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Hybrid Method based Retinal Optic Disc Detection

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ABSTRACT

We propose a hybrid method based for the Optic Disc (OD) detection in the retinal image. This research consists of three main steps. First, blood vessel removal with homomorphic and median filtering. Second, edge detection using canny operator. Third, OD detection using the Hough transform. The Hough transform is used since the objective object is the curve with circle shape, i.e. optic disc region. Therefore, we can find the shape by using the Hough transform with the circle equation. In this research, the generated circles from Hough transform are matched with the edge pixels of the retinal image. The closest match (showed by the maximum value of accumulator) means that the optic disc is detected. The experiments show that the best accuracy is achieved when the distance value between the generated circles is 3. The average sensitivity, specificity, and balanced accuracy are 64.6182575%, 98.58545%, and 81.6018%, respectively.

KEYWORDS

Homomorphic Filtering, Canny Edge Detection, Hough Transform, balanced accuracy, sensitivity, specificity.

1 INTRODUCTION

Nowadays, research on biomedics has been growth increasingly since many advantages are obtained from the research. Especially, the early screening of a certain deathly disease. Some research are conducted to detect the disease automatically using computational artificial intelligence method [1,2]. Therefore, the result of these researches will help the physicist or as the second opinion of finding disease.

This research proposes on automatically finding the location of Optic Disc (OD) in the retinal image using the Hough transform. This research is one of the preliminary researches of early detection of Diabetic Retinopathy disease. Early detection of Diabetic Retinopathy (DR) has been an importance issue since this disease makes the irreversible blindness. To identify the DR disease, some features in the retinal images are important, i.e. microaneurysms, exudates, and haemorrhage [3]. Other features are less important, for instance, blood vessel and optic disc. We will remove the less important features to obtain the important features for DR disease identification; therefore, we have to find the location of blood vessel and optic disc (segmentation), in order to eliminate those features.

We have done several researches to detect the location of blood vessel pixels in the retinal images[4,5]. This research focus on the OD segmentation using Hough transforms. The remainder of the paper is organized as follows, section 2 will describe the Research Method. Section 3 explains the Hough transform for the detection process, and section 5 describes the result and discussion, and finally the conclusion section in section 6.

2 RESEARCH METHOD

Three main stages are required in the Optic Disc (OD) detection of this research. First, preprocessing using homomorphic and median filtering . Second, edge detection using canny operator, and third OD detection using Hough transform. These stages are depicted in Fig. 1.

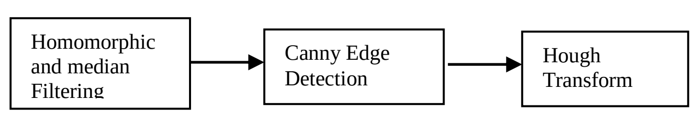

Fig. 1. Automatic Optic Disc Detection Research Method

In the first stage, homomorphic and median filtering is implemented for blood vessel removal in the retinal images. Since the blood vessel pixels are removed, then only the optic disc pixels and small noises are remained in the retinal image. Therefore, the accuracy of optic disc will increase. The result of homomorphic filtering and median filtering can be seen in Fig. 2.

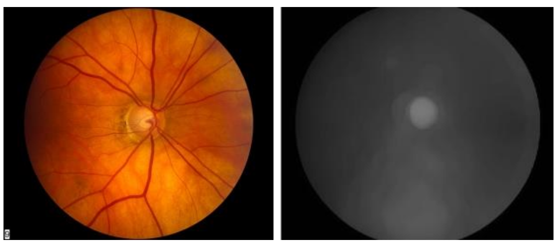

Fig. 2. (Left) Original retinal image ; (Right) homomorphic and median filtered image

As seen in the Fig.2, other features besides the optic disc pixels are removed. Hence only optic disc and some noises pixels are considered in the next stage.

The Second stage of this research is edge detection process. In this stage, we use canny detection algorithm since it is an optimal edge detection algorithm [6,7]. Edge detection is required since we need to find the certain shape in the retinal image, i.e. circle that is the shape of an optic disc. To ease the finding of circle shape in the image, we need the extract the edge of the retinal image. Therefore, we implement the edge detection using Canny algorithm for the retinal image. The example of the result in this stage is shown in Fig. 3.

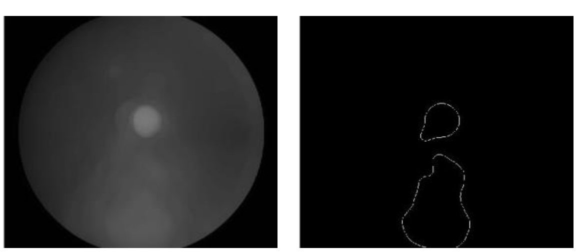

Fig. 3. (Left) Homomorphic and median filtered image ; (Right) edge detection image using Canny algorithm.

As seen in the figure, canny detection algorithm shows the optimal result of edge detection process. This edge detection image is used in the final stage, that is, optic disc detection using Hough transform.

2 HOUGH TRANSFORM

The objective of this research is finding the location of Optic Disc (OD) pixels. The OD pixel in the retinal images is the feature with circle shape. Therefore, in this research we use Hough Transform for this purpose. The Hough transform can detect certain shape in the image using the shape equation [8,9]. The circle shape is represented by the equation as seen in (1).

$$R^2 = (x-a)^2 + (y-b)^2 , \qquad (1)$$

where (a,b) is the centre coordinate of the circle, R is the radius of the circle, and (x,y) is the pixel coordinates at the edge of the circles shape.

The Hough transform will generate circles using (1) and the information of edge pixels from the previous stage. Hence, the generated circles will only focus in the candidate area of the optic disc pixels. The example of generated circles based on the edge pixels can be seen in Fig.4.

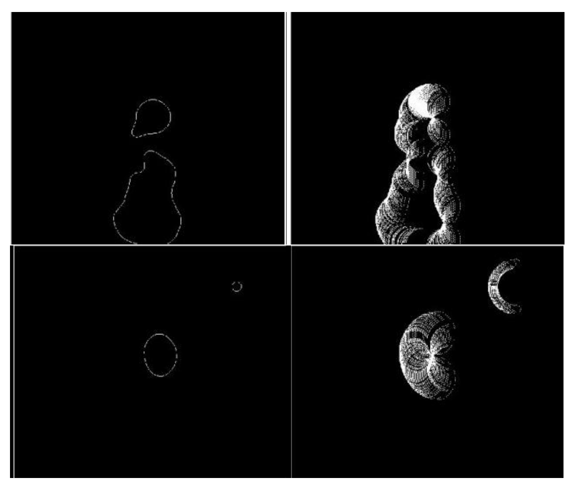

Fig. 4. (Left) Edge Detection Image; (Right) Generated circles using Hough transform

The entirely generated circles are then matched with the edge pixels from the previous stage. The matched pixels between every generated circle and the edge pixels from the edge detection image are calculated. The most maximum number of matched pixels of the generated circle is considered as the closest match. Hence, the generated circle is the detected optic disc pixels.

4 RESULT and DISCUSSION

Forty retinal images from INSPIRE (Iowa Normative Set for Processing Images of Retina) dataset [10] are used for the experiment in this research. The dataset provides the retinal image and also its Ground truth image. Therefore, we can justify our result of the experiment with this ground truth image. Three kinds of performance measure are used to measure the accuracy of the detection result, i.e. sensitivity, specificity, and balanced accuracy, as seen in (2) , (3), and (4).

$$BalancedAccuracy = \frac{Sensitivity + Specificity}{2}, \quad (2)$$

$$Sensitivity = \frac{TruePositives}{TruePositives + FalseNegatives}, \quad (3)$$

$$Specificity = \frac{TrueNegatives}{TrueNegatives + FalsePositives}. \quad (4)$$

Sensitivity is the probability of true detected optic disc pixel (foreground), specificity is the probability of true detected background pixel, and meanwhile the balanced accuracy is the average accuracy of sensitivity and specificity.
Description of True Positive pixels (TP), True Negative pixels (TN), False Positive pixels (FP), and False Negative pixels (FN) are shown ini Table. 1.

TABLE I. DEFINITION OF TP, TN, FP, AND FN

	Optic Disc Pixels	Background Pixels
Detected as Optic Disc Pixels	True Positives	False Positives
Detected as Background Pixels	False Negatives	True Negatives

Three scenarios are conducted in this experiment based on the distance of interval between the generated circles in the Hough transform process, i.e. 5, 3, and 1. The average accuracy of all scenarios is shown in Table 2.

The scenario 1 obtains the lowest sensitivity rate, i.e. 50.883%. Meanwhile, the scenario has the highest specificity rate, i.e. 99.4862. The lowest sensitivity rate is obtained, since in the maximum accumulator of generated pixels from Hough transform only cover the small part of optic disc in the retinal image (see blue pixels on the right image of Fig 5). On the contrary, this result makes the specificity is high, since all pixels beside the detected optic disc pixels considered as background pixels. Left images in the figure show the detected optic disc pixels. Meanwhile the right images show the detected optic disc pixels are superimposed on the original of the retinal images.

TABLE II. AVERAGE ACCURACY RATE FOR THE OPTIC DISC DETECTION

No	Dist	Average Accuracy (%)		
		Sensitivity	***Specificity***	***Balanced Accuracy***
1	5	50.88359	99.4862	75.1849
2	3	64.6182575	98.58545	81.6018
3	1	56.623305	99.386	78.004675

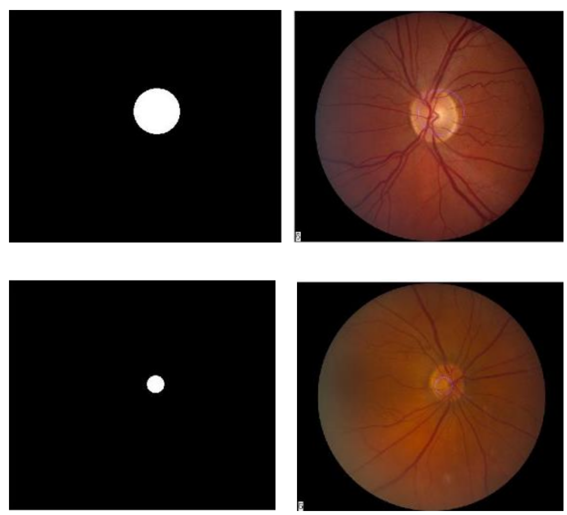

Fig. 5. (Left) Detected Optic Disc pixels and (right) Detected Optic Disc pixels superimposed on original retinal image (blue pixels)

The scenario 2 is the highest balanced accuracy that is 81.6018% accuracy. Moreover, the scenario 2 has the highest sensitivity rate, i.e. 64.6183%, and unfortunately it has the lowest specificity rate, i.e. 98.585%. The example result of this scenario is depicted in Fig 6. As seen in the Figure, the detected optic disc pixels almost cover up all the entire pixels of the optic disc pixels in the original retinal image. Therefore in this scenario, the highest sensitivity rate is achieved. The accuracy of Hough transform also depends on the edge detection process since generated circles on Hough transform are checked on the edge pixels only.

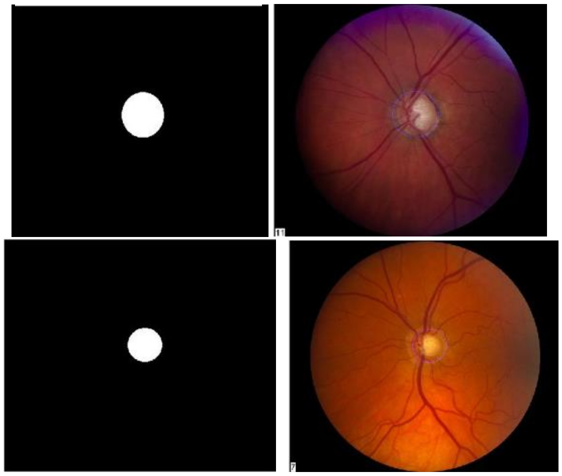

Fig. 6. (Left) Detected Optic Disc pixels and (right) Detected Optic Disc pixels superimposed on original retinal image (blue pixels)

6 CONCLUSION

Detection of the optic disc of the retinal image in this research implements the combination of Homomorphic filtering and Hough transform. The preprocessing stage uses the Homomorphic filtering. The result of this stage is blood vessel pixels are reduced. The main stage of this research, i.e. the detection of optic disc pixels uses the Hough transform. Hough transform generates a number of circles and the circles is matched to the edge image of the retinal image.

The closest match is used as the detected optic disc pixels. The experiment results on the INSPIRE dataset prove that the best value of the distance between generated circles in Hough transform is 3 pixels. The sensitivity, specificity, and balanced accuracy of this detection process are 64.6182575%, 98.58545%, and 81.6018%, respectively. The closer distance of the generated circles makes the accuracy decreased since many noises in the edge image; therefore the Hough transform accumulator makes the false detection.

On the contrary, the further distance makes the accuracy is also decreased since there will be candidate optic disc pixels are missed during the Hough transform process. Hence the best value of the distance in this research is 3 pixels. The Hough transform depends on the edge pixels in the retinal image since the generated circles are matched to the edge pixel, therefore in the future research improvement of the edge detection pixels is recommended.

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