FUZZY LOGIC BASED DIGITAL IMAGE EDGE DETECTION

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Abstract - In this paper fuzzy based edge detection algorithm isdeveloped. In the proposed algorithm, edginess at each pixel ofa digital image is calculated. Based on the Gaussianmembership functions and fuzzy rules the fuzzy system decidewhether a pixel in focus belong to an edge or non-edge. Thefinal pixel classification of a given image is produced bygenerating output pixel value using Mamdani Defuzzifier methodAlgorithm for the noise removal has been implemented at different levels of processing.Experimental results show theability and high performance of proposed algorithm.

Keywords - Fuzzy Logic, Fuzzy inference system, Edgestrength, Edge detection.

I. INTRODUCTION AND BACKGROUND

Edge Detection has been very useful low-level image processing tool for image analysis in computer vision and pattern recognition field. In image, edges carries essential information of an object of interest in image as they separate dissimilar regions in an image. Specific linear time-invariant (LTI) filters is the most common procedure applied to the edge detection problem, and the one which results in the least computational effort. In the case of first order filters, an edge is interpreted as an abrupt variation in gray level between two neighbor pixels. The goal in this case is to determine in which points in the image the first derivative of the gray level as a function of position is of high magnitude. By applying the threshold to the new output image, edges in arbitrary directions are detected.

Early edge detection methods, such as the Sobel and Prewitt detectors [1], [2] were based on the concept of spatial derivative filtering, where local gradient operators are used to detect edges of certain orientations only. Derivative filters suffer when the edges are blurred and noisy and are not flexible. Marr and Hildreth [3] proposed an algorithm that finds edges at the zero crossings of the Laplacian of an image. Canny [4] proposed a method to counter noise problems from gradient operators, where the image is convolved with the first-order derivatives of Gaussian filter for smoothing in the local gradient direction followed by edge detection by thresholding.

Most edge detector detect edges by applying local first order and second order derivative operator followed by some noise removal algorithm to reduce the noise. SUSAN edge detector [5] is a non-linear techniques to find the edges. Such technique have also gained popularity.Hou and Kuo [6] have used simple arithmetic and logical operation to find the edges in an image. Jiang and Bunke[7] have presented a novel scan line approximation method of edge detection. Their algorithm showed superior segmentation quality and computational cost to many region based algorithms. Caragea [8] computes the difference between central pixel and surrounding pixel and uses the highest value among these for detecting the edges. Genming [9] applied a 5x 5 window to reduce the noise efficiently while does not increasing the width of the edges which always happen in case of taking 5×5 window. Since this detector uses a self-adjusting threshold, therefore it is capable of detecting the edges in the area of variable grayscale background.

In the past few years, fuzzy logic emerged as a different yet powerful tool to decision making [10], [11], [12]. In 1965 Zadeh proposed the concept of fuzzy logic and soon fuzzy concept gained popularity in the image processing field. Many technique have been proposed by researcher for fuzzy logic based edge detection [13], [14], [15]. Zhao[16], proposed an edge detection technique by dividing the image into 3-fuzzy partitions (regions) and then finding the maximum entropy to give the best edge. He also derived the necessary condition to maximize the entropy function. Based on these condition three-level thresholding is obtained. Bloch [17] proposed morphological operation based fuzzy set to detect the edges. Russo and Ramponi [18] utilized fuzzy rule-based operators built on IF-THEN-ELSE rule-based architecture for edge detection.

The drawback of these algorithm is that they have neglected the global information. In most of these methods[19],[20] the neighboring pixel around a center pixel are assumed in some classes and then using some appropriate membership function, fuzzy inference system is designed which extract the edges from the image.

Mansoori [21], grouped all the adjacent pixel around a considered pixel in 6 different set. Then he determined the membership value for each group by applying some bell shape function. Then by using these membership value and fuzzy rule, existence of the edge pixel is determined.

Applications of Edge Detection:

Some of the practical applications of edge detection are:-

1. Medical Imaging
- Locate tumors and other pathologies
- Measure tissue volumes
- Computer guided surgery
- Treatment planning
- Study of anatomical structures

2. Locate objects in satellite images (roads, forests, etc.)
3. Face recognition
4. Fingerprint recognition
5. Automatic traffic controlling systems
6. Machine vision

II. PROPOSED ALGORTHM

In this paper, at first an input image is pre-process to accentuate or remove a band of spatial frequencies and to locate in an image where there is a sudden variation in the grey level of pixels. Then In order to detect the edge in the image, a fuzzy inference system has been designed which take different pixel value as inputs, fuzzified these input i.e. convert it into fuzzy plane and then using some predefined rule mark the considered pixel as edge, Black White.Mandani method is chosen as the defuzzification method and the output of the system is calculated as the centroid of the resulting membership functions. Block diagram of proposed method is shown in figure.1 and Resulted Block diagram of proposed algorithm is shown in figure 2.

2.1. PREPROCESSING STAGE

In preprocessing some essential Image improvement and commotion diminishment procedures are actualized. Aside from that diverse approaches to identify edges and doing divisions have likewise been utilized. The motivation behind these process is essentially to enhance the image and the input image quality to get more surety and simplicity in recognizing the edges. Three essential strides in preprocessing are the accompanying.

1. In Digital image enhancement the median filter is commonly used for nonlinear digital image filtering to mitigate the noise. such elimination is used in initials stage to help in the improvement in the later proceeding operation. This type of filtering is broadly utilized in digital image processingbecause, it preserves edges during reduction process.

- Image is transformed to gray scale in first.
- Appling median filter.
  K = medfilt2(s).

2. Performs morphological opening on the gray scale or binary image with have high pass filter consist of structuring element of disk having a radius of 3 for the purpose of smoothing and identification of the Edges.
3. Then the obtained image is added to original image to enhance it.

2. OBATAINING IMAGE GRADIENT

The fuzzy logic edge-detection algorithm for this example relies on the image gradient to locate breaks in uniform regions. Calculate the image gradient along the x-axis and y-axis.

An image gradient is a directional change in the intensity or color in an image. Image gradients may be used to extract information from images.

In graphics software for digital image editing, the term gradient or color gradient is used for a gradual blend of color which can be considered as an even gradation from low to high values, as used from white to black in the images to the right. Another name for this is color progression.

Mathematically, the gradient of a two-variable function (here the image intensity function) at each image point is a 2D vectorwith the components given by the derivatives in the horizontal and vertical directions. At each image point, the gradient vector points in the direction of largest possible intensity increase, and the length of the gradient vector corresponds to the rate of change in that direction.
The gradient of an image is given by the formula.

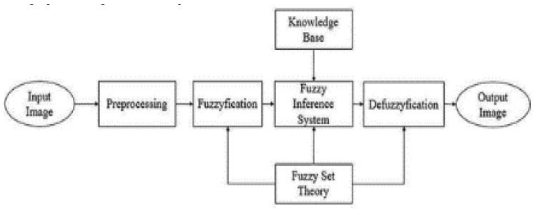


Figure 1: Block Diagram of Proposed Algorithms

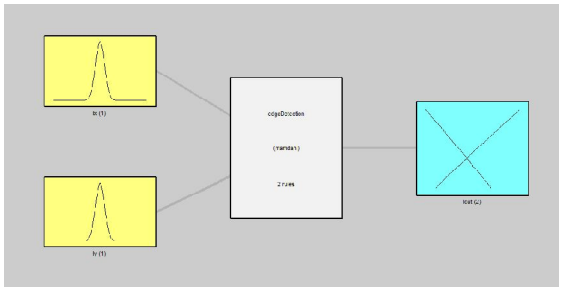


Figure 2:Resulted Blockdiagram ofProposed FIS System

The gradient is a vector which has magnitude and direction.

$$magnitude(grad(f)) = \sqrt{\frac{\partial f^2}{\partial x} + \frac{\partial f^2}{\partial y}}$$

$$direction(grad(f)) = \tan^{-1}\left(\frac{\partial f}{\partial y} / \frac{\partial f}{\partial x}\right)$$

Magnitude: indicates edge strength.
Direction: indicates edge direction.

III. FUZZY INFERENCE SYSTEM (FIS) FOR EDGE DETECTION

Fuzzy inference is the process of formulating the mapping from a given input to an output using fuzzy logic. The mapping then provides a basis

from which decisions can be made, or patterns discerned. The process of fuzzy inference involves all of the pieces that are described in the sections: membership functions, fuzzy logic operators, and if-then rules.

1. Membership Function.

A membership function (MF) is a curve that defines how each point in the input space is mapped to a membership value (or degree of membership) between 0 and 1. The input space is sometimes referred to as the universe of discourse, a fancy name for a simple concept.

The choice of membership function is problem dependent. In this algorithm Triangular Membership functions is used for output and Gaussian membership furcation is used for input of gradient Ix and Iy.The standard membership function is definedas

A. Triangular Membership Function

The triangular curve is a function of a vector, x, and depends on three scalar parameters a, b, and c, as given by in figure 3.

$$f(x;a,b,c) = \begin{cases} 0, & x \le a \\ \frac{x-a}{b-a}, & a \le x \le b \\ \frac{c-x}{c-b}, & b \le x \le c \\ 0, & c \le x \end{cases}$$

Figures: 3 triangular membership function

Parameters a and c locate the "feet" of the triangle and the parameter b locates the peak. The shape of triangular membership function is described below in figure 4.

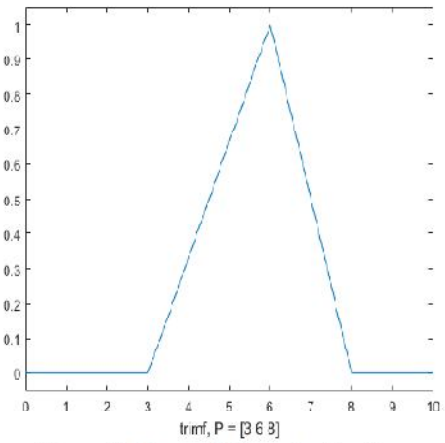


Figure 4: shape of triangular function

B. Gaussian Membership Function.

The symmetric Gaussian function depends on two parameters σ and c as given as figure 5

$$\text{gaussian}(x;c,\sigma) = e^{-\frac{1}{2}\left(\frac{x-c}{\sigma}\right)^2}.$$

Figure 5: Mathematical expression of Gaussians

Syntax:

```
y = gaussmf(x,[sig c])
```

The parameters for gaussmf represent the parameters σ and c listed in order in the vector [sig c].

Fuzzy sets.

The input pixels are divided in to two fuzzy sets i.e. Black & White while the output pixel is divided into threefuzzy sets i.e. Black ,Edge and White. Membershipfunction associated with input fuzzy sets and output fuzzy set is shown in figure 6.

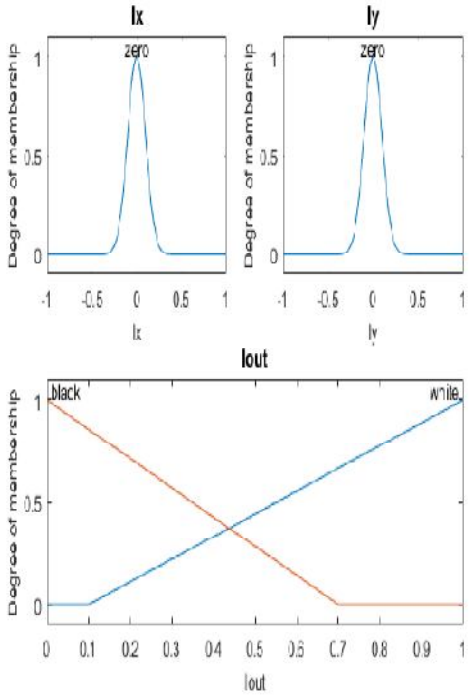


Figure6: Input and output Membership function graph using FIS editor.

3. Specify FIS Rules.

Add rules to make a pixel white if it belongs to a uniform region. Otherwise, make the pixel black.

```
r1 = 'If Ix is zero and Iy is zero then Iout is white';
r2 = 'If Ix is not zero or Iy is not zero then Iout is black';
r = char(r1,r2);
edgeFIS = parsrule(edgeFIS,r);
```

A. Rule List.

1. If (Ix is zero) and (Iy is zero) then (Iout is white)
2. If (Ix is not zero) or (Iy is not zero) then (Iout is black).

IV. EVALUATE FIS

Evaluate the output of the edge detector for each row of pixels in I using corresponding rows of Ix and Iy as inputs.

```
Ieval = zeros(size(I));% Preallocate the output matrix
for ii = 1:size(I,1)
Ieval(ii,:) = evalfis([(Ix(ii,:));(Iy(ii,:));]',edgeFIS;
end.
```

V. EXPERIMENTAL RESULTS

The proposed fuzzy edge detection method was simulated using MATLAB on different images. The figure below 7, 8 and 9 and shows the edge detection Analysis of Brain tumor, a knife and a model girl respectively are self-explanatory.

CONCULSION

In this paper, effective fuzzy logic based edge detection has been presented. The fuzzy system inputs were fuzzified using Gaussian membership functions. Fuzzy ifthen rules are applied to modify the membership to one of low, medium, or high classes. Finally, Mamdanidefuzzifier method is applied to produce the final edge image.Through the simulation results, it is shown that the proposed algorithm is far less computationally expensive, its application on the image improve the quality of edges as much as possible compared to the Sobel and Kirsch methods.This algorithm is suitable for applications in various areas of digital image processing such as Brain tumor Analysis ,face recognition, fingerprint identification, remote sensing and medical imaging where boundaries of specific regions need to be determined for further image analysis.

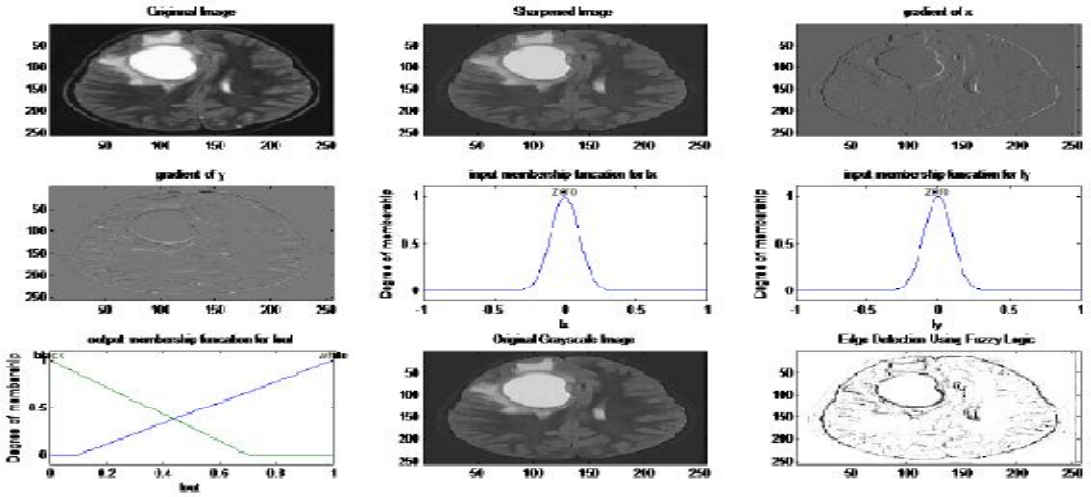


Figure 7: Brain Tumor Detection

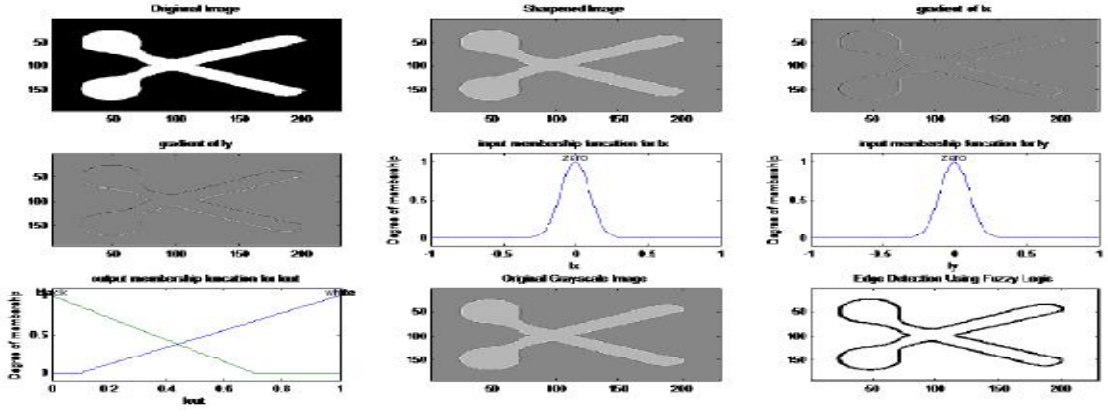


Figure 8: A knife edge Detection

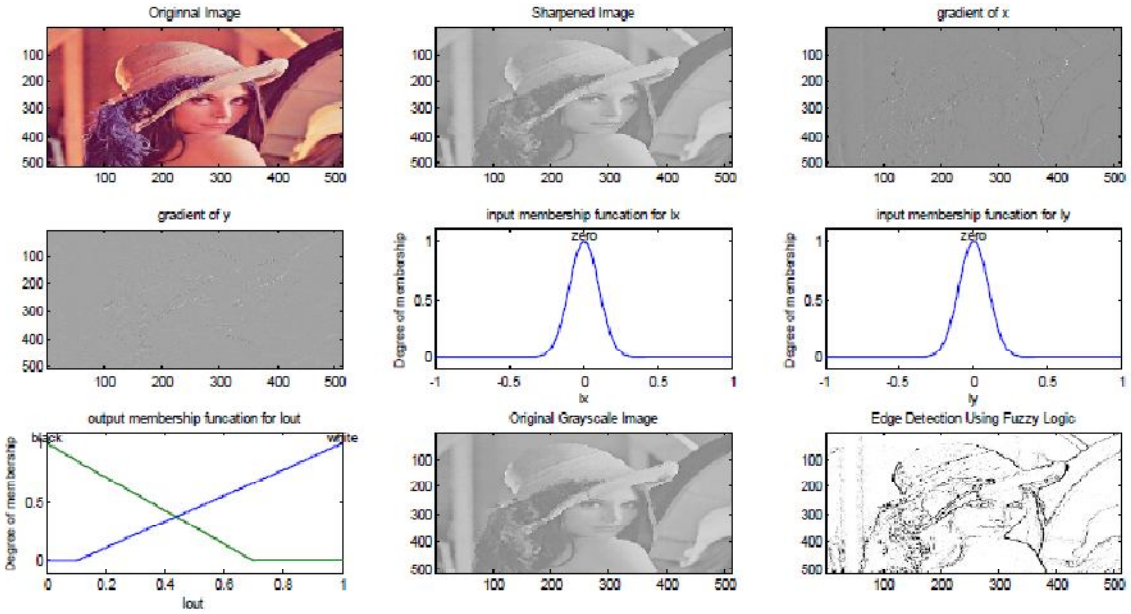


Figure 9: A model Girl

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