Fuzzy Logic Project Report

Fuzzy Edge Detection Using Gradient and Standart Deviation

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1. Introduction

Edge is a basic feature of an image to obtain image characteristic. In a digital image, an edge occurs when the brightness changes sharply. Edges correspond to discontinuities in depth, or in surface orientation, changes in material properties, and variations in scene illumination. In the fuzzy logic system, we have used input and output variables and rule based algorithm for detecting edges. In the literature, there are some classical techniques to find sudden changes of discontinuties in the image is called as 'edges' such as Sobel, Robert, Prewitt, Laplacian of Gaussian, Canny, Kirsch. A novel approach to find adges in the image is fuzzy rule based algorithm. Mamdani fuzzy model is used and for this algorithm. Inputs and output of the system are defined using gradient and standart deviation. Fuzzy sets, membership functions and interval of them are selected intuitively.

2. Problem Definition

In this study, 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. To obtain output value, 'centroid' method is used as defuzzification method and applying a proper threshold value.

First step of the process it to find direcional gradient of the gray scale image into the direction of x and y. After that gradient maginitude of the image is obtained.

$$Gx = \frac{\partial I(x,y)}{\partial x} = \lim_{\Delta x \to} \frac{I(x+n,y) - I(x-n,y)}{\Delta x}$$

$$Gy = \frac{\partial I(x,y)}{\partial y} = \lim_{\Delta y \to} \frac{I(x,y+n) - I(x,y-n)}{\Delta y}$$

, n is usually unity.

By combining partial derivative of the image in the x and y direction, gradient vector of the image is written like that :

$$\nabla I = (Gx, Gy\ )$$

Using gradient vector, gradient magnitude and direction are calculated below equations:

$$g(x,y) = (\Delta x^2 + \Delta y^2)^{1/2}$$

Gradient of an image and mapping into 0 to 100 and higher values of the gradient magnitude will be considered as edge candidate.

Second step is to find standart deviation of each pixel over adjasent neighbourhood as shown below Figure 1.

P1	P2	P3
P4	P5	P6
P7	P8	P9

Figure 1: Adjasent neighbourhood of center pixel

SD of each pixel and mapping into 0 to 100 and similarly pixels of standart deviation image, higher values will be correspond as edge candidate[3].

In the first two steps, inputs of the Fuzzy Inference System is defined and ready to create fuzzy set, membersip funcitons, rules and the output of the system. As a third step, inputs, appropriate membership functions are defined for fuzzy system inputs. Then both of the mapped values are classified to one of the low, medium, or high classes. Using the classified values, specify and apply rules to the system. The output of fuzzy system explains to how extent a pixel could be edge. By the using fuzzy rules and centroid defuzzificaiton method, the output of this fuzzy system is classified to one of three classes which are correspond to pixels with low, medium, high probability value to belong to edge pixels set.

In general, flow chart of the system can be seen Figure 2.

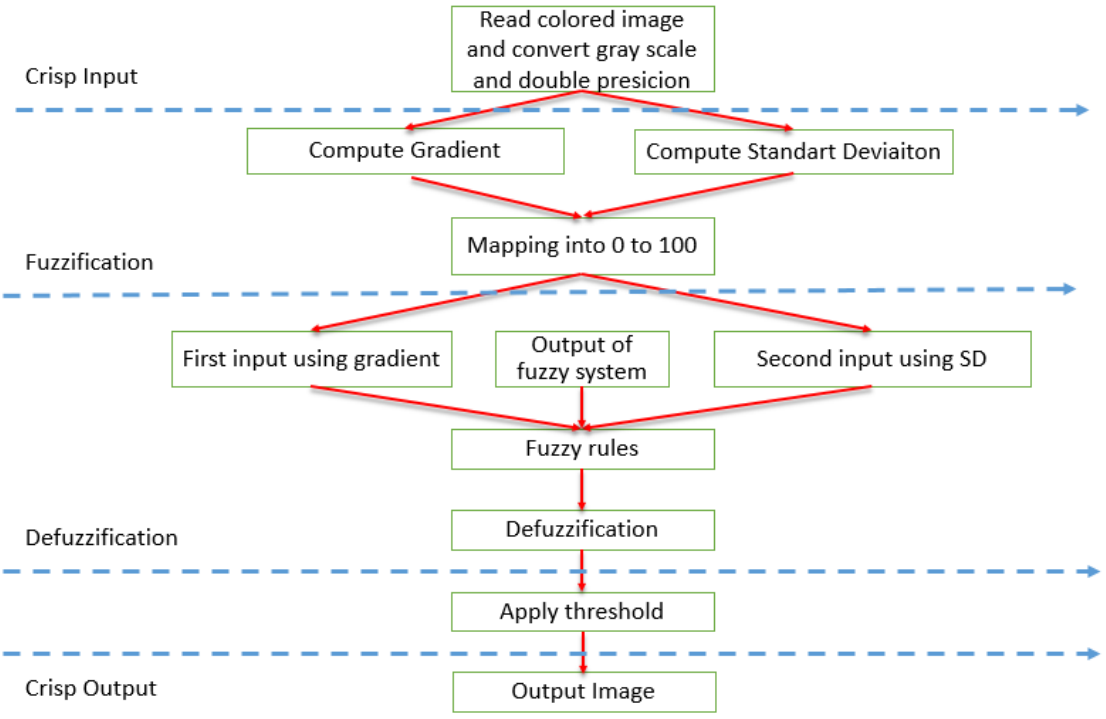

Figure 2 : Flow chart of the system. Source: Author

3. Method Evaluation

A colored scale image is converted into the gray scale to intensity information and compute the directional change of the image in the x and y direction. Figure3 and Figure 4 show the colored and grayscale images, respectively.

Figure 3: Colored image. Source: Author.

Figure 4: Grayscale image. Source: Author.

Directional derivatives of the grayscale image are computed by using Sobel gradient operator. The results are shown in the Figure 5 and Figure 6, respectively. They show how much the gray levels in image change in the positive x and y directions, this change in the intensity is encoded in the gray level of the image of the horizontal and vertical components.

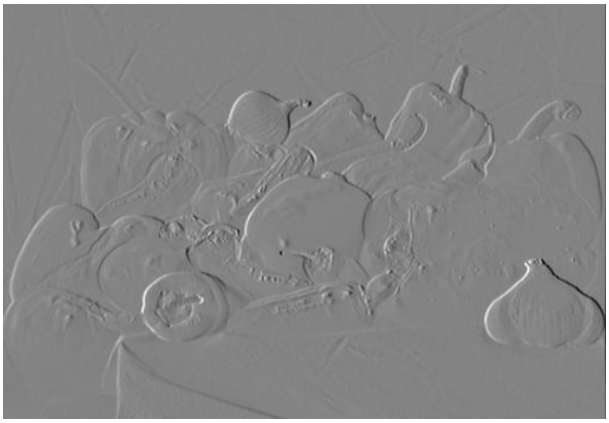

Figure 5: x direction gradient. Source: Author.

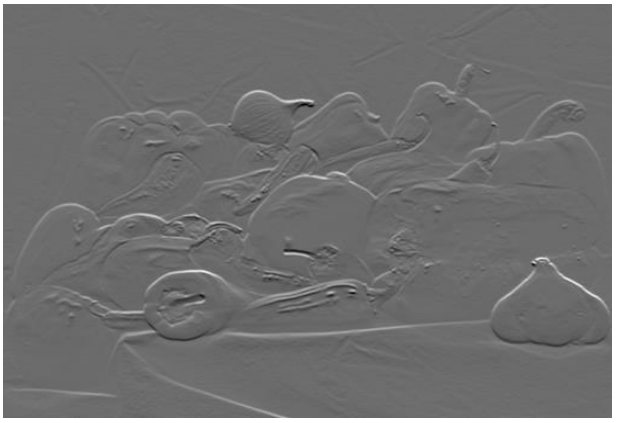

Figure 6: y direction gradient. Source: Author.

After directional changes of the image are computed, gradient magnitude and gradient direction can be found by using above mathamatical equations. Again, Figure 7 represents magnitude values as an image in the range of 0 and 100. In the magnitude image edge pixels has more value than background.

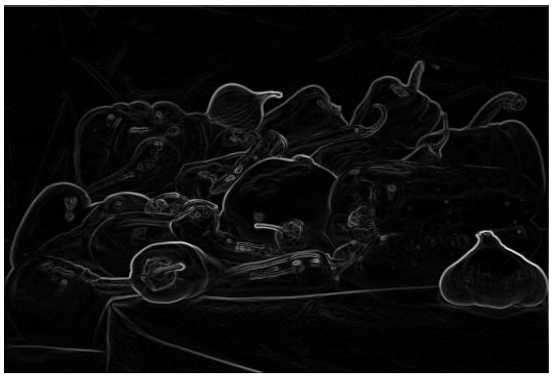

Figure 7: Gradient magnitude. Source: Author

As a second input, for each pixel SD is computed by 3×3 mask and result Figure 8 represents standart deviation of each pixel values as an image in the range of 0 and 100. Similarly pixels with SD image edge pixels has more value than background.

Figure 8: Standart Deviation of image. Source: Author

Then both inputs gradient magnitude image and standart deviation of the mapped values and output of the system are classified to one of the low, medium, or high classes as shown in the Figure 9.

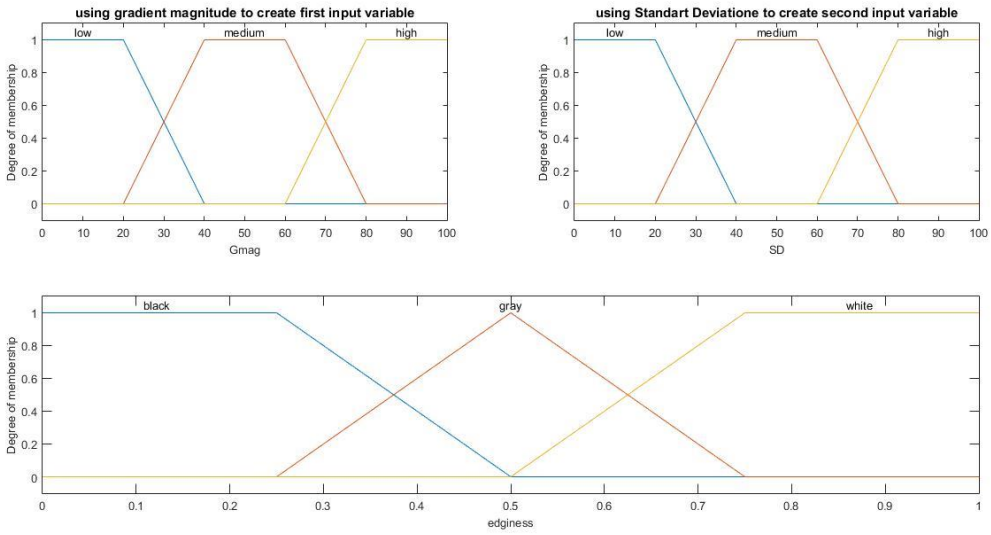

Figure 9: Inputs and output membersip functions

After specifiying inputs and output, *IF-THEN* rules must be designed. In the Table 1 inputs and output relations depending on the *IF-THEN* rules are represented.

Some of the rules like that:

1. If (Gmag is low) and (SD is low) then (edginess is black) (1)

2. If (Gmag is low) and (SD is medium) then (edginess is black) (1)

3. If (Gmag is low) and (SD is high) then (edginess is gray) (1) ...

Inputs		Output
Gradient	SD	Edginess
L	L	L
L	M	L
L	H	M
M	L	L
M	M	M
M	H	H
H	L	M
H	M	H
H	H	H

L : low

M : medium

H: high

Table 1: Rules of the Fuzzy Inference System. Source: Author

As a last step centroid defuzzification is applied and output image is getting. Using output image and a proper threshold value, edge of the image is show as black in the Figure 10.

Figure 10: Output image

4. Conclusion

In this work, Fuzzy based new edge detection algorithm is done. Based on the primary edge detection methods, gradient and standard deviation computed at each pixel, and are used as fuzzy system input. The fuzzy system includes appropriate defined membership function and fuzzy rules, decide about pixel classification as edge or non-edge. Improving fuzzy system performance by the ways such as using different kind of input, different fuzzy membership functions and rules also need to be investigated in future works [4]. This solution is strongly depend on the threshold value and interval of the fuzzy sets but is less computationally expensive

5. References

[1]https://www.tutorialspoint.com/artificial_intelligence/artificial_intelligence_fuzzy_logic_systems.htm

[2] Gonzalez, R.C., and Woods, R.E., Digital Image Processing, Addison- Wesley, Reading, M.A., 1992.

[3] Er. Manpreet Kaur, Ms. Sumeet Kaur, 'A New Approach to Edge Detection Using Rule Based Fuzzy Logic', Journal of Global Research in Computer Science, Volume 2, No. 9, September 2011

[4] Wafa barkhoda, Fardin Akhlaqian Tab, Om-Kolsoom Shahryari, ' *Fuzzy Edge Detection Based on Pixel's Gradient and Standard Deviation Values*', Proceedings of the International Multiconference on Computer Science and Information Technology, pp. 7 – 10.