algorithm is successful in edge detection in images which are difficult with Sobel operator. Thus developed algorithm will have scope of application in various areas of digital image processing.

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