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An Improved Fuzzy Rule Based Edge Detection Technique

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Abstract- Edge detection is imperative part of image processing. In this paper the development of fuzzy rule based edge detection technique is presented. The proposed technique makes use of three linear spatial filters i.e. high-pass, low-pass and first order edge detector filters to produce three edge values at each pixel location of the digital image through spatial convolution process. These three edge values are cogitated as fuzzy inputs and edge values along with Gaussian membership functions helps to decide that whether pixel in focus is an edge or not. The comparison operators are applied and the experimental results show that the proposed technique shows better results than Sobel, Prewitt and traditional fuzzy logic technique.

Keywords- Edge detection, Fuzzy logic, Fuzzy inference system, Edge strength.

I. INTRODUCTION

Edges are one of the most important visual evidences in image processing [1]. Edges are defined on those pixel locations where there are abrupt changes in intensities. Edge detection is of great interest as it is a crucial issue in image processing,object recognition, locate object in satellite images, medical imaging, automatic driving, computer guided surgery diagnosis, automatic traffic controlling systems, face and finger print recognition, etc. [2,3].

Many edge detection approaches have been proposed till now. The classical approaches include Sobel, Prewitt, Kirsch and Robert's cross. These are simple to compute and are capable to detect the edges, but the smoothing stage is missing, also they have sensitivity to noise and results are less accurate [4, 5]. The Laplacian of Gaussian (LoG) gives sharp edges but malfunctions when examining corners. The Canny algorithm has better performance than the above operators as it reduces probability of false edge detection in this a large amount of calculation is to be done and performance of real time is poor.

In the recent years, a variety of new edge detection techniques have been explored based upon fuzzy logic, mathematical morphology, wavelet transform, neural networks etc. Fuzzy logic represents a powerful approach for decision making. The concept of fuzzy logic was given by Zadeh on 1965. In this paper rule based fuzzy logic technique is proposed. Firstly[4] for each input image three edge values are calculated by using three 3*3 linear filters after which fuzzy sets characterized by three Gaussian membership functions associated to linguistic variables 'low', 'medium' and 'high' are created to represent the edge strength. Secondly, the application of fuzzy inference rules to the fuzzy sets to modify membership functions to get the output. Depending upon the edge values, fuzzy inference rules define that whether fuzzy output would be low, medium or high.

II. FUZZY INFERENCE SYSTEM

Fuzzy logic technique is a collection of different fuzzy approaches. Edge detection with fuzzy logic comprises of fuzzification, expert knowledge, membership modification, fuzzy set theory and defuzzification[6]. As shown in fig1. The fuzzification and defuzzification steps are required because of the fact that no fuzzy hardware is available. Therefore, the coding of image data called fuzzification and decoding of the results called defuzzification are steps that are required to process images with fuzzy techniques. The fuzzy sets were created to symbolize each variable's intensities as "White", Edge and "Black [7]. The dominance of fuzzy image processing is with the middle step, all inputs that are fed into fuzzy inference systems (FIS) [10] are obtained by first applying a high-pass filter to the original image and a first-order edge detection filter such as Prewitt operator and a low-pass filter [9].

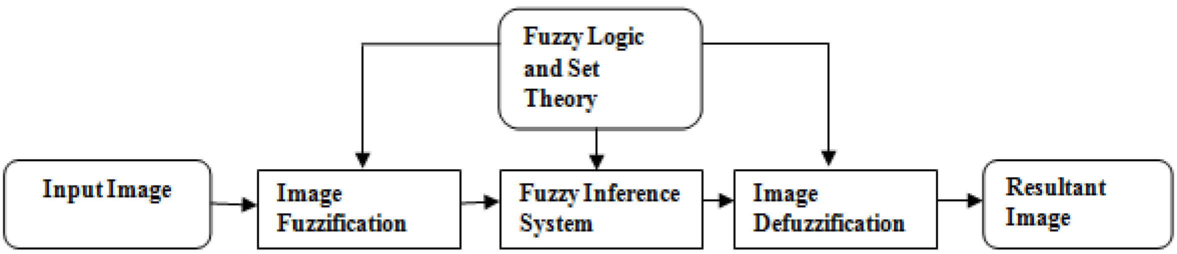

Figure 1. Fuzzy Inference System

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III. PROPOSED ALGORITHM

In this paper firstly the pre-processing of the image is done. The pixels where there are abrupt changes in intensity are to be located. For this purpose the edge value is calculated with three 3*3 linear spatial filters i.e. a low-pass, a high-pass, and edge enhancement filter (Prewitt) through spatial convolution process. For carring out 3*3 convolution, 9 convolution coefficients called convolution masks are defined as shown below [6]:

[i-1,j-1]	[i-1,j]	[i-1,j+1]
[i,j-1]	[i, j]	[i,j+1]
[i+1,j-1]	[i+1,j]	[i+1,j+1]

Figure2. 3*3 convolution mask

Prewitt operators are used to firstly find the first derivative of Image in horizontal and vertical directions. The following masks are used.

-1	0	+1
-1	0	+1
-1	0	+1

+1	+1	+1
0	0	0
-1	-1	-1

Ph
Pv

Figurre 3. Prewitt Masks

Then the convolution operation is applied on the filtered images.

$$Ch = Ph*I$$

$$Cv = Pv*I$$

The result of the two Prewitt kernels is combined to get the final value.

$$Val = \sqrt{(Ch^2 + Cv^2)}$$

A high-pass filter is defined as:

H_{hf}=

0	-1/4	0
-1/4	2	-1/4
-1/4	0	-1/4

The filtered image is calculated through a bidimensional convolution operation.

$$HF = H_{hf}*\text{Original Image}$$

The median filter is calculated as shown below by using the 3*3 mask.

$$mf = \text{median}\{x_1,x_2,x_3,x_4,x_5,x_6,x_7,x_8,x_9\}$$

The filtered image is also calculated through a bidimensional convolution operation.

$$MF = mf*\text{Original Image}$$

IV. FUZZY SETS AND FUZZY MEMBERSHIP FUNCTIONS

Three fuzzy sets are made up to represent each variable's strengths; these sets are represented by the linguistic variables "low", "medium" and "high". The implemented membership functions for the fuzzy sets are Gaussian function and sigmoidfunction. For the linguistic variables "low" and "high", sigmoid function is chosen; Gaussian
Function is used for the variable "medium" with the mean 120 as shown in Figure.

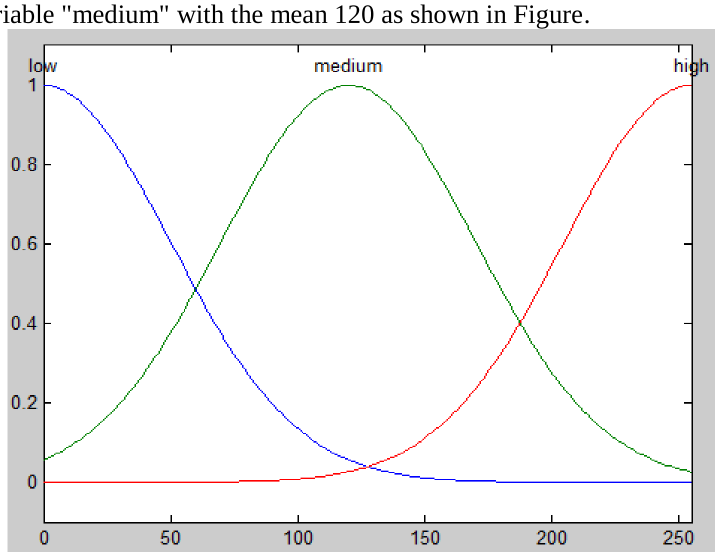

Figure 4. Input Membership Functions

By the defined fuzzy rules, the output of this fuzzy system is classified to one of threeclasses [9]. Output membership functions are shown in figure 5.

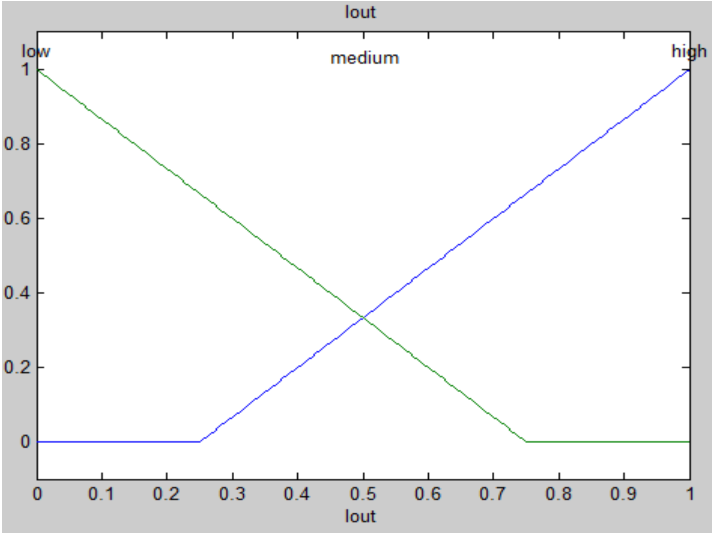

Figure 5. Output Membership Functions

Fuzzy inference rules are applied to assign the three fuzzy sets characterized by membership functions High, Mediumand Lowto the output set [11].

V. FUZZY INFERENCE RULES

The fuzzy inference rules are defined as shown below [6,8]:

1. If (MF is low) and (Val is low) and (HF is low) THEN (“Edge is low”).
2. If (MF is low) and (Val is low) and (HF is medium) THEN (“Edge is low”).
3. If (MF is low) and (Val is low) and (HF is high) THEN (“Edge is low”).
4. If (MF is low) and (Val is medium) and (HF is low) THEN (“Edge is low”).
5. If (MF is low) and (Val is medium) and (HF is medium) THEN (“Edge is low”).
6. If (MF is low) and (Val is medium) and (HF is high) THEN (“Edge is medium”).
7. If (MF is low) and (Val is high) and (HF is low) THEN (“Edge is low”).
8. If (MF is low) and (Val is high) and (HF is medium) THEN (“Edge is high”).
9. If (MF is low) and (Val is high) and (HF is high) THEN (“Edge is high”).
10. If (MF is medium) and (Val is low) and (HF is low) THEN (“Edge is low”).
11. If (MF is medium) and (Val is low) and (HF is medium) THEN (“Edge is low”).
12. If (MF is medium) and (Val is low) and (HF is high) THEN (“Edge is medium”).
13. If (MF is medium) and (Val is medium) and (HF is low) THEN (“Edge is medium”).
14. If (MF is medium) and (Val is medium) and (HF is medium) THEN (“Edge is medium”).
15. If (MF is medium) and (Val is medium) and (HF is high) THEN (“Edge is high”).
16. If (MF is medium) and (Val is high) and (HF is low) THEN (“Edge is medium”).
17. If (MF is medium) and (Val is high) and (HF is medium) THEN (“Edge is high”).
18. If (MF is medium) and (Val is high) and (HF is high) THEN (“Edge is high”).
19. If (MF is high) and (Val is low) and (HF is low) THEN (“Edge is low”).
20. If (MF is high) and (Val is low) and (HF is medium) THEN (“Edge is medium”).
21. If (MF is high) and (Val is low) and (HF is high) THEN (“Edge is medium”).
22. If (MF is high) and (Val is medium) and (HF is low) THEN (“Edge is medium”).
23. If (MF is high) and (Val is medium) and (HF is medium) THEN (“Edge is medium”).
24. If (MF is high) and (Val is medium) and (HF is high) THEN (“Edge is high”).
25. If (MF is high) and (Val is high) and (HF is low) THEN (“Edge is medium”).
26. If (MF is high) and (Val is high) and (HF is medium) THEN (“Edge is high”).
27. If (MF is high) and (Val is high) and (HF is high) THEN (“Edge is high”).

The above rules are applied on different images and the results are as shown below:
The outputs of the images in MATLAB R2013a are as shown below:
4 input images have been taken for finding the outputs (1) Road (2) Flower (3) Flower1 (4) Clock

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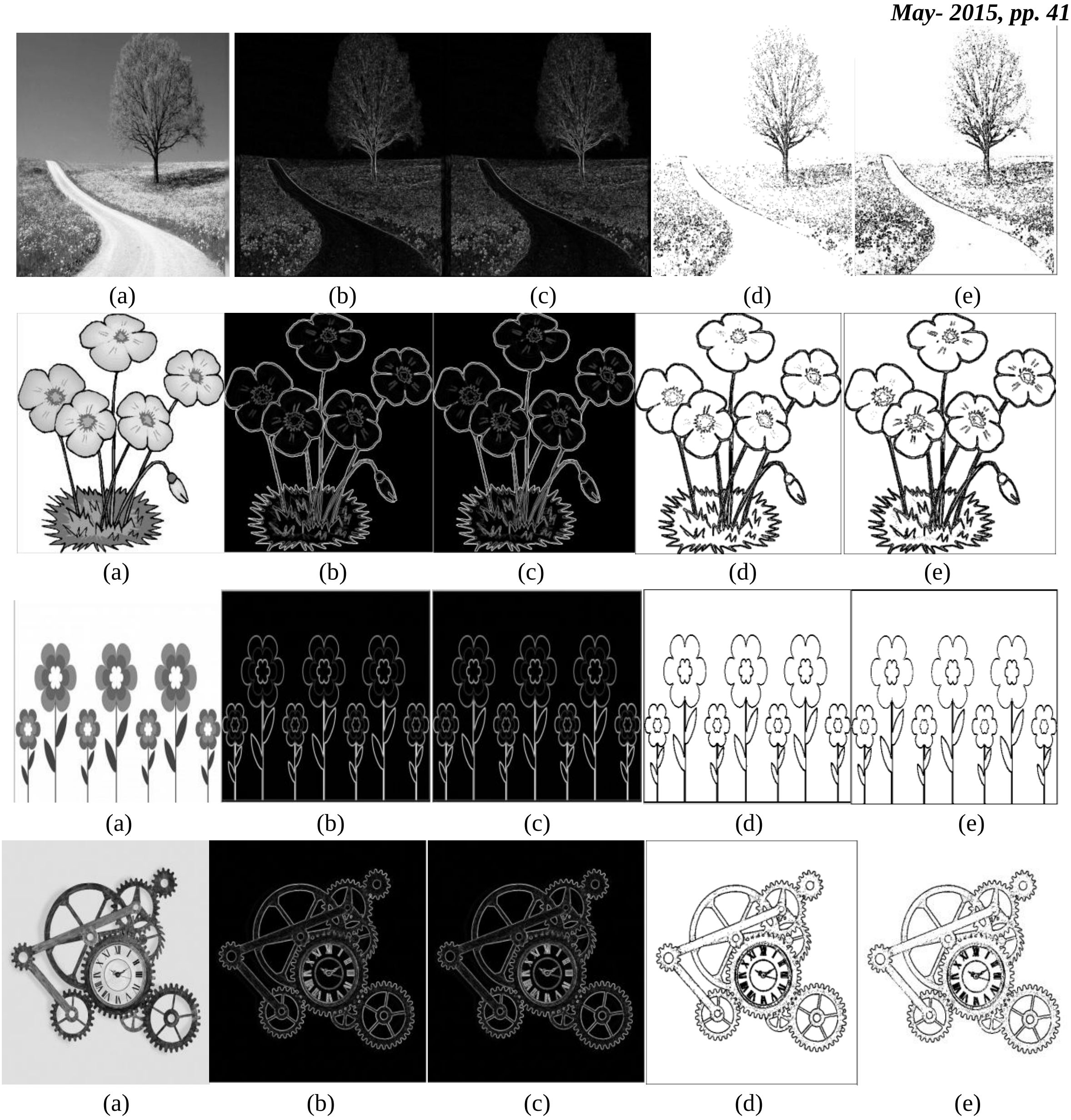

Fig 9: (a)Original Image (b) Sobel (c) Prewitt (d) Old Fuzzy (e) New Fuzzy

The results are compared on the basis of 4 comparison parameters that are Edge Density, Edge Intensity, Root Mean Squared Error(RMSE) and Peak Signal to Noise Ratio(PSNR)[12,14].
The above experimental results are shown in the form of graphs.

VI. EXPERIMENTAL RESULTS

The results are shown below:

Table 1. Edge Density

Image	Sobel	Prewitt	Old fuzzy	Proposed Fuzzy
1.Road	71.2333	51.2791	82.7691	**88.7314**
2.Flower	94.2612	70.1091	102.7131	**105.3814**
3.Flower1	54.1565	40.6249	105.7789	**107.5632**
4.Clock	61.9526	45.7669	109.7256	**112.1047**

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Table 2. Total Edges

Image	Sobel	Prewitt	Old Fuzzy	Proposed Fuzzy
1.Road	18673388	13442517	21696896	**23260544**
2.Flower	25694288	19110759	27998144	**28725504**
3.Flower1	7902516	5927987	15435264	**15695616**
4.Clock	16240507	11997510	28763904	**29387584**

Table 3. Root Mean Squared Error

Image	Sobel	Prewitt	Old Fuzzy	Proposed Fuzzy
1.Road	120.1068	113.7099	67.7109	**61.7059**
2.Flower	302.7057	259.4696	119.1733	**117.3248**
3.Flower1	241.7595	226.7418	122.0049	**120.1902**
4.Clock	223.3248	204.7409	95.6515	**94.2429**

Table 4. Peak Signal to Noise Ratio(PSNR)

Image	Sobel	Prewitt	Old Fuzzy	Proposed Fuzzy
1.Road	6.5395	7.0148	11.5176	**12.3243**
2.Flower	-1.4896	-0.1509	6.6072	**6.7430**
3.Flower1	0.4631	1.0240	6.4033	**6.5334**
4.Clock	1.1521	1.9067	8.5170	**8.6458**

In the above results the bold results are the best ones. The more the value of Edge Density, Edge Intensity, PSNR the better the results and the lesser the RMSE value the better the results. The above results are shown graphically below.

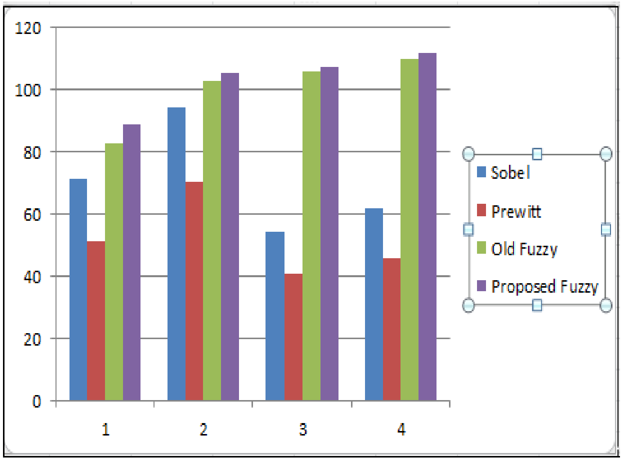

Figure10: Edge Density

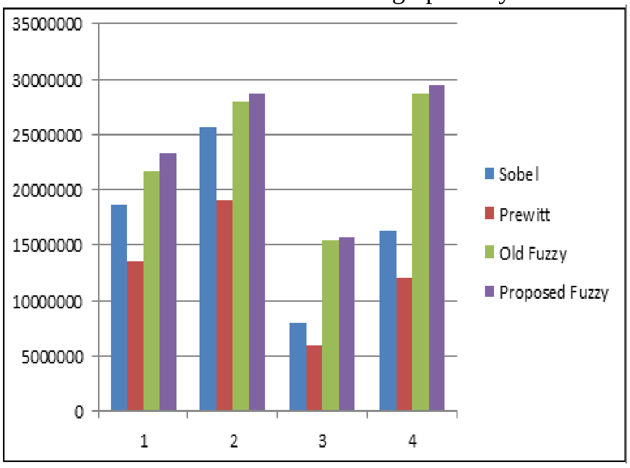

Figure 11: Total Edges

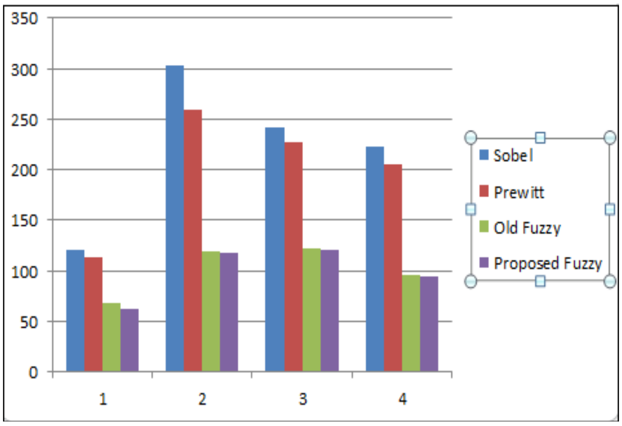

Figure 12: Root Mean Squared Error

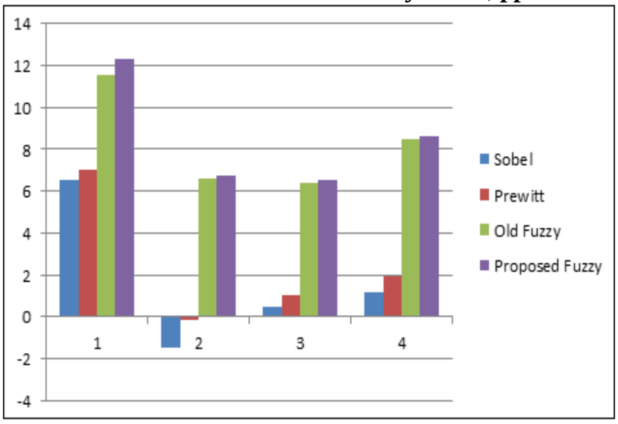

Figure 13: Peak Signal to Noise Ratio

VII. CONCLUSIONS

From the above inferences it can be concluded that the new fuzzy technique gives better results than all other techniques. It has more Edge Density, Edge Intensity and PSNR than the other techniques, and it has lesser value for error i.e. RMSE So it is concluded that from the results of comparison parameters, Improved fuzzy gives the most efficient results.

VIII. FUTURE SCOPE

1. Apply rules at different membership functions to check for better results.
2. In this technique firstly the image is converted into grayscale image so because of that in some images the object colour becomes almost similar to the background colour and because of that some edges go undetected.
3. Apply neural networks for edge detection so that after getting trained, the edges can detected be automatically.

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