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Fuzzy Logic Based Vehicle Edge Detection Using Trapezoidal and Triangular Member Function

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Abstract—Edge detection is considered to be fundamental step in the field of image processing and computer vision. There are 3 types of discontinuities in a digital image: point, line, edge. The most common way is to use spatial masks which have properties to detect these discontinuities .More than isolated points and lines detecting edges are important because they form an important part of image segmentation. Edge detection is basically a method of segmenting an image into regions based on discontinuity, enhancing the presence of these discontinuities in the image allows us to improve the perceived image quality under certain conditions. Edge detection makes use of differential operators to detect changes in the gradients of the grey or color levels in the image. Edge detection is divided into two main categories: first-order edge detection, example for first order edge detection are Sobel, Robert, Perwitt and second-order edge detection, example for second order edge detection are Laplacian and Canny. Image edge is often buried by noise, so it's necessary to research edge detection algorithm. Since traditional edge detection like Sobel, Perwitt, Robert operator are sensitive noise, to overcome that problem, some new algorithm is applied in edge detection such as Canny, Morphology, Neural network and Fuzzy logic. This paper presents the implementation in MATLAB, of a simple, very flexible and efficient fuzzy logic based algorithm to detect the edges of vehicle in an input image by scanning it through the 2*2 mask. Fuzzy logic is one of the new methods and it was based on set theory. The main benefit of fuzzy set theory is the able to model the ambiguity and the uncertainty. In the proposed method trapezoidal and triangular membership function of mamdani type FIS is used for four inputs containing two fuzzy set and one output containing one fuzzy set. The 2*2 masks is slide over entire vehicle image, and then pixels values of masks are examined through various ten rules which are defined in FIS rule editor. Based on these set of rules the output of fuzzy is decided that particular pixel is edge or not. For getting better results Gaussian filtering is used. Experimental result shows the ability of the proposed method in finding the thin edges of vehicle image.

Keywords— Edge, Edge detection operators, Fuzzy logic

INTRODUCTION

Edge detection is a well developed field on its own within image processing. Edge is the important characteristic of image. Edges come in an image because of variation of the discontinuities of the scene features, usually brightness, and give rise to edges. In other words, edges are representation of the discontinuities of the scene intensity function. There could be various reasons such as type of materials, surface texture, lighting conditions, which play important role in forming these discontinuities. An edge is a set of connected pixels that form a boundary between two disjoint regions. Edge can be described based on edge strength, edge direction and edge position. And different types of edges are step edge, ramp edge, roof edge, ridge edge. The quality of edge detection can be measured from several criteria. The five criteria for edge detection are: Good detection, Noise sensitivity, Good localization, Orientation Sensitivity, Speed and efficiency. 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. Many edge detection techniques have been developed for extracting edges from digital images, each designed to be sensitive to certain type of edges. There are two different edge detection operators: first order edge detection or gradient based classical operators as their names suggest, first order edge detection is based on the use of first-order image derivatives, example for first order edge detection operator are Robert, Prewitt, Sobel operator and second order edge detection or Laplacian based operators is based on the use of second-order image derivatives example for second order edge detection operator are canny detection. Nowadays fuzzy techniques plays main role in image processing and in its applications. It seems that fuzzy approaches produce more efficient results than existing techniques.

Edge detection techniques:

Traditional edge detection methods employ small convolution masks to approximate either the first derivative or the second derivative of an image; for example, Roberts filter, Sobel filter, Prewitt filter, and Laplacian filter [7]. They focus on the edge enhancement part of edge detection, with none or very little smoothing. A threshold is then applied to the output of these filters to identify the edge points. These filters, though easy to implement and generally with the advantage of speed over later edge detectors, provide very little control over smoothing and edge localization, by which noise is reduced. Therefore, these filters are very noise-sensitive.

The **Robert operator** is the gradient operator. The simple 2*2 Robert operators were one of the earliest methods used to detect edges. It responds maximally to edges running at ±45º to the edge pixel grid. The advantage of Robert operator is its simplicity and its disadvantage is that it is very sensitive to noise because of its small kernel and inaccurate. It is not compatible with today's technology.

The **Sobel operator** is also gradient operator. It uses 3*3convolution mask for estimating gradient in X and Y direction. The Sobel operator responds maximally to edges running in vertical or horizontal direction to the pixel grid. The advantage of using Sobel operator is computationally cheap and disadvantage is that edge detection is poor in the presence of noise. Sobel operator detects the noisy area as edge.

The **Prewitt operator** is same as Sobel operator. It uses 3*3 convolution masks to detect edges in X and Y direction. The advantage of using Prewitt operator is its robustness in finding edges. It is only suitable for well-contrasted noiseless images.

The **second order or Laplacian method** searches for zero crossing in the second derivative of the image to find edges. In general, first-order edge operators are not commonly used as a means of image enhancement. Rather, their main use is in image segmentation procedures. A much more common means of image enhancement is through the use of a second-order derivative operator: - the Laplacian. Laplacian edge detection is a very popular second-order derivative operator. This can easily be implemented in a 3*3 kernel filter. The most well known conventional methods like Laplacian edge detection and canny operators are belong to second order based edge detection.

Another example for second order edge detection is **canny edge detection [6][8].** Although research into reliable edge-detection algorithms continues, the canny method is generally acknowledged as the best 'all-round' edge detection method developed to date**.** The disadvantages with first order edge detection technique are sensitive to noise and directional can be solved by canny edge detection for some extent. Even though it gives better performance it still suffers from detecting weak edge along with strong edge.

The following are **disadvantages of first and second order edge detection technique:** The first order and second order edge detection like Robert , Sobel operators are Directional, Sensitive to noise, because many small local maxima will be generated by noise and Corners are often missed due to the smallness of 1D gradient at the corners. The magnitude of lapalcian operator produces double edges, an undesirable effect because complicates image segmentation. Lapalcian method is unable to detect edge directions. Canny edge detection is sensitive to weak edges and complex process. Having small kernel is highly sensitive to noise.

RELATED WORK

There are lot of works are being carried out on edge detection techniques. This section reviews the few of the related works to this paper.

Mrs.Abhradita Deepak Borkar et al [1] proposed a technique to detect the edges of images by using fuzzy logic in MATLAB environment without determining threshold value. In this paper , developed fuzzy inference system with nine input pixel containing two fuzzy sets one for white and another for black range from [0 0 255] for black colour and range from [0 255 255] for white colour pixel and one output pixel containing three fuzzy sets first for white second for black and third for edge range from [0 20 40 60] for black color and range from [100 120 140 160] for edge value and range from [195 215 235 255] for white color of the output pixel . In this paper 33 if then rules are set for various conditions that can occur. They concluded that the Fuzzy inference system developed is successfully which can detect edges of images for fuzzy set and apply defuzzification of the output generated by fuzzy inference system.

E. Boopathi Kumar et al [2] proposed a fuzzy logic based edge detection using trapezoidal membership function of mamdani type FIS to get effective results. In this paper they make use of 2*2 masks with 16 rules to detect edges and they concluded that the results of trapezoidal membership function are better than ones that have been found out by triangular edge detection method.

Shikha Bharti [3] proposed a novel edge detection algorithm based on fuzzy inference system. The proposed approach uses a 3x3 sliding window with eight inputs and the center pixel as the output, and then the pixel values of window are subjected to various fuzzy rules designed. Based on these set of rules the output of fuzzy is decided whether that particular pixel is an edge or not .Moreover the developed algorithm is compared with sobel ,prewitt etc to find the respective mean square error and peak signal to noise ratio of images containing noise.

Nanjesh B.R et al [4] proposed a implementation of edge detection algorithm that uses fuzzy logic. In this paper they 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. Instead of giving the blurred image directly to the fuzzy logic based edge detection module as an input, increase the quality of blurred, noise removed image (image enhancement) by using Gaussian high pass filtering method. Finally they concluded that the results of fuzzy logic based edge detection can be optimized by using Gaussian high pass filtering.

Madhavi Arora et al [5] proposed the way to overcome traffic problems in large cities through the development of an intelligent traffic control system which is based on the measurement of traffic density on the road. They presented techniques with which this problem of traffic is solved. They also discussed the morphological edge detection for detecting vehicle edges that helps in finding traffic density and fuzzy logic technique to solve this problem and comparison between two techniques is presented.

Ritesh Vyas et al [9] proposed a method based on fuzzy logic for edge detection in digital images without examining threshold value. The proposed approach uses 2*2 masks for segmenting the image into regions. The edge pixels are mapped to a range of values distinct from each other.

Er Kiranpreet Kaur et al [10] proposed a efficient fuzzy logic based algorithm to detect the edges of an input image by scanning it throughout using a 2*2 pixel window. The proposed FIS has four inputs, which corresponds to four pixels of instantaneous scanning matrix, one output that tells whether the pixel under consideration is "black", "white" or "edge" pixel. Sixteen rules are defined, which classify the target pixel. To reduce noise, the noise removal algorithm has been implemented at different levels of processing. The proposed method make use of smallest mask i.e. 2*2 mask. The results of proposed method are compared with 'Canny', 'Sobel', 'and Prewitt' and 'Roberts' edge detection operators.

Suryakant et al [11] proposed the implementation of a very simple but efficient fuzzy logic based algorithm to detect the edges of an image without determining the threshold value. The proposed approach begins by scanning the images using floating 3x3 pixel window. Fuzzy inference system designed has 8 inputs, which corresponds to 8 pixels of instantaneous scanning matrix, one output that tells whether the pixel under consideration is "black", "white" or "edge" pixel. Rule base comprises of sixteen rules, which classify the target pixel. The proposed method results for different captured images are compared to those obtained with the linear Sobel operator.

Bijuphukan Bhagabati et al [12] proposed a very simple but novel method for edge detection without determining threshold value. The technique uses the smallest possible 2*2 mask that slides over the whole image pixel by pixel. This fuzzy inference system highlights edge pixels using fuzzy rules. It has 4 inputs corresponding to 4 pixels of instantaneous scanning matrix and has one output identifying the pixel under consideration whether it is "edge" pixel. The rule base includes only ten fuzzy rules to classify the pixels. The results obtained by this method are compared with those of the existing standard algorithms and comparatively found better results.

This paper presents fuzzy logic based edge detection for detecting vehicle edges in day time. Fuzzy inference system is developed with four input containing two fuzzy sets one for white and another for black and one output pixel containing one fuzzy sets for edge and 10 if then rules are set for various conditions that can occur. For better optimization of results obtained by fuzzy logic, Gaussian high pass filtering is used.

FUZZY LOGIC

Fuzzy logic is one of the new methods introduced in 1960 by Lutfi Zadeh at University of California. Fuzzy logic provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy, or missing input information. Fuzzy logic is a mathematical representation of human concept formulation and reasoning. Fuzzy logic is a widely used tool in image processing since it gives very efficient result. It can be implemented in hardware, software, or a combination of both. Fuzzy reasoning is nothing else than a straightforward formalism for encoding human knowledge or common sense in a numerical framework. Fuzzy Logic has been applied to problems that are either difficult to face mathematically or applications where the use of Fuzzy Logic provides improved performance and/or simpler implementations. At present, the application of Fuzzy Logic exceeds the control domain since it is also

employed for other knowledge based decision making tasks. It involves medical diagnosis, business forecasting, traffic control, network management, image processing, signal processing, computer vision, geology and many more.

SYSTEM DESIGN

The following block diagram [figure 1] shows the methodology of fuzzy logic based edge detection. First the color vehicles image is given as input and converted to gray scale image than for getting better results and to highlight edges Gaussian filtering is applied for gray scale image, since the Fuzzy Logic Toolbox software operates on double-precision numbers so, filtered image, is converted to a double array next is the main step that is fuzzy logic based edge detection to detect vehicle edges .The fuzzy logic edge detection can performed by using FIS ,the block diagram of FIS is shown in figure 2.

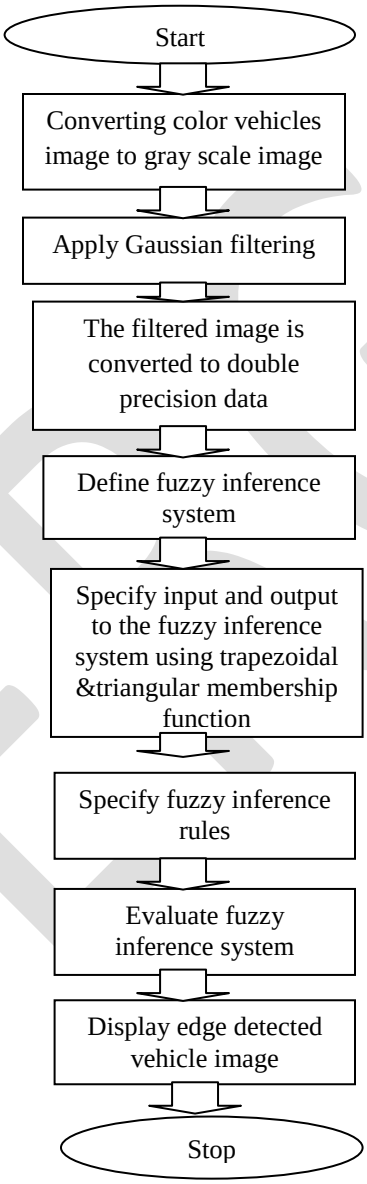

Figure1. Steps involved in fuzzy logic based edge detection

Gaussian filtering:

Edges and fine detail in images are associated with high frequency components. High pass filters – only pass the high frequencies, drop the low ones. High pass frequencies are precisely the reverse of low pass filters.

The Gaussian high pass filter is given as: $H(u,v) = 1 - e^{-D^2(u,v)/2D_0^2}$ where D_0 is the cut off distance.

FUZZY INFERENCE SYSTEM

Fuzzy inference is the procedure of transmitting a given input value to an output based on fuzzy inference rules. The fuzzy inference operation involves membership functions, fuzzy logic operators, and fuzzy inference if-then rules. There are two types of FIS: Mamdani type and Sugeno type. Mamdani's fuzzy inference scheme is a more compact and computationally efficient representation of fuzzy approach and it expects the output membership functions to be fuzzy sets. The output membership functions are either linear or constant in which any inference system can be used to Sugeno-type systems.

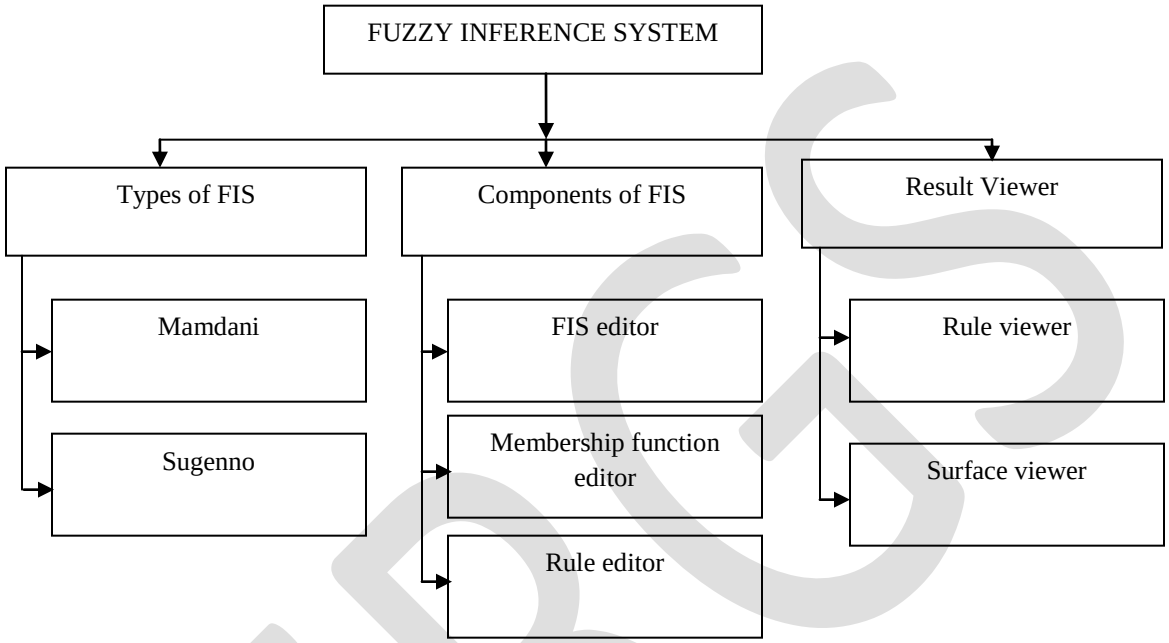

Figure2. Block diagram of fuzzy inference system

The block diagram of FIS is discussed below.

FIS Editor:

The FIS Editor which allows us to provide number of input and output variables and their names, there's a simple diagram [figure 4] that shows the FIS editor. FIS editor it displays name of each input and output variable. It also displays the type of FIS used. There are two types of FIS i.e. mamdani and sugeno, the proposed method uses mamdani type FIS. FIS editor also includes some pop-up menus which helps in modifying the inference operation. That is Applying Fuzzy Operators: After inputs have been fuzzified, if the antecedent of a rule has more than one part, the fuzzy AND method is set to MIN and OR method is set to MAX is applied to obtain the result. Applying Implication Method :Implication method is the process of determining the output of each fuzzy rule's consequent that is it is set to MIN. Aggregating All Outputs: All defined rules are aggregated by using MAX operator. Defuzzifying: It is desirous that the output is a single number, so the output fuzzy set of aggregation process is converted into a single number using the centroid method.

Membership function editor:

The shape of membership function associated with all variables can be defined by using membership editor. The Membership Function Editor lets you display and edit all of the membership functions associated with all of the input and output variables for the entire fuzzy inference system. There are 11 different shapes of membership functions; Triangular, Trapezoidal, Piecewise-linear, Gaussian, Generalized bell-shaped, Sigmoidal, etc. The sample trapezoidal and triangular membership functions in figure 5.

Rule editor:

The rule editor is used for editing list of rules that defines the behavior of the system. The proposed system is implemented using 10 if-then rules; table 1 shows the possible if-then rules for four pixels of 2*2 masks. Example **If p1 is black AND If p2 is black AND If p3 is black AND If p4 is white Then p4 is edge.** The if part of the rule is called "premise" while then part of the rule is called "conclusion".

Rule viewer and surface viewer:

Rule viewer is used to view the fuzzy inference diagram. The Rule Viewer allows you to interpret the entire fuzzy inference process at once. The Rule Viewer also shows how the shape of certain membership functions influences the overall result.
Surface viewer to view the dependency of one of the outputs on any one or two of the inputs i.e it generates and plots an output surface map for the system. The Surface Viewer has a special capability that is very helpful in cases with two (or more) inputs and one output.

Each fuzzy logic system can be divided into three elements [Figure 3]: fuzzification, define membership function or inference operation and defuzzification.

Fuzzification: Fuzzy logic system input data are most often crisp values. During fuzzification crisp inputs are translated into the fuzzy domain through membership functions. Each crisp value is assigned a membership value to a fuzzy concept as defined by the membership functions. The fuzzifier decides the degrees of membership from the crisp inputs.

Fuzzy set: A fuzzy set is represented by a membership function which expresses the degree that an element of the universal set belongs to the fuzzy set: larger values denote higher degrees of membership, smaller values indicate lower degrees of membership. The most commonly used range of values of membership functions is the unit interval [0,1].

Inference operation or define membership function: The resulting fuzzy values after fuzzification are then entered into the fuzzy inference engine. Fuzzy inference is based on a fuzzy rule base which contains a set of If-then fuzzy rules and different types of membership functions. Fuzzy if-then rules will combine and manipulate the input variables to produce one or more fuzzy outputs. The membership function is a graphical representation of the magnitude of participating of each input. There are 11 different shapes of membership functions are available in fuzzy inference system; Triangular, Trapezoidal, Piecewise-linear, Gaussian, Generalized bell-shaped, Sigmoidal, etc.

Defuzzification: This is the process of calculating single-output numerical value for a fuzzy output variable on the basis of the inferred resulting membership function for this variable. The input in the defuzzification process is a fuzzy number and the output is a crisp number. Membership functions are used to map fuzzy consequences back to the crisp domain. There are five defuzzification methods: Centroid , Bisector , Middle of Maximum ,Smallest of Maximum, Largest of Maximum .

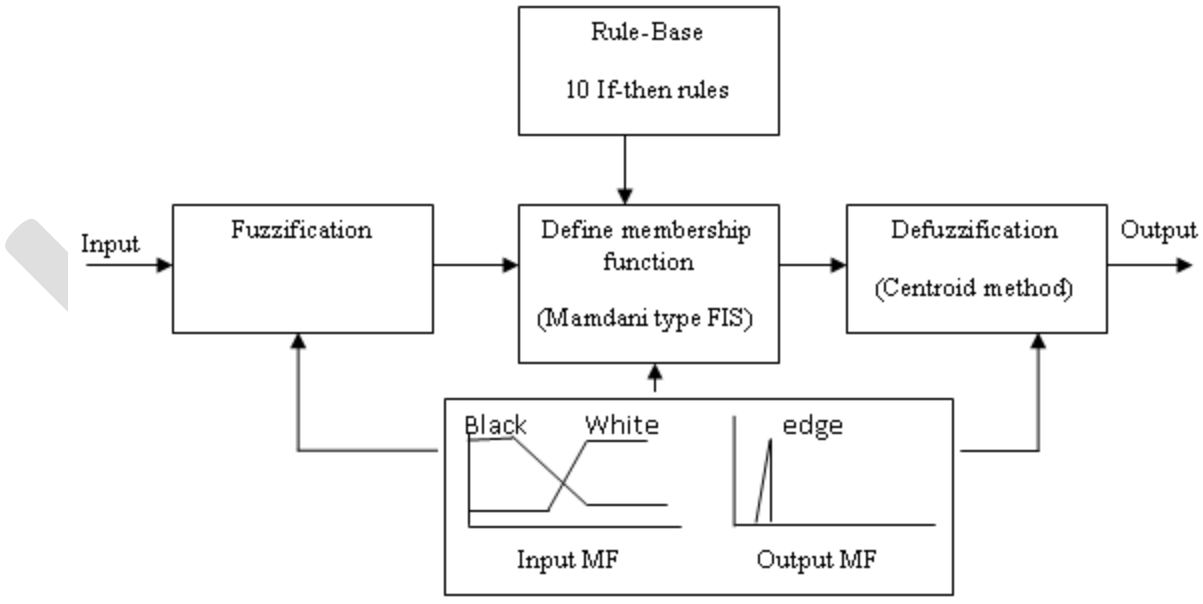

Figure 3. Steps involved in fuzzy image processing

The proposed approach is concerned with the development of a fuzzy logic algorithm for the detection of vehicle edges. Here mamdani type fuzzy inference system is adopted to detect the vehicle edge. The algorithm detects edges of an input image by using a window mask of size 2*2 .The 2*2 mask is slid over an entire input image and process continues till the whole image is scanned. In the proposed system four inputs with two fuzzy set and one output with one fuzzy set is given to FIS is shown in below figure 4. The four inputs are the four pixels of the 2*2 mask window [p1 p2 p3 p4]. Here pixel values of image are used as fuzzy set. Two fuzzy sets are used for input – black and white and one fuzzy set are used for output –edge.

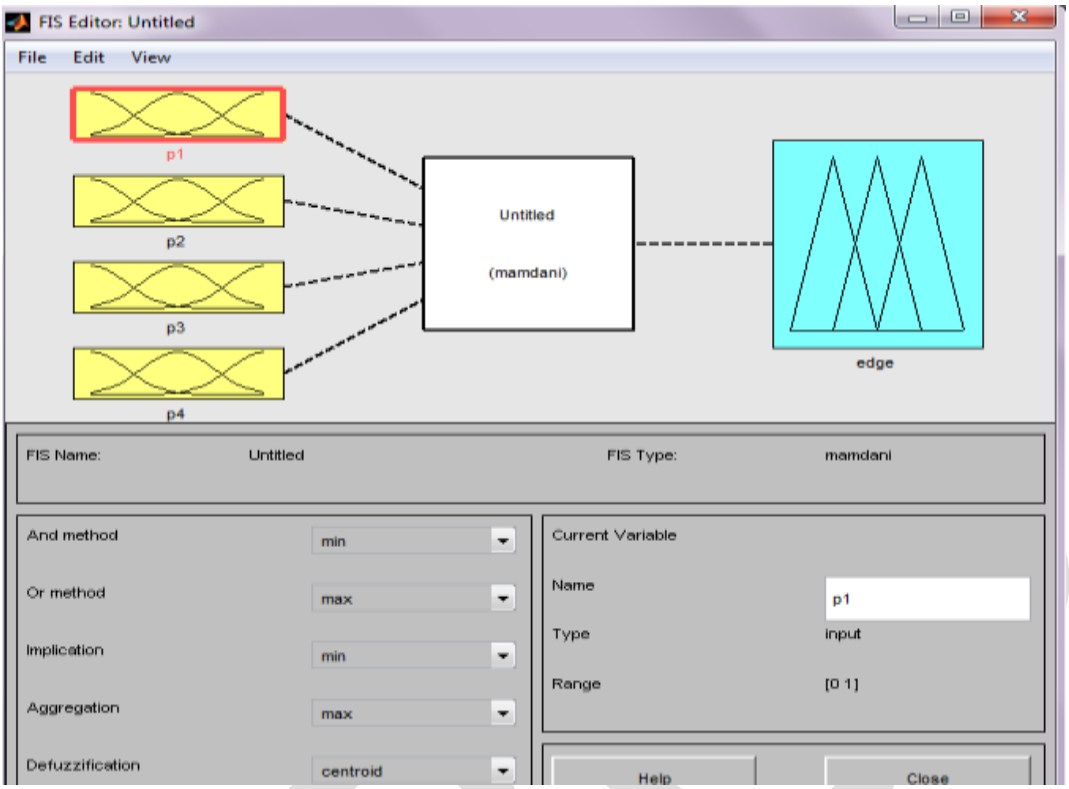

Figure 4. FIS editor

Membership function is a curve that defines how each point in the input space is mapped to a degree of membership between 0 and 1. Fuzzy sets are created to represent each variables intensities and elements of fuzzy set exposes membership values between 0 and 1 , these set are associated with linguistic variables “black” and “white” for input and “edge” for output in the membership function. The degree of which an element belongs to given set is called grade of membership. Based on membership grade, input variables check the pixels of the image which is black ,white or edge and output are fetched based on the rules. Here trapezoidal membership function is adopted for 4 inputs p1 p2 p3 p4 and triangular membership function for one output which is shown in below figure 5 . The functions adopted to implement the AND and OR operations are the MIN and MAX functions respectively.

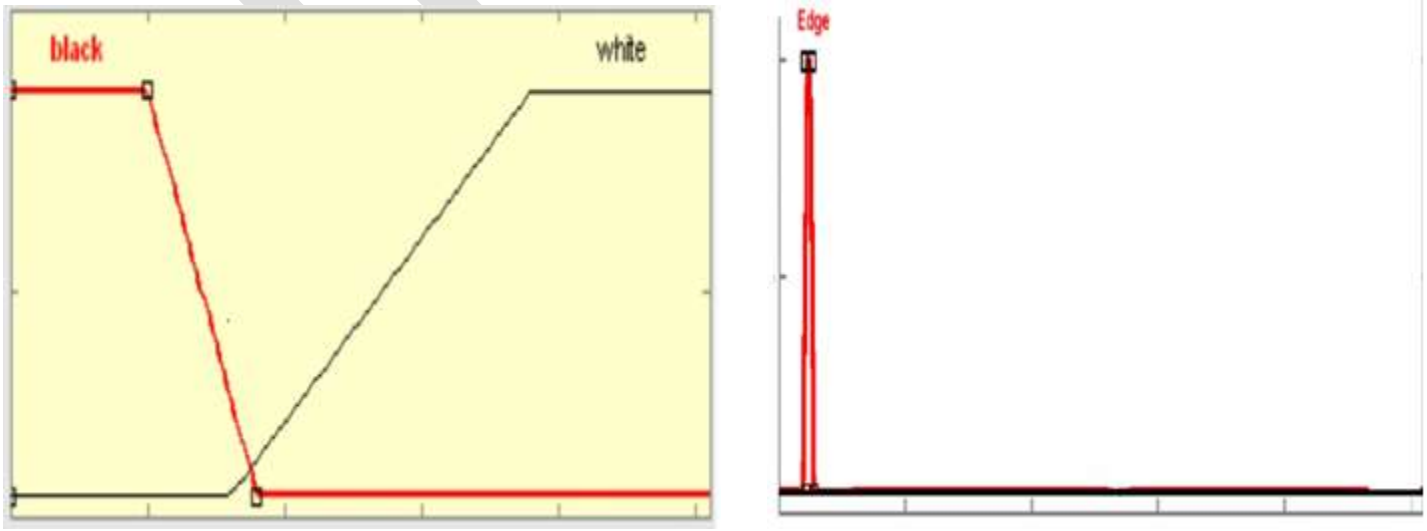

Figure 5. Sample of trapezoidal MF based input with triangular MF based output

The inference rules depend on the weights of the 3 neighbor in the 2*2 mask i.e p1 p2 p3 ad p4 itself, if the neighbor’s weights are degree of blacks or degree of whites. The defined rules are combined using AND operator in rule editor .The powerful of these rules is the ability to extract all edges in the processed image directly. The condition of each pixel is decided by using the 2*2 mask which can

be scanning the all grays. In this paper 10 if then rules are set for various conditions that can occur. B=black value of pixel, W=white value of pixel, E=edge output.

Fuzzy inputs				Fuzzy output
P1	P2	P3	P4	Edge
B	B	B	W	E
B	B	W	B	E
B	B	W	W	E
B	W	B	B	E
B	W	B	W	E
B	W	W	B	E
W	B	B	W	E
W	B	W	B	E
W	W	B	B	E
W	W	W	B	E

Table 1. 10 If- then rules

The Mamdani method is chosen as the defuzzification procedure. During defuzzification the output of all rules are combined into a single fuzzy set by aggregating them with the OR operation. As mentioned earlier there are so many methods for defuzzification in this paper defuzzification operation is performed by calculating centroid in order to get single crisp value from the aggregated fuzzy output set.

EXPERIMENTAL RESULTS

In this paper fuzzy logic based edge detection is mainly used to detect vehicle edges which are a standing at traffic light. In MATLAB environment the fuzzy inference system can be read by using readfis( ) function and Output is evaluated by using evalfis function. The proposed method has been applied in MATLAB environment on the image of "original image " in Figure 7, "Gaussian filtered image" in Figure 8 and "fuzzy logic without filtering" in Figure 9 and "fuzzy logic with filtering" in Figure 10 . It can be seen from the results that the proposed method fuzzy logic based edge detection is able to find out thin, clear edges with Gaussian filtering

Figure7. Original image

Figure 8. Gaussian filtered image

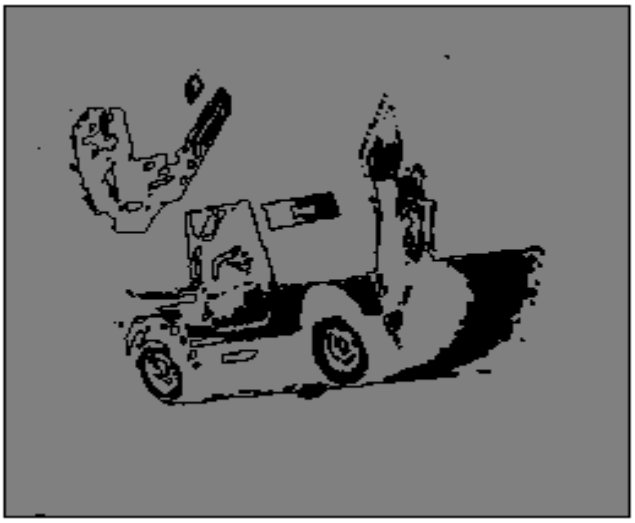

Figure9. Fuzzy logic without filtering

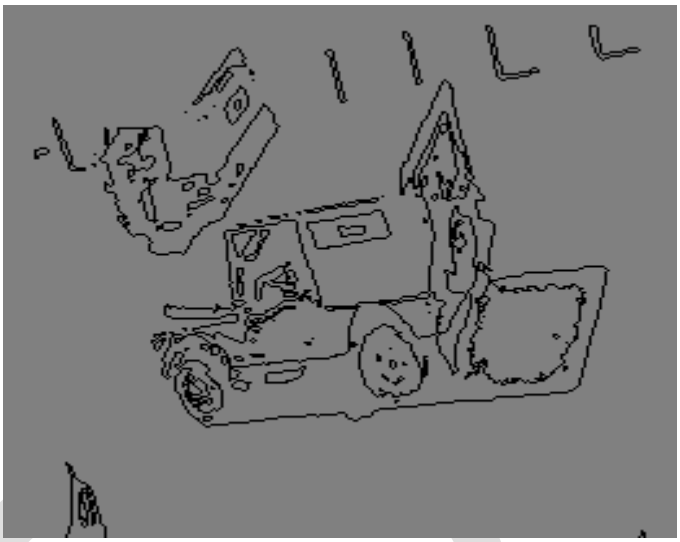

Figure 10. Fuzzy logic with filtering

CONCLUSION

Edge detection is well known research topic in image processing since it supports wide range of application. Edge detection can be performed by two techniques that are gradient based and Laplacian based edge detection, gradient based edge detection like Sobel, Robert, Perwitt operators are more sensitive to noise where as Laplacian based edge detection like canny edge detection is less sensitive to noise. Even though canny edge detection gives better performance it still suffers from detecting weak edge along with strong edges. The disadvantages of first order and second order edge detection can be overcome by using fuzzy logic based edge detection. This paper mainly discussed about fuzzy logic based edge detection for detection vehicle edges during day time using trapezoidal and triangular membership function. By observing results can conclude that fuzzy logic based edge detection are able to detect thin and clear vehicle edges with Gaussian filtering.

As future work, rather than using trapezoidal and triangular membership function can try different membership function. And Gaussian high pass filtering can be replaced by other filtering method for getting better result. The proposed method is implemented for detecting vehicle edges in day time, the same method can be used for detecting vehicle edges in night time with some proper filtering technique

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REFERENCES:

[1] Mrs.Abhradita Deepak Borkar , Mr.Mithilesh Atulkar "Detection of Edges Using Fuzzy Inference System" IJIRCCE vol. 1, issue 1, March 2013

[2] E. Boopathi Kumar and M. Sundaresan " Edge Detection Using Trapezoidal Membership Function Based on Fuzzy's Mamdani Inference System" 2014 IEEE

[3] Shikha Bharti "New Technique of Edge Detection based on FIS" (IJITEE) Volume-4 Issue-6, November 2014

[4] Nanjesh B.R et al "Optimization of Fuzzy Logic Based Edge Detection of Noisy Images using Filtering Techniques" International Journal of Advance Electrical and Electronics Engineering (IJAEEE) Volume-3 Issue-2, 2014

[5] Madhvi Arora, V.K Banga,"Real time traffic light control system using morphological edge detection and fuzzy logic", 2nd International Conference on Electrical, Electronics and Civil Engineering, April, 2012.

[6] .Arvind B.K And Dinesh S, Arun Karthik S And Ganga Ambrish "Traffic Gridlock Control Using Canny Algorithm Aided By Fuzzy Logic" 3rd International Conference On Advanced In Computing And Emerging Elearning Technologies (ICAC2ET 2013) – Singapore On November 6 – 7, 2013

[7] G.T. Shrivakshan and Dr.C. Chandrasekar " A Comparison of various Edge Detection Techniques used in Image Processing" IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 5, No 1, September 2012

[8] P.Srinivas ,Y.L. Malathilatha,Dr. M.V.N.K Prasad "Image Processing Edge Detection Technique Used For Traffic Control Problem" (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 4 (1) , 2013, 17 – 20

[9] Ritesh Vyas and Archna Aggarwal **"**Edge Detection Technique Based on Fuzzy Logic" Proc. of the Intl. Conf. on Advances in Electronics, Electrical and Computer Science Engineering— EEC 2012

[10] Er Kiranpreet Kaur, Er Vikram Mutenja and Er Inderjeet Singh Gill "Fuzzy Logic Based Image Edge Detection Algorithm in MATLAB" 2010 International Journal of Computer Applications (0975 - 8887) Volume 1 – No. 22

[11] Suryakant, Neetu Kushwaha " Edge Detection using Fuzzy Logic in Matlab" www.ijarcsse.com Volume 2, Issue 4, April 2012

[12] Bijuphukan Bhagabati and Chumi das " Edge Detection of Digital Images Using Fuzzy Rule Based Technique" Volume 2, Issue 6, June 2012 International Journal of Advanced Research in Computer Science and Software Engineering

[13] Chris Solomon and Toby Breckon " Fundamentals of digital image processing : a practical approach with examples in MATLAB" 2011

[14] Adel Abdennour,Electrical Engineering Department King saud University "Tutorial on fuzzy logic using MATLAB