Edge detection for Diabetic Retinopathy using fuzzy logic

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Abstract

Diabetic retinopathy is an eye disease, because of pressure in eye nerve fiber. It is a major cause of blindness in middle as well as older age groups; therefore it is essential to diagnose it earlier. Some of the challenges are in the diagnosis of the disease is detection edges of the image, may be some important edges are missed outcome the noise around the corners.

Wherefore, in order to reduce these effects in this paper, we proposed a new technique for edge detection using traditional operators in combination with fuzzy logic based on fuzzy inference system. The results show that the proposed fuzzy edge detection technique better than of traditional techniques, where vascular are markedly detected over the original.

Keywords: Diabetic retinopathy, Fuzzy logic, edge detection,

كشف الحافة لأعتلال الشبيكة السكري باستخدام المنطق الضبابي

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الخلاصة:

إعتلال الشبيكة السكري هو مرض يصيب العين نتيجة ارتفاع الضغط في الالياف العصبية ، لذا يعتبر من الاسباب الرئيسية للعمى للفئات العمرية المتوسطة أو الأكبر عمرا ، وبالتالي لا بد من تشخيصه في وقت مبكر. بعض التحديات في تشخيص هذا المرض هي الكشف عن حواف الصورة، ربما نفقد بعض الحافات المهمة نتيجة الضوضاء حول الزوايا.

لذلك، من أجل الحد من هذه التأثيرات في هذه الورقة، اقترحنا تقنية جديدة للكشف عن الحافات باستخدام المؤثرات التقليدية بالاشتراك مع المنطق الضبابي بالاعتماد على نظام الأستدلال الضبابي. اظهرت النتائج ان تقنية كشف الحافات المضببة أفضل من التقنيات التقليدية ، إذ تم الكشف عن الاوعية الدموية بشكل واضح بالنسبة للأصل.

Introduction:

Eye is most important organ for human beings; it helps them to sense the color, shape and state of physical objects, but an eye infection like Fungal Keratitis is one of the major causes of blindness. Diabetic retinopathy is the most common cause of low vision and blindness which a complication of diabetes mellitus [1, 2]. Approximately 33% of patients with diabetes have signs of diabetic retinopathy. According to medical test results, early detection and treatment may prevent more than 95% of the vision reductions that are observed in diabetic patients [3]. Diabetic retinopathy is composed of a characteristic group of lesions found in the retina of individuals having had diabetes for

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several years [4]. There are techniques have been employed to assist the diagnosis of by identifying the region of infection in the corneal images using fuzzy edge detection. R. Zhang et. al. (2005) proposed a technique based on the integer logarithm.Ratio of gray levels. They proposed a ratio of gray levels between the two successive image points rather than the difference of gray levels to denote the variation in the gray levels Analyzing and interpreting retinal images [5]. M.Hanmandlu et. al. (2006) proposed a technique based on the structure of the edge present in the neighborhood of a pixel and can thus be considered as a unique feature of the pixel and is fuzzified [6]. A. Osare et. al. (2007) used pattern recognition with machine learning techniques to analyze diabetic retinal images [7]. Agurto et. al. (2009) developed the technique for detection of DR by using instantaneous amplitude and instantaneous frequency characteristics of an image [8]. I. Jamal et. al. (2012) present the retinal image preprocessing technique that detects the background using local mean and variance and removes noise using HSI color space [9].

Fuzzy image processing:

Fuzzy image processing is a combination of fuzzy approach to image processing. Nevertheless, the following definition can be regarded as an attempt to determine the boundaries. It is the collection of all approaches that understand, represent and process the images, their segments and features as fuzzy sets. The representation and processing depend on the selected fuzzy technique and on the problem to be solved. Fuzzy image processing has three main stages: image fuzzification, modification of membership values and image defuzzification. 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 main power of fuzzy image processing is in the middle step (modification of membership values). After the image data are transformed from gray-level plane to the membership plane (fuzzification), appropriate fuzzy techniques modify the membership values. This can be a fuzzy clustering, a fuzzy rule-based approach, a fuzzy integration approach and so on[10].

In order to compute the output of a given FIS from the inputs, these five steps should be done [11]:

• Fuzzifying Inputs: The first step is determining the degree of membership of each input using membership functions.

• Applying Fuzzy Operators: After inputs have been fuzzified, if the antecedent of a rule has more than one part, the fuzzy operator is applied to obtain the result. The result will then be given to the output function. So the input is two or more membership values from fuzzified inputs and the output is a truth value.

• Applying Implication Method: Implication method is the process of determining the output of each fuzzy rule's consequent. Before applying the implication method, we must take care of the rule's weight which is a number between 0 and 1. Generally this weight is 1 and so it has no effect on the implication process. The input of implication is a single number given by the antecedent, and the output is a fuzzy set.

• Aggregating All Outputs: At this stage, all fuzzy sets that represent the outputs of each rule, are combined into a single fuzzy set. The input is output functions returned by the implication process of each rule and the output is one fuzzy set for each output variable. There are different methods to apply the aggregation such as maximum, probabilistic or, and sum.

• Defuzzifying: Although fuzziness helps during the previous steps, the desired final output is a single number. To do so the output fuzzy set of aggregation process must be converted into a single number. The most common method is the centroid calculation.

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 related to membership functions, fuzzy logic operators, and if-then rules [12]. There are two types of fuzzy inference systems that can be implemented in the Fuzzy Logic Toolbox: Mamdani type [13] and Sugeno-type [14]. These two types of inference systems vary somewhat in the way outputs are determined. Fuzzy inference systems have been successfully applied in fields such as automatic control, data classification, decision analysis, expert systems, and computer vision. Because of its multidisciplinary nature, fuzzy inference systems are associated with a number of names, such as fuzzy-rule-based systems, fuzzy expert systems, fuzzy modeling, fuzzy associative memory, fuzzy logic controllers, and simply fuzzy systems.

Proposed fuzzy edge detection:

In this paper we have proposed a new fuzzy edge detection differs of traditional edge detection techniques for detecting the edges in digital images. The proposed algorithm to diagnosis for diabetic retinopathy image has the following steps:

1. Read the original image.
2. If image is RGB colour, convert it to gray image.
3. Calculate size of original image.
4. Apply traditional edge detection.
5. Apply Fuzzy Inference system.
6. Compare among methods from image statistical.

Proposed Fuzzy inference system is applied a Mamdani FIS by taking a movable window over the image of 2x2 size, where the pixels around the center pixel are named according to the direction to identify them. For the Fuzzy Inference System, 4 inputs are required, 2 of them are the gradients with respect to x-axis and y-axis, and we will call DH and DV respectively. Other two inputs are filters that, HP produce calculate by high-pass filter convolution to the original image, and M is a low-pass filter convolution to the original image. For all the fuzzy variables, the membership functions are Gaussian. According to the tests performed the values in DH, DV and HP, go from -800 to 800, In the case of variable M, the tests use the values in the rank from 0 to 255, The output variable is EDGES that also adjusted the ranks between 0 and 255, where the membership functions are:

LOW: gaussmf(43,0),
MEDIUM: gaussmf(43,127),
HIGH: gaussmf(43,255).

Figure 1 show the main viewport of the Fuzzy Inference Systems Editor. The FIS Editor displays general information about a fuzzy inference system. There's a simple diagram at the top that shows the names of each input variable on the left, and those of each output variable on the right.

The seven fuzzy rules that allow evaluating the input variables:

1. If (DH is LOW) and (DV is LOW) then (EDGES is LOW).
2. If (DH is MEDIUM) and (DV is MEDIUM) then (EDGES is HIGH).
3. If (DH is HIGH) and (DV is HIGH) then (EDGES is HIGH).
4. If (DH is MEDIUM) and (HP is LOW) then (EDGES is HIGH).
5. If (DV is MEDIUM) and (HP is LOW) then (EDGES is HIGH).
6. If (M is LOW) and (DV is MEDIUM) then (EDGES is LOW).
7. If (M is LOW) and (DH is MEDIUM) then (EDGES is LOW).

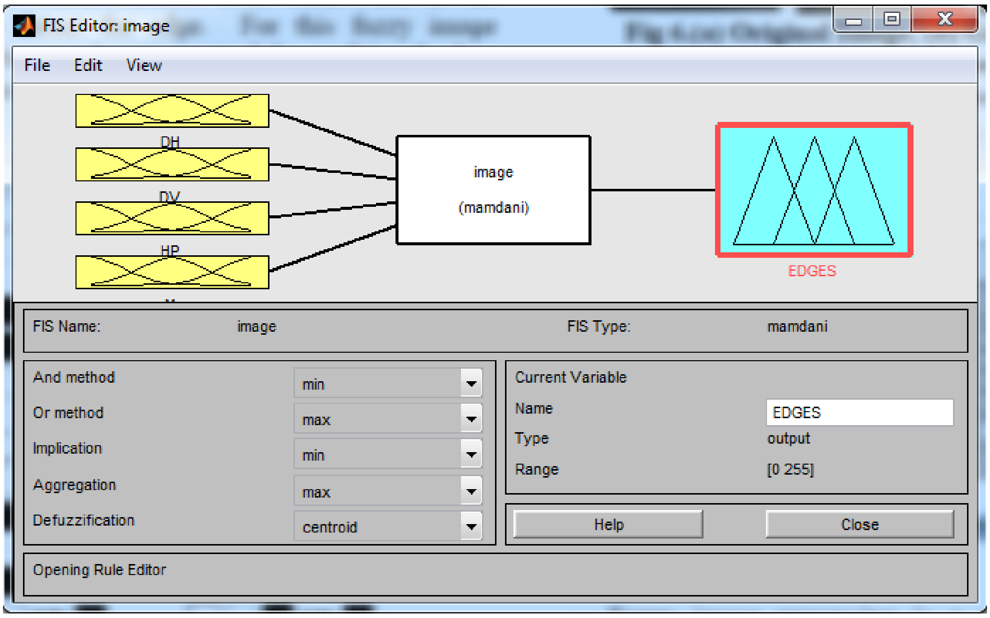

Figure 1- Fuzzy Inference System editor.

Constructing rules using the graphical rule editor interface is fairly self-evident, based on the descriptions of the input and output variables defined with the FIS editor. Figure 2 show rule viewer, the three small plots across the top of the figure represent the antecedent and consequent of the first rule. Each rule is a row of plots, and each column is a variable. The first two columns of plots (the yellow plots) show the membership functions referenced by the antecedent, or the if-part of each rule. The last column of plots (the blue plots) shows the membership functions referenced by the consequent, or the then-part of each rule.

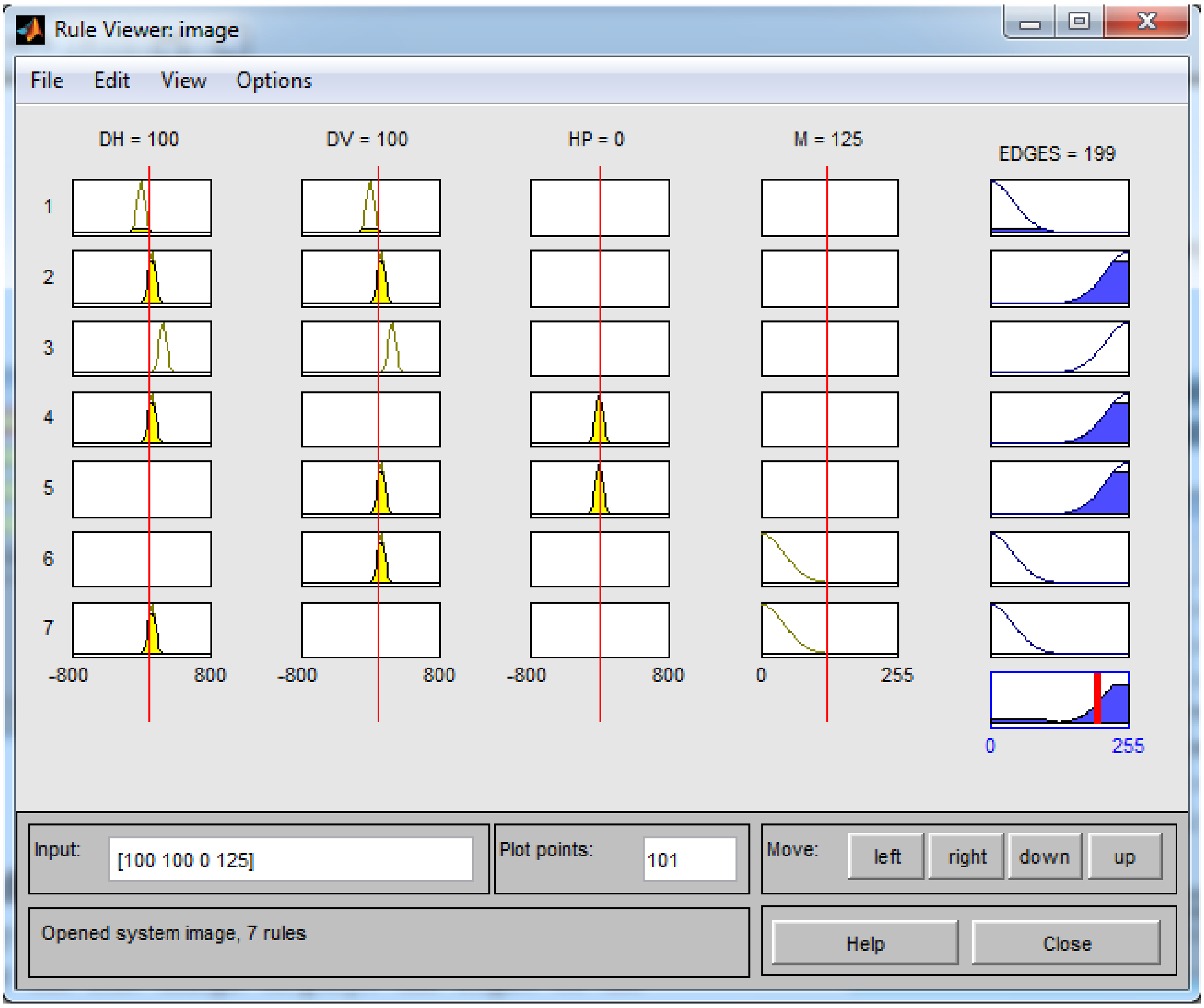

Figure 2- Proposed Fuzzy Inference System rule viewer.

Experimental results and discussion:

Multiple diabetic retinopathy images from CASIA database (Central Asia Student International Academic) were taken for the experiment, the validity and evaluation of automated diagnostic systems are very important so we have used three groups standard retinal image databases. First group contain 30 retinal images with a resolution of 288 X 243 pixels and of different qualities in terms of noise and illumination. Second and third group databases consist of 25 and 20 images respectively with a resolution of 493 X 335 pixels, all the images are: 24 bit - RGB, file format: JPG.

The proposed fuzzy algorithm is simulated using MATLAB on different images. The original image and the resultant images obtained after applying conventional operators is shown in figures 3, 4 and 5. For measure the principle of probability of gray level distribution in the image used Mean Square Error (MSE) is considered as one of the criterion that identifies image quality, the MSE values are shown in the table 1. Figure 6 show comparisons among methods from image statistical.

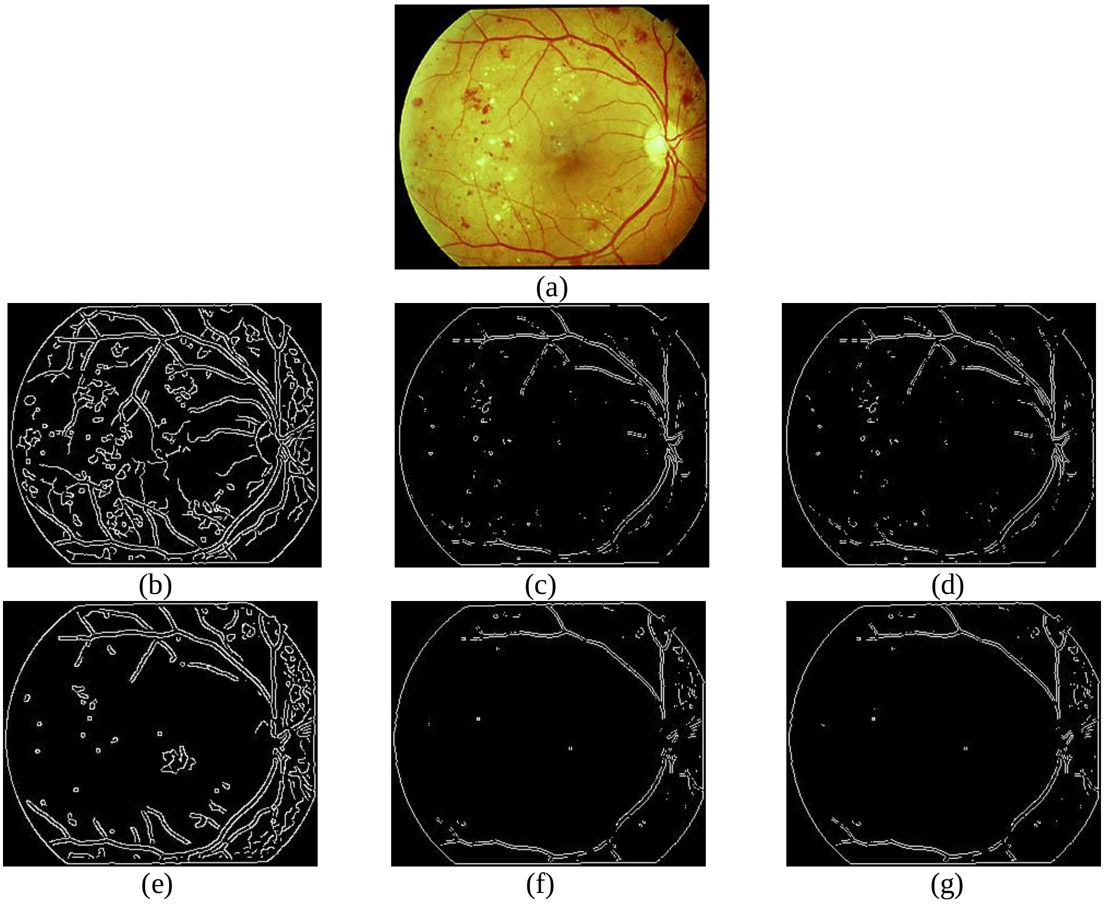

Figure 3- sample from first group, (a) Original image, (b) Canny, (c) Prewitt, (d) Sobel, (e) fuzzy Canny, (f) fuzzy Prewitt, (g) fuzzy Soble.

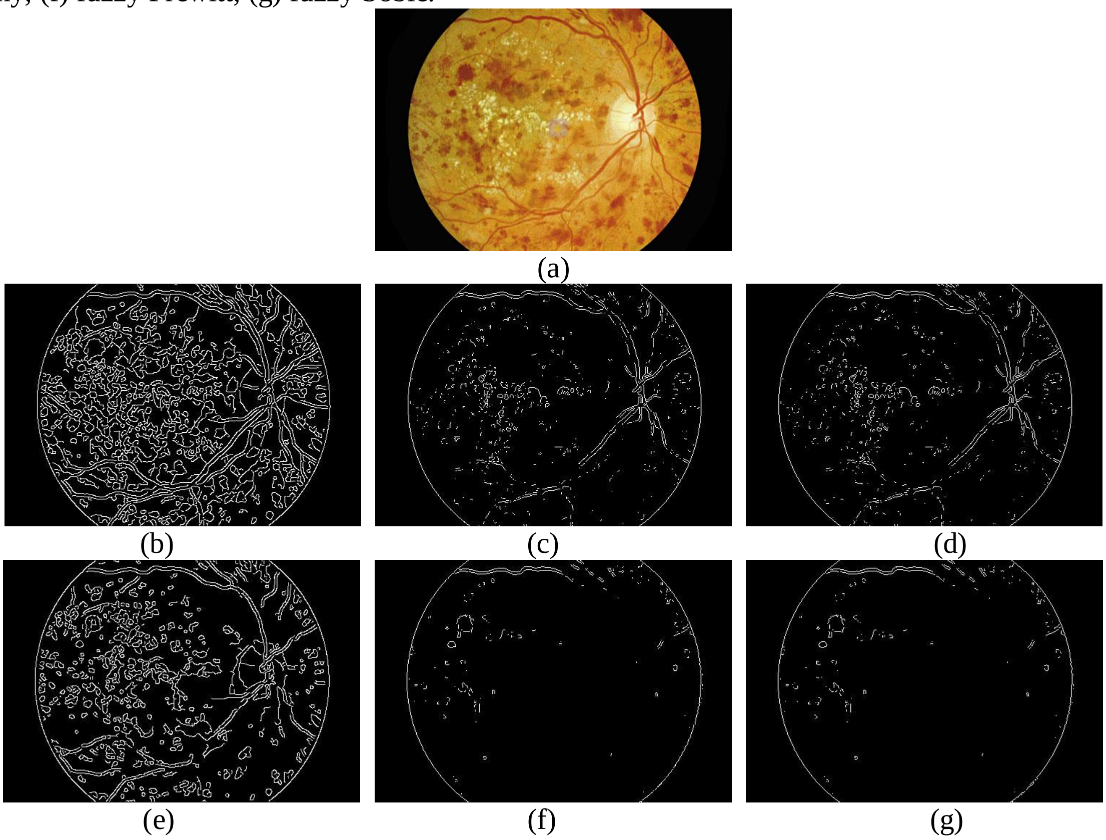

Figure 4- sample from second group, (a) Original image, (b) Canny, (c) Prewitt, (d) Sobel, (e) fuzzy Canny, (f) fuzzy Prewitt, (g) fuzzy Soble.

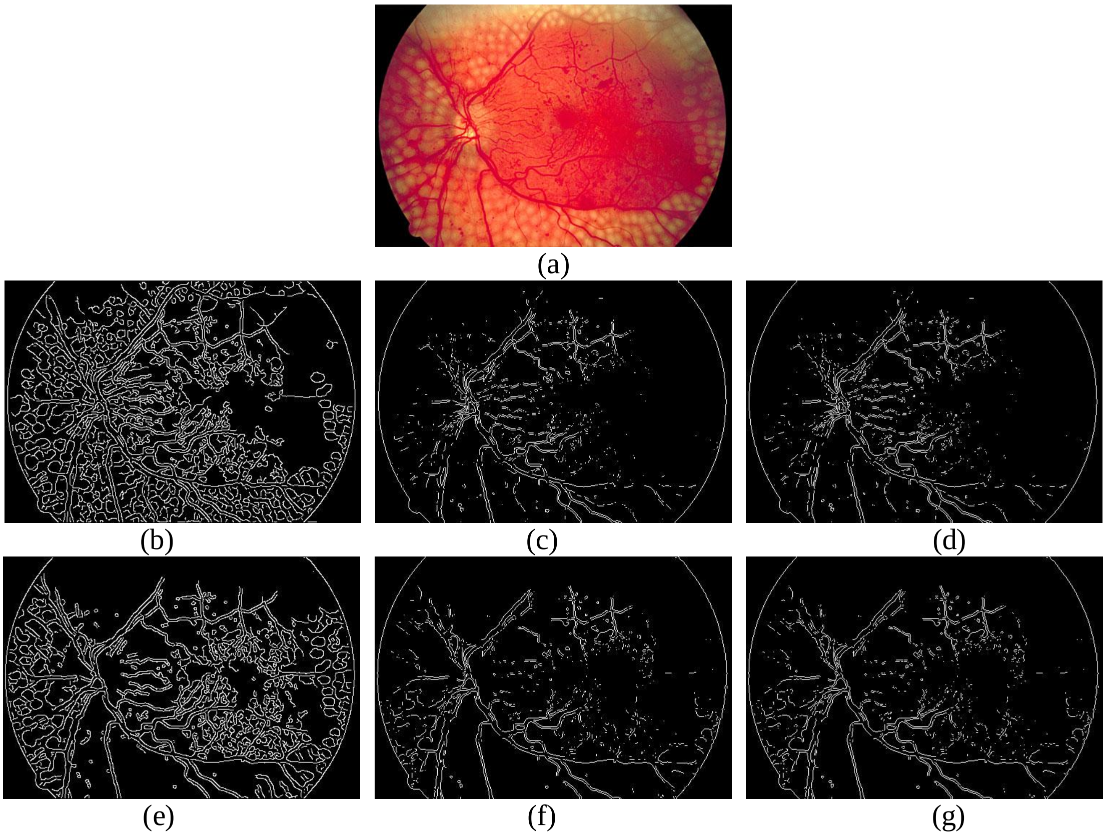

Figure 5- sample from third group, (a) Original image, (b) Canny, (c) Prewitt, (d) Sobel, (e) fuzzy Canny, (f) fuzzy Prewitt, (g) fuzzy Soble.

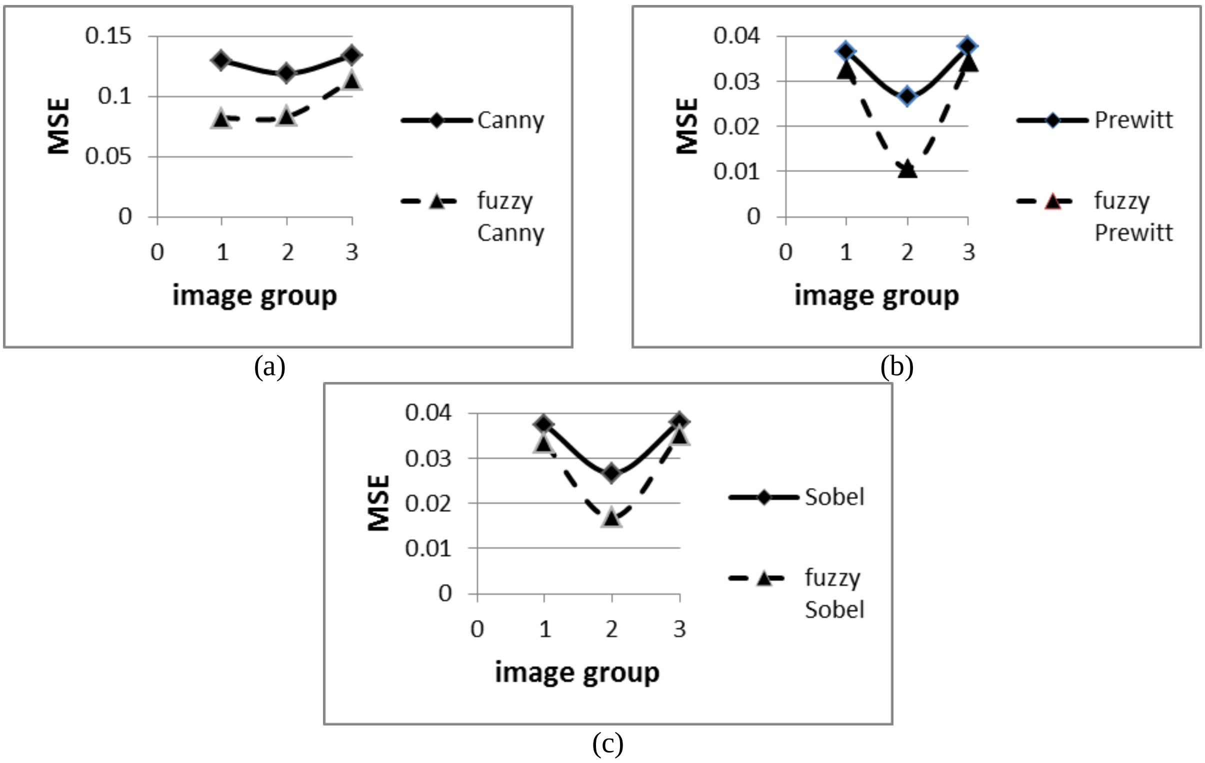

Figure 6- comparisons among the used methods, (a) Canny and fuzzy Canny, (b) Prewitt and fuzzy Prewitt, (d) Sobel and fuzzy Soble.

Table 1- Comparison of Canny, Prewitt, Sobel and proposed methods based on MSE.

Image group	Canny	Prewitt	Sobel	fuzzy Canny	fuzzy Prewitt	fuzzy Soble
First	0.1294	0.0365	0.0374	0.0819	0.0327	0.0333
Second	0.1189	0.0266	0.0267	0.0832	0.0108	0.0169
Third	0.134	0.0375	0.038	0.1138	0.0343	0.0352

The performance of the proposed method for detection was assessed quantitatively by comparing the results of extractions with the traditional methods. From fig. 6 shows that Soble method is better than the other methods in this paper because the MSE value to be less than others.

Conclusions:

The proposed method is adapted to deal with different types of images through taking all image information into account. The performance of the proposed method was measured against clinician hand-labelled images. The present work use fuzzy edge detection features of images. It is very essential to extract infected blood vessels to diagnose early for diabetic retinopathy. This results show that the proposed modified Fuzzy technique has been able to overcome the drawbacks of traditional techniques, and our analysis has mainly relied on subjective evaluation and image statistical (MSE). The experimental results based on calculating MSE values show that this proposed fuzzy edge detection images (often) better than the conventional methods.

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