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A New Modified Fuzzy Rule Based Edge Detection

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Abstract: Edge is a basic feature of image. The image edges include rich information that is very significant for obtaining the image characteristic by object recognition.Edge detection is the most commonly used technique in image processing. So this paper represents a modified rule based fuzzy logic technique, because fuzzy logic is desirable to convert the uncertainties that exist in many aspects of image processing. Here firstly the gradient and standard deviation is calculated and used as input for fuzzy system. This is applied on traditional algorithm like Sobel, Prewitt , LoG and then the results are compared with modified algorithm and concluded that the proposed technique is to find the more fine edges and reduce the pixels that are not belonging to the edge.

Keywords: Image Processing, Edge detection, Fuzzy logic, Defuzzification, Edge, Fuzzy Inference system

I. INTRODUCTION

When we imitate the human visual system by using computer algorithms, quite a lot of problems can be encountered. Penetration of computers into each area of the market and living has forced the designers to add the capability to see and analyze and to innovate more and more into the area of electronic vision or image processing. At the level of computational intelligence for electronic vision, 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. The goal of the edge detection process in a digital image is to determine the frontiers of all represented objects, based on automatic processing of the color or gray level information in each present pixel. This procedure has many applications in image processing and computer vision, and is an indispensable technique. An edge is defined by a discontinuity in gray level values. In other words, an edge is the boundary between an object and the background. The shape of edges in images depends on many parameters: The geometrical and optical properties of the object, the illumination conditions, and the noise level in the images. Edges include the most important information in the image, and can provide the information of the object's position.[1] Edge detection is an important link in computer vision and other image processing, used in feature detection and texture analysis. Most previous edge detection techniques used first-order derivative operators such as the Sobel edge operator,[2] the Prewitt edge operator and the Robert edge operator. The Laplacian operator is a second order derivative operator for functions of two-dimension operators and is used to detect edges at the locations of the zero crossing. Recent examples include edge detectors using fuzzy logic, neural networks, or wavelets [Sun and Sclabassi 1995, Law *et al*. 1996, Bezdek *et al*. 1996, Wang *et al*. 2005]. Comparison of edge detection approaches and an assessment of their performance may be found in [Demigny et al. 1995, Ramesh and Haralick 1994].In this paper, fuzzy logic based approach to edge detection in digital images is proposed. Firstly, for each pixel in the input image edginess' measure is calculated using three 3 x 3 linear filters after which three fuzzy sets characterized by three (3) Gaussian membership functions associated to linguistic variable Low, Medium and High were created to represent each of the edge strengths. The second phase involves application of fuzzy inference rule to the three fuzzy sets to modify the membership values in such a way that the fuzzy system output (edge) is high only for those pixels belonging to edges in the input image. The last step is final pixel classification as edge or non-edge using Mamdani defuzzification method.

II. APPLICATION OF FUZZY LOGIC BASED EDGE DETECTION

Many techniques have been suggested by researchers in the past for fuzzy logic-based edge detection [Cheung and Chan 1995, Kuo, *et al*. 1997, El-Khamy *et al*. 2000]. In [Zhao, *et al*. 2001], Zhao, *et al*. proposed an edge detection technique based on probability partition of the image into 3-fuzzy partitions (regions) and the principle of maximum entropy for finding the parameters value that result in the best compact edge representation of images. In their proposed technique the necessary condition for the entropy function to reach its maximum is derived. Based on this condition an effective algorithm for three-level threshold is obtained. Several approaches on fuzzy logic based edge detection have been reported based on fuzzy If-Then rules. A similar work is proposed by Mansoori, *et al*. [Mansoori, *et al*. 2006], wherein adjacent points of each pixel are grouped in six different set. Then by using of appropriate bell shape membership function, the value from zero to one is determined for each group. Based on the membership values, and fuzzy rules, decision about existing/not existing and direction of edge pixels are obtained. Some advantages and disadvantages of Fuzzy Logic are as follows:

Advantages:

-Helpful for very complex or lightly nonlinear processes.

-Allows use of "fuzzy" concepts like medium, low, etc.

-Biggest impact is for control problems.

-Help avoid discontinuities in behavior.

Disadvantages :

-sometimes results are unexpected and hard to debug.

-Computationally complicated

-According to literature ,Fuzzy Logic is not recommendable ,if conventional approach yields a satisfying result.

A. Fuzzy Inference System

Fuzzy systems are made of a knowledge base and reasoning mechanism called fuzzy inference system. A fuzzy inference system (FIS) consists of four functional blocks as shown in figure.

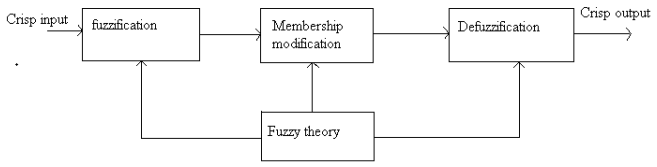

Figure : 1 Fuzzy Inference System

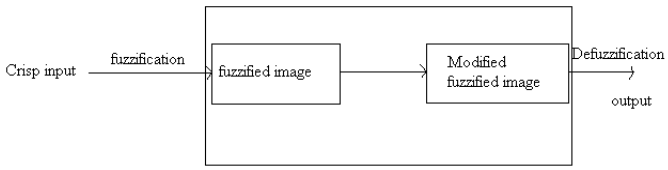

Figure:2 Membership Modification

Fuzzification: Transforms the crisp inputs into degrees of match with linguistic values. Reverse process of defuzzification.

***Knowledge Base*:** Consists of a rule base and a database. A rule base contains a number of fuzzy if-then rules. A database defines the membership function of the fuzzy sets used in the fuzzy rules.

Fuzzy Inference Engine: Fuzzy Inference engine performs the inference operations on the rules.

Defuzzification: This conversion of fuzzy set to single crisp value is called defuzzification.

B. Motivation behind Fuzzy Image Processing There are many reasons to do this. The most important of them are follows:

- Fuzzy is powerful tool to knowledge representation and process human knowledge in form of fuzzy if then rules.
- Fuzzy techniques can manage the ambiguity efficiently and vagueness (an image can be represented as a fuzzy set).

III. PROPOSED WORK

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. For each pixel in the image edge strength value is calculated with three (3) 3× 3linear spatial filters i.e. low-pass, high-pass and edge enhancement filters (Sobel) through spatial convolution process. In carrying out a 3× 3 kernel convolution, nine convolution coefficients called the convolution mask are defined . The edge strength values derived from the three (3) masks served as the inputs used in the construction of the fuzzy inference system based on which decision on pixel as belonging to an edge or not are made. Membership functions are defined for fuzzy system inputs.

For fuzzy logic rules depends on the weights of 8 neighbors grey level pixels .The ability of the rule is to extract all the edges directly in the processed image. The four rules are dealing with the checked or centre pixel of mask .If the greys in one line are black then checked pixel will be white otherwise it will remain same because there is no need to convert it into black otherwise. So this group of rules is to find edges, black pixel or white pixel. In the fuzzy inference system the input will be given from the range of 0-1.Then the fuzzy construction side the input greys is ranged from 0-255 grey intensity. And here these grey levels are converted into the mathematical values for input to the membership functions and the output is again presented to values from 0-255 after applying defuzzification process. It is found that the best results are obtained by using the threshold value 80; here we get black between 0-80 and white between 80-255. There are different methods used for edge detection so in first method the gradient values are computed and is compared with the threshold value ,pixels with greater gradient value than the threshold value will be considered as edge candidate[3] .similarly the second method is calculating the standard deviation and compared with threshold value and pixel with higher SD then threshold value will be the edge candidate .The next step is to apply first order gradient and standard deviation and then apply fuzzy rules .so two computed values are used as inputs for the fuzzy system.[2] The final decision will be based on the output. Before applying rules ,both the gradient and SD are mapped to range of [0 to 100] and are classified as low ,medium ,high classes the classes are represented as SL,SM and SH, there are four thresholds used a1 ,c1 ,a2 , c2 .and the classification of edges will be according to the values ,if SD value is in range of [0 c1] the pixel is SL SD value is in range of [a1 c2] the pixel is SM SD value is in range of [a2 100] the pixel is SH. Similarly for the gradient values.

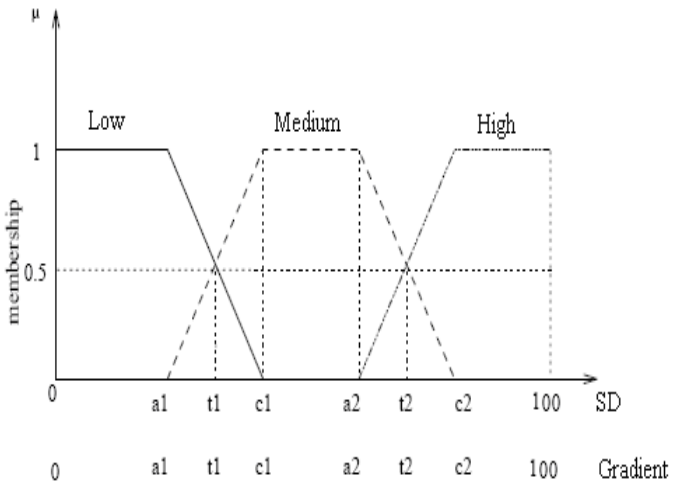

Fig.3 -The defined classes and membership functions

Table I –Fuzzy System rules

Rule-1	If {(i, j-1)& (i+1, j)} are blacks If{(i-1)&(j-1) &(i-1,j) &(i-1,j+1) &(i,j+1)&(i+1,j+1)} are whites If{(i+1,j+1)} are whites	Checked pixel is white (edge)
Rule-2	If {(i, j-1) &(i-1, j)}are blacks If{(i-1,j+1)&(I,j+1)&(i+1,j+1)&(i+1,j)&(i+1,j-1)} are whites If {(i-1,j-1)} are whites	Checked pixel is white (edge)
Rule-3	If {(i-1,j) & (i,j+1)} are blacks If {(i-1,j-1)&(i,j-1) & (i+1,j-1) &(i+j, j) &(i+1,j+1)} are whites If {(i-1,j+1)} are whites	Checked pixel is white (edge)
Rule-4	If{(i,j+1) &(i+1,j)} are blacks If{(i-1,j-1) &(i-1,j) &(i-1,j+1) &(i,j-1) &(i+1,j-1)} are whites If{(i+1,j+1)} are whites	Checked pixel is white (edge)

So the values for these classes are

$$C_L = 0.25 \ , C_M = 0.5 \ , C_H = 0.75$$

Then the final edge pixel will be calculated as

Edgefinal=(sl*gl*cl)+(sl*gm*cl)+(sl*gh*cm)+(sm*gl*cl) +(sm*gm*cm)+(sm*gh*ch)+(sh*gl*cm)+(sh*gm*ch)+(sh*gh *ch)

Finally compared to the threshold equal to 0.26, pixel is classified as edge.

IV. CONCLUSION

Modified rule based edge detection technique is presented in this paper. The standard deviation and gradient values are used as input for fuzzy system using membership function .Fuzzy if-then else rules are applied to modify the membership to one of Low, medium and high classes. Finally defuzzification is performed. The three edge strength values used as fuzzy system inputs were fuzzified using Gaussian membership functions. Fuzzy if then rules are applied to modify the membership to one of low, medium, or high classes.

It is shown that the proposed technique is less computationally expensive. It improves the quality of edges as compared to Sobel ,Prewitt and LoG operator.This algorithm is suitable for applications in the area of digital image processing for face recognition, medical imaging, remote sensing, where specific boundaries need to be specified for further image analysis.

V . RESULTS

The proposed algorithm is modified rule based edge detection using fuzzy logic. A new modified algorithm is implemented and its results are compared with the existing edge detectors like Prewitt (b) and LoG (c) and sobel (d).

The results are applied on different images, as shown in fig4(a), the original images of Lena, Beans, and Bamboon. The output image fig 4(b) with operator Prewitt is showing clear but very thick edges, similarly LoG in fig-4(c) and Sobel in fig 4(d) are thicker than the output of the proposed algorithm shown in fig-4(e).

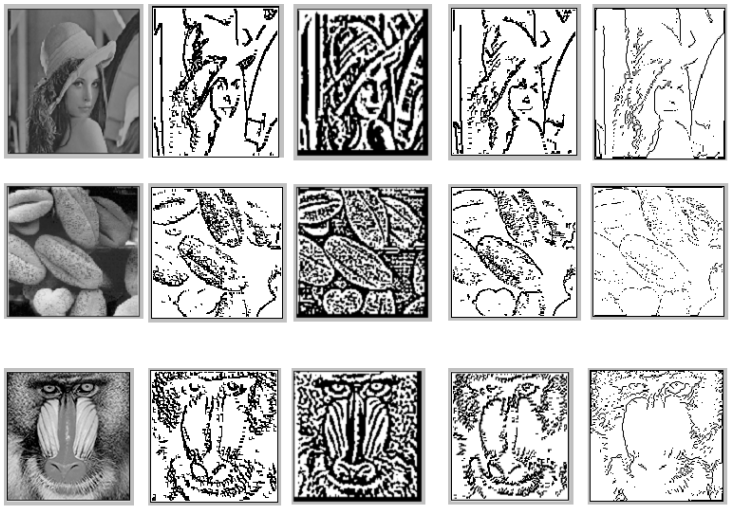

Fig- 4-Outputs showing results

VI. FUTURE SCOPE

The designed fuzzy rules are a good solution to improve the quality of edges .In this paper a modified technique of edge detection is introduced that is based on primary edge detection methods including gradient and standard deviation is calculated here. Then the fuzzy inference system decides that whether the pixel is an edge candidate or not. The proposed method shows better outputs as compared to sobel, Log, Prewitt.

The future scope for this work can be modification of membership functions to get good results for very low contrast images and it can be applied on the colour images also.

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