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Abstract. Disease diagnosis based on retinal image analysis is very popular in order to detect a few critical diseases such as diabetic retinopathy, high blood pressure, cancer and glaucoma. The important part in the retinal is a blood vessel. Besides, the blood vessel study plays an important part in different medical areas such as ophthalmology, oncology, and neurosurgery. The significance of the vessel analysis was helped by the continuous overview in clinical studies of new medical technologies intended for improving the visualization of vessels. In this paper, a new blood vessel detection based on a combination of Kirsch's templates and Fuzzy C-Means (FCM) was proposed. The main objective of this study is to improve the detection result of FCM and achieved more effective performance compared to the Kirsch's templates result. The proposed method experimented on 20 images is utilized namely from Digital Retina Images for Vessel Extraction (DRIVE) dataset. The resulting images are compared with the benchmark images based on a few image quality assessment (IQA) such as accuracy, sensitivity and specificity. The total average of accuracy is 92.64%, while sensitivity and specificity got 95.73% and 60.45% respectively.

1. Introduction

The retinal blood vessel is recognized as a crucial part in both cardiovascular disease diagnosis and ophthalmological such as diabetic retinopathy and glaucoma [1,2]. Diabetic retinopathy is a diabetes complication that affects the eyes [3–5]. The statistic of this disease increases in community health and it's also the reason for the loss of sight. Hence, precise recognition of retinal blood vessel is vital. Manual diagnosis is usually performed by analyzing the images from a patient, as not all images show signs of diabetic retinopathy [6]. It raises the time and tips to an incorrect diagnostic decision for ophthalmologists. Hence, an automatic segmentation of the vasculature might preserve the work of the ophthalmologists and will support in portraying spotted injuries. The characteristics of retinal vasculature together with tortuosity, width, length, angles, and branching pattern can play a part in the diagnostic result. Nevertheless, even though promising, manual segmentation of retinal blood vessels is a repetitive work and time consuming, and it involves specialized expertise for even though the finest vessel could contribute to the differential diagnosis list [7]. The demand for faster and automatic study of the retinal vessel images must upraise for supporting ophthalmologists with this unpredictable and monotonous work.

2. Literature Review

In the retinal image, the blood vessel is one vital part and it acts as milestones for registration of retinal images of the similar patient collected from dissimilar sources. Over the previous era, blood vessel studies enable to determine several eye diseases. The extraction of blood vessels and vascular intersections in retinal images may assist physicians to diagnose eye disease on behalf of patient screening and clinical study [8–11]. The presence of a blood vessel may deliver data about the pathology of diseases, including diabetes and high blood. In recent developments, many approaches to automated retinal blood vessel segmentation were suggested. The summary of a few research and study about blood vessel diagnosis was shown on table 1.

Table 1. Summary the previous research about blood vessel detection

No.	Author	Research focus	Method	Performance
1.	Elbalaoui *et al.* [12]	Detection of Blood Vessel	-Adaptive thresholding - Hessian multiscale enhancement filter	Accuracy = 93.43%
2.	Wilfred Franklin *et al.* [13]	Blood vessel segmentation	-Multilayer perceptron neural network.	-
3.	Fan *et al.* [14]	Blood Vessel Segmentation	- Hierarchical Image Matting Model	Accuracy = 94.1%
4.	Wan Azani [15]	Blood Vessel Extraction	- Morphological Operation	Sensitivity = 99.6% Specificity = 47.9%
5.	Roychowdhury *et al.* [16]	Blood Vessel Segmentation	- High-pass filtering - Gaussian Mixture Model	Accuracy = 92.3%
6.	Salazar-Gonzalez *et al.* [17]	Blood Vessel Segmentation	- Graph cut technique	Accuracy = 94.12%
7.	Bandara *et al.*[18]	Blood Vessel Segmentation	-Hough line transformation	Accuracy = 93.11%
8.	Barua *et al.* [19]	Segmentation of Blood Vessels	-Artificial Neural Networks (ANN) classifier	Accuracy = 92%
9.	Lili Xu and Shuqian Luo [8]	Segmentation of Blood Vessels	- Adaptive local thresholding - Support Vector Machine (SVM)	Sensitivity = 77% Accuracy = 93.2%.

3. Research Methodology

The proposed system consists of three stages, in the pre-processing part, the aim is to covert the retinal color image to the grayscale image and the second stage is the feature extraction of the image. Next, the third stage is a blood vessel segmentation using Fuzzy C-Means. The proposed method for blood vessel detection is illustrated in Figure 1**.**

3.1. Pre-Processing

Many researchers agree that the pre-processing process is very important, especially in the medical image [20,21]. Pre-processing able to eliminate noise and reduce the illumination and contrast effect [22,23].

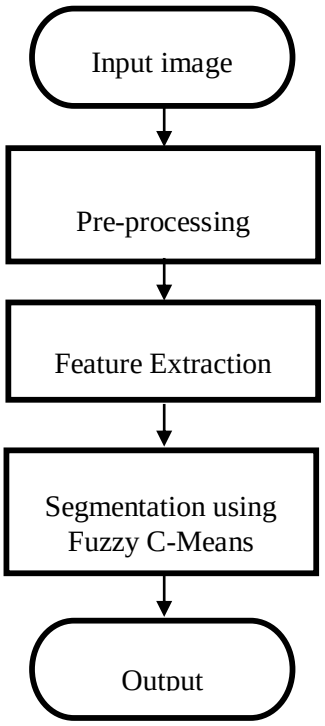

Figure 1: Flowchart blood vessel extraction

3.2. Feature Extraction

Image feature attributes or distinctive aspect was important in image processing. Features extracted from the image useful especially for classification and image recognition. Characteristics of extracted during this phase helps to classify pixels whether it is vessel or not. In this paper, the extraction using threshold, elements of the restructuring, closing morphology and Kirsch template used.

3.3. Kirsch's templates

Kirsch template is one of the first order derivative versions of discrete for enhancement and detection. This technique was used in order to detect the edge of blood vessel by using the eight direction of template which rotated fairly by 45 °. From the templates result, the greater will be considered for the output of products and then extracted. Kirsch template can set and reset thresholds to find the perfect image [24]. Figure 2 shows the arrays of Kirsch's templates.

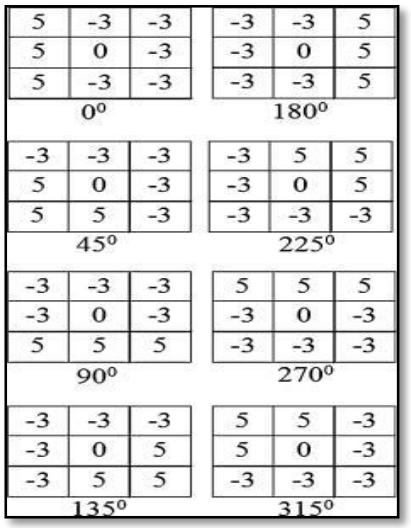

Figure 2: Arrays of Kirsch's method

3.4. Segmentation using Fuzzy C-Means (FCM)

Fuzzy C-Means (FCM) is widely used in pattern recognition as a clustering method. By updating the cluster centers and the membership grades for each unique pixel, FCM shifts the cluster centers to the "true" location within a set of pixels. To accommodate the introduction of fuzzy partitioning involved the membership matrix is randomly and membership of function of the data point [25]. FCM consist a few mathematical equation and complicated, however the segmentation performance is good.

4. Result And Discussion

In this research, the programs were run in MATLAB R2017b from an HP laptop with Intel® Core™ i7-45000 CPU @2.40GHz and 8.00GB RAM. The method experimented with the 20 retinal images from DRIVE online database and can be download at https://www.isi.uu.nl/Research/Databases/DRIVE/. A DRIVE image is an established database and specific for the blood vessel detection. The size image of each is 565 x 584 pixels with 24-bit depth and 96 dpi. The original image is shown in Figure 3 (a). Different channels namely red, green and blue will be extracted. The vessels are visible in the red channel. In the pre-processing stage, the input image is resized and the green channel image is separate because the blood vessel appears brighter in the green channel image will be employed as shown in Figure 3 (b). In this paper, a comparison between ground truths vessel extractions from DRIVE Database as a benchmark is compared with the Kirsch Template method and is shown in Figure 3 (c) and Figure 3 (d). Then, a comparison is made between ground truths with our proposed method as shown in Figure 3 (e). Table 2 shows the result in term of accuracy, sensitivity and specificity between the two methods and the benchmark images.

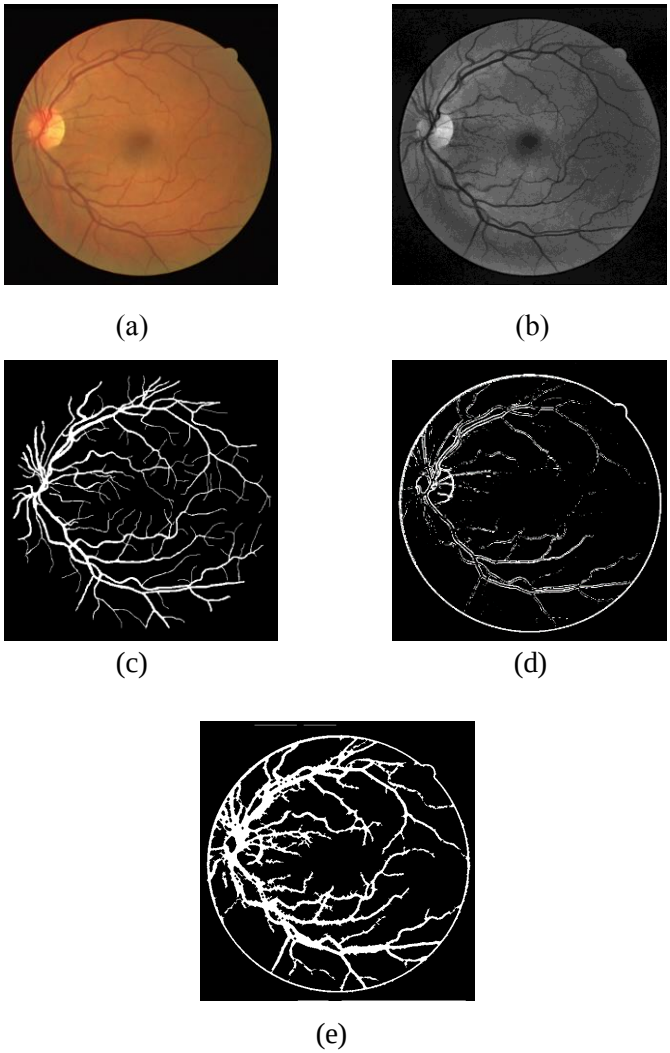

Figure 3: Resulting of the retinal image; (a) original image, (b) image after applying pre-processing, (c) ground truth image, (d) image after applying the Kirsch's technique and (e) image after applying the proposed method.

Table 2. Comparison of resulting performance after applying proposed method

Image	Ground truth vs Kirsch Templates			Ground truth vs Proposed method		
	Accuracy %	Sensitivity %	Specificity %	Accuracy %	Sensitivity %	Specificity %
1	90.25	96.35	28.04	92.08	94.25	69.96
2	90.13	96.83	31.41	93.02	94.52	79.87
3	89.36	97.59	14.91	91.69	96.80	45.49
4	90.92	96.66	34.26	93.48	96.33	65.44
5	90.28	97.52	20.25	93.23	96.80	58.64
6	89.68	97.31	18.84	92.29	96.81	50.33
7	90.97	97.11	29.96	92.74	95.76	62.63

8	90.21	96.97	18.41	92.32	96.79	44.80
9	90.77	97.33	16.35	93.00	96.83	49.59
10	91.10	97.34	21.62	93.28	96.46	57.88
11	91.27	96.53	37.76	92.17	93.92	74.33
12	90.53	96.99	22.13	92.32	95.61	57.48
13	90.07	96.97	26.35	92.60	96.14	59.95
14	91.15	96.85	26.37	93.06	95.28	67.90
15	92.69	97.08	35.82	93.76	95.37	72.98
16	90.49	96.56	29.36	92.23	95.95	64.85
17	90.09	96.48	20.93	92.06	95.75	52.10
18	90.10	96.33	17.68	91.65	94.61	57.28
19	90.75	96.77	24.19	92.96	96.37	66.37
20	91.04	97.00	15.89	92.92	96.24	51.07
Average	90.59%	96.93%	24.53%	92.64 %	97.73 %	60.45 %

In order to demonstrate the effectiveness, three parameters are used namely the accuracy, sensitivity and specificity. The equation for accuracy, sensitivity and specificity can refer to [26,27]. In this work, the proposed method is compared with Kirsch Templates method in term of accuracy, sensitivity and specificity. Based on the result, a proposed method obtained slightly higher in term of accuracy which is 92.64 % compare than 90.59%. The specificity result also shown improvement from 24.53% to 60.45 %. Lastly, performance based on sensitivity give the highest result which is 97.73 % compare than 96.93%.

5. Conclusion

Diabetic retinopathy is a diabetes complication that affects the eyes. The statistic of this disease increases in community health and it also the reason of loss of sight. Hence, precise recognition of retinal blood vessel is vital. In this paper, new approaches based on a combination of Kirsch Templates and FCM were proposed. The aim is to improve the detection technique of Kirsch Templates. Based on the result, the proposed method successful to overcome the Kirsch Templates performance shown by Accuracy = 92.64%, Sensitivity = 97.73% and Specificity = 60.45. Although our proposed method can detect blood vessel effectively but still fail to detect small vessels. The future way of segmentation research will be to develop quicker and more accurate more automated methods.

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