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Approach for Optimizing the Fuzzy Logic Based Edge Detection of Noisy Images

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Abstract— Edge detection aims to mark sharp intensity changes in an image and is a basis for a large number of image analysis and machine vision applications. We implement an edge detection algorithm that uses fuzzy logic. We generally use the median filtering to remove the Pepper noise or black dots present over the image. This results in blurring effect of the image. When this smoothened or blurred image is given as an input to the fuzzy logic based edge detection method, the resultant edge detected image will not be clear due to blurring effect in input image. In our work, instead of giving the blurred image directly to the fuzzy logic based edge detection module as an input, we increase the quality of blurred, noise removed image (image enhancement) by using Gaussian high pass filtering method. And also we compare the proposed method with the approach of direct input of smoothened noise removed image, based on the number of correct edge pixels and number of false edge pixels detected.

Keywords— Fuzzification, Membership Function, Fuzzy Logic.

INTRODUCTION

Edge is an important feature in an image and carries important information about the objects present in the image. Extraction of edges is known as edge detection. Edge detection aims to localize the boundaries of objects in an image and significantly reduces the amount of data to be processed [9]. Edge detection aims to mark sharp intensity changes in an image and is a basis for a large number of image analysis and machine vision applications.

Fuzzy logic provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy, or missing input information. There are two types of fuzzy inference system Mamdani type FIS and Sugeno type FIS. Mamdani method is widely accepted for capturing expert knowledge. It allows us to describe the expertise in more intuitive, more human-like manner. However, Mamdani-type FIS entails a substantial computational burden. On the other hand, Sugeno method is computationally efficient and works well with optimization and adaptive techniques, which makes it very attractive in control problems, particularly for dynamic non linear systems.
The membership function is a graphical representation of the magnitude of participation of each input. It associates a weighting with each of the inputs that are processed, define functional overlap between inputs, and ultimately determines an output response. Once the functions are inferred, scaled, and combined, they are defuzzified into a crisp output which drives the system. There are different shapes of membership functions; triangular, trapezoidal, piecewise-linear, Gaussian, bell-shaped, etc.

RELATED WORKS

In order to recognize objects, in computer vision, a digital image is divided into multiple segments (sets of pixels). Image segmentation is generally used to locate objects and boundaries in images [6]. Kiranpreet Kaur, Vikram Mutenja and Inderjeet Singh Gill have proposed a Fuzzy Inference System (FIS) for edge detection [3]. However, they have used threshold value and 16 number of fuzzy rules for detecting edginess. Aborisade, D.O proposed the Novel Fuzzy logic Based Edge Detection Technique [4] in which the proposed technique used three linear spatial filters to generate three edge strength values at each pixel of a digital image through spatial convolution process. Decision on whether pixels in focus belong to an edge or non-edge is made in the proposed technique based on the Gaussian membership functions and fuzzy rules. Mamdani defuzzifier method is employed to produce the final output pixel classification of a given image. The edge detection method using

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fuzzy logic proposed by Bhagbhati and Chumidas [5] uses 10 fuzzy rules using 2*2 mask and triangular fuzzification method is applied. Image Edge Detection Using Ant Colony Optimization by Anna Veronica Baterina and Carlos Oppus [6] proposed the method establishes a pheromone matrix that represents the edge information at each pixel based on the routes formed by the ants dispatched on the image. In a Hybrid Approach to Edge Detection using Ant Colony Optimization and Fuzzy Logic [1] uses 3*3 mask and only 6 fuzzy rules are applied and Gaussian method is used for fuzzification. The heuristics information for ants movement is decided by fuzzy logic with simple rules. Our work considers Gaussian High Pass filtering for increasing the edge quality of the blurred image and then result is given to fuzzy logic based edge detection module.

SYSTEM DESIGN

A. Design considerations

For the proper working of this method of finding total correct edge pixels, total edge pixels, and total false pixels it must satisfy following conditions based on which we justify the proposed method is better.:

1) The input image (colour image) must be converted to gray image then converted to binary image.

This is because when we use the direct conversion of colour image to binary, it may consider any one plane among three planes as input image and then it results in incorrect count of actual edge pixels present in input image. This is tested with small image 12*13 containing red colour background over which small black line which has to be detected. Even though the above condition fails in giving the correct values for required parameters (total number of edge pixels detected, total number of correct edge pixels and total number of false pixels detected), it finally gives the edge detected image based on the membership function used. It is shown in the snapshot 10.

2) The image must have only the white back ground with the shape outline of one pixel thickness only.

Even though the first condition is satisfied by the image the colour of image background must be white because any other colour background image converted to gray image, the background pixels also considered as edge pixels when converted to binary image. This is tested with small image 12*13 containing red colour background over which small black line which has to be detected. Even though the above condition fails in giving the correct values for required parameters (total number of edge pixels detected, total number of correct edge pixels and total number of false pixels detected), it finally gives the edge detected image based on the membership function used. It is shown in the snapshot 11.

B) Proposed System

Fig.1 shows the block diagram of the modules involved in the proposed method for edge detection of noisy images.

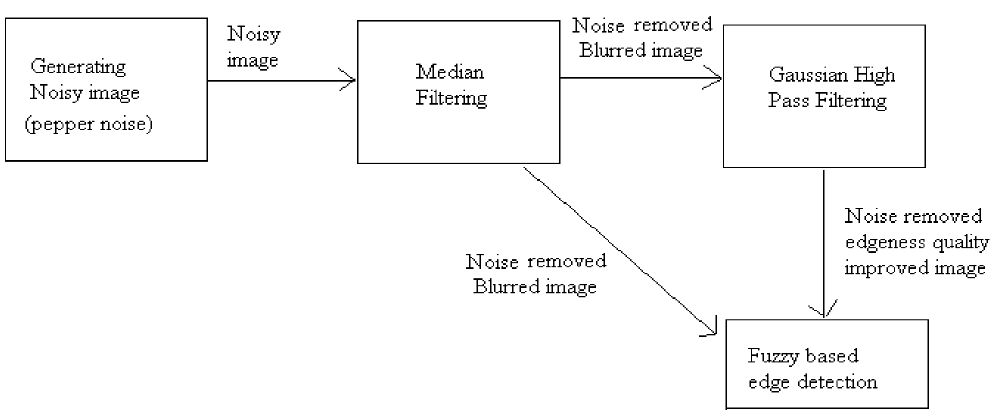

Fig 1: Block diagram of the edge detection of noisy images using filtering methods

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Fuzzy image processing has three main stages: image fuzzification, modification of membership values, and, if necessary, image defuzzification as shown in Fig. 1. The fuzzification and defuzzification steps are due to the fact that we do not possess fuzzy hardware. Therefore, the coding of image data (fuzzification) and decoding of the results (defuzzification) are steps that make possible to process images with fuzzy techniques.

The new fuzzy rule based edge detection system is used by designing a Fuzzy Inference System (FIS) of Mamdani type using MATLAB toolbox. The algorithm detects edges of an input image by using a window mask of 2x2 size that slides over the whole image horizontally pixel by pixel. The FIS is implemented by considering four inputs which correspond to four pixels P1, P2, P3 and P4 of the 2*2 mask in Fig-4 and one output variable.

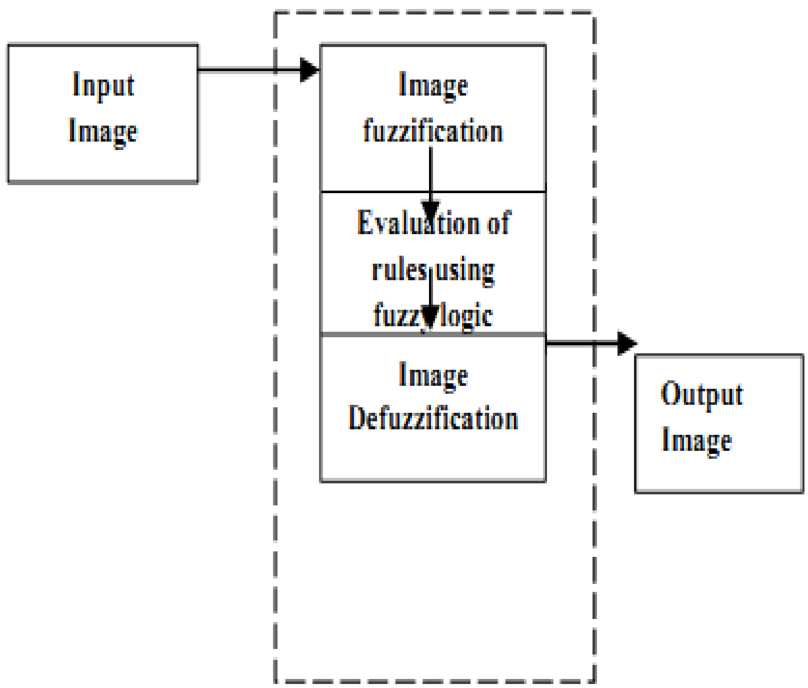

Fig.2. Structure of Fuzzy Image Processing

IMPLEMENTATION

In the first phase of the FIS, the fuzzification of input is performed by defining trapezoidal, triangular and Gaussian membership functions called Black and white separately for each membership function. On evaluation of these two functions, all the image pixels (crisp set) are classified into Black or White fuzzy sets. Once the pixels are fuzzified, in the second phase of the FIS, a rule base is evaluated to get the output. A triangular membership function for the output is defined called as Edge In the rule base of the FIS, 10 numbers of rules have been defined to apply implication on the inputs [1].

The inference rules depend on the weights of 3 neighbors i.e. P1, P2 and P3 and P4 itself, if the weights are degree of Black or degree of White. These weights are combined using AND operator as defined in the rule base. The output of applying implication is again fuzzy. These fuzzy output of all rules are combined into a single fuzzy set by aggregating them with the OR (max) operation. In the final phase of the FIS, the output fuzzy set. Edge is defuzzified to get a crisp set and the desired final output. Here the defuzzification operation is performed by calculating the centroid. In order to resolve a single crisp value from the aggregated fuzzy output set we calculate the center of the area under the curve. The block diagram of the FIS designed here is depicted in the Figure 2.

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1. The rule base used in the FIS comprises the following 10 fuzzy rules for considering the weights of the 3 neighbors P1, P2 and P3 with P4.
2. If P1 is Black and P2 is Black and P3 is Black and P4 is White then P4 is Edge.
3. If P1 is Black and P2 is Black and P3 is White and P4 is White then P4 is Edge
4. If P1 is Black and P2 is White and P3 is Black and P4 is White then P4 is Edge
5. If P1 is White and P2 is Black and P3 is Black and P4 is White then P4 is Edge
6. If P1 is White and P2 is White and P3 is White and P4 is Black then P4 is Edge
7. If P1 is White and P2 is White and P3 is Black and P4 is Black then P4 is Edge
8. If P1 is Black and P2 is White and P3 is White and P4 is Black then P4 is Edge.
9. If P1 is White and P2 is Black and P3 is White and P4 is Black then P4 is Edge
10. If P1 is Black and P2 is Black and P3 is White and P4 is Black then P4 is Edge
11. If P1 is Black and P2 is White and P3 is Black and P4 is Black then P4 is Edge.

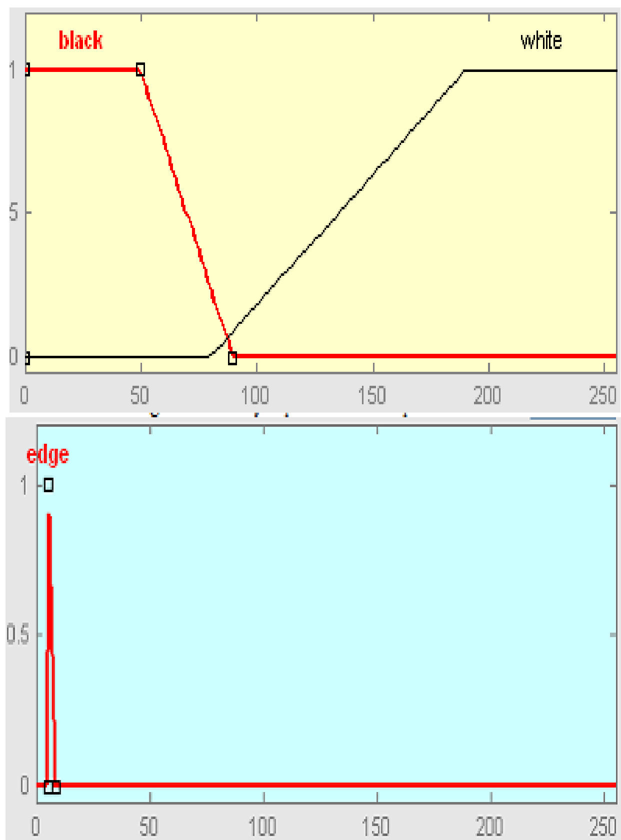

Fig 3: Sample of trapezoidal MF based input with triangular MF based output

P1 **x(i-1,j-1)**	**P2** **x(i-1,j)**
P3 **x(i,j-1)**	**P4** **x(i,j)**

Fig 4: 2*2 mask

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V. RESULTS AND DISCUSSION

To make the comparison easier we are considering the images which are having object shape triangle in it which of thickness 1 pixel. The results are tabulated as shown in Table form for 5 trials. Fig 4 shows the input image.

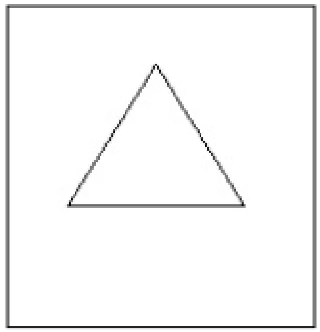

Fig 5: Image containing triangle shaped object.

The three membership functions are compared based on the number of edge pixels detected, number of correct edge pixels detected and number of false pixels detected, the method used to find these values must be tested for correctness. We do testing of this method by taking a small image of size 11*12 and displayed the contents or pixels values of the image and manually verified for total edge pixels, correct edge pixels and total false pixels obtained. [7] proposed a method in which the minimization is per-formed in a sequential manner by the fusion move algorithm that uses the QPBO min-cut algorithm. Multi-shape GCs are proven to be more beneficial than single-shape GCs. Hence, the segmentation methods are validated by calculating statistical measures. The false positive (FP) is reduced and sensitivity and specificity improved by multiple MTANN. [8] proposed a system, this system has concentrated on finding a fast and interactive segmentation method for liver and tumor segmentation. In the pre-processing stage, Mean shift filter is applied to CT image process and statistical thresholding method is applied for reducing processing area with improving detections rate. In the Second stage, the liver region has been segmented using the algorithm of the proposed method. Next, the tumor region has been segmented using Geodesic Graph cut method. Results show that the proposed method is less prone to shortcutting than typical graph cut methods while being less sensitive to seed placement and better at edge localization than geodesic methods. This leads to increased segmentation accuracy and reduced effort on the part of the user. Finally Segmented Liver and Tumor Regions were shown from the abdominal Computed Tomographic image.

Trial 1			
Input image having triangle shaped object of thickness 1 pixel 238 edge pixels	**Method**	**Number of correct edge pixels detected**	**Number of false edge pixels detected**
	Using Gaussian High pass filtering	232	16
	Without Using Gaussian High pass filtering	201	23

Trial 2			
Input image	**Method**	**Number of correct edge**	**Number of false edge**

having triangle shaped object of thickness 1 pixel 238 edge pixels		pixels detected	pixels detected
	Using Gaussian High pass filtering	221	21
	Without Using Gaussian High pass filtering	198	43

Trial 3			
Input image having triangle shaped object of thickness 1 pixel 238 edge pixels	**Method**	**Number of correct edge pixels detected**	**Number of false edge pixels detected**
	Using Gaussian High pass filtering	**226**	**16**
	Without Using Gaussian High pass filtering	207	28

Trial 4			
Input image having triangle shaped object of thickness 1 pixel 238 edge pixels	**Method**	**Number of correct edge pixels detected**	**Number of false edge pixels detected**
	Using Gaussian High pass filtering	**225**	**17**
	Without Using Gaussian High pass filtering	213	34

Trial 5			
Input image having	**Method**	**Number of correct edge pixels**	**Number of false edge pixels**

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triangle shaped object of thickness 1 pixel 238 edge pixels		detected	detected
	Using Gaussian High pass filtering	229	26
	Without Using Gaussian High pass filtering	211	54

Summary of 5 trials taking the average of results obtained		
Method ↓	Average Number of correct edge pixels	Average Number of false pixels detected
Using Gaussian high pass filtering	227	19
Without Using Gaussian high pass filtering	206	36

CONCLUSION

Based on the above experimental results we can conclude that the proposed method for edge detection of noisy images using median and high pass filtering in combination gives the better result with comparatively more number of correct edge pixels detected and less number of false edge pixels detected. The results are compared with edge detection results for blurred noise removed image.

FUTURE WORKS

We used Gaussian High pass filtering method for increasing the quality of edges present in noise removed blurred image, further it can modified replacing Gaussian high pass filtering with othe high pass filtering methods. Image quality can also be increased by using homomorphic filtering in future.

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