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A Novel Approach to Method for the Detection of Optic Disc Location in Retinal Images using Image Processing Techniques

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Abstract – Biomedical image analysis used for which is applied to assist in clinical diagnosis processes, is one of the research areas that draw intense interest of scientists. The retinal fundus oculi images are used in clinics extensively for the diagnosis and treatment of various eye diseases. The detection of optic disc is one of the most basic steps that should be taken during automatic screening of Diabetic Retinopathy (DR) in particular. In this study, three different solutions are proposed for detecting the optic disc location, using the brightness and circularity properties of the related region. As a result of the comparison of the findings of these three experiments, the Circular Hough Transform method applied with HSV color space is was found to be more successful by 99.16% accuracy, and therefore it is proposed as a viable method for the detection of optic disc.

Keywords *-*
Retina, optic disk, Image processing, Hough transform.

1. Introduction

The diabetes-induced diabetic retinopathy (DR) is the leading cause of blindness and reduction in visual acuity worldwide [1]. It is estimated that, there are approximately 93 million people with DR, and about 28 million people experienced a loss of vision worldwide for this reason [2]. Although many factors are effective in the DR, the most significant factor is the advanced glycation end-products, caused by increased blood glucose. This deterioration of the blood vessel walls leads to bubbles, obstructions and

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leaks in the veins. The diabetes-induced microvascular and macrovascular complications are seen in the retinal veins as well as all blood vessels in the body [3]. Renal failures, coronary artery occlusion, stroke due to the obstruction of cerebral vessels are the major systemic vascular locations of vital risk that may lead to death due to diabetes. Observing retinal vascular circulation without any invasive intervention is very important for monitoring systemic diseases. In this regard, the data obtained by retinal examination is an indicator for systemic inflammation in diabetes. According to the results of a comprehensive study conducted in the U.S., DR presence carries a risk of mortality in the range of 34% to 89% [4]. Microaneurysm, hemorrhage, soft exudates and exudates are the findings of the DR. Images of fundus oculi need to be analyzed in order to investigate the symptoms of DR disease that severely affects human health in modern society. And, this necessity continues in an ever-increasing manner. For this reason, systems to help ophthalmologists for diagnosis with fundus oculi images have to be developed [5]. The exudate, which is one of the important symptoms of DR disease, has a similar color and structure with optic disc (OD). For this reason, determining the location of the OD constitutes a fundamental step in terms of the identification of exudate and other DR signs.

Considering the studies in the literature on the detection of OD location, various image processing techniques such as pixel-based image segmentation, circular Hough transform, morphological operations, matched filter and edge detection algorithms were found to be used.

In one of the optic disc detection studies using pixel-based image segmentation approach, 99.1% success rate has been achieved on 112 images, which have been thresholder using brightness value after applying pre-processing such as contrast adjustment, brightness adjustment and histogram equalization on the retinal images [6]. And, in another study on optic disc detection, a 90% success rate has been achieved on 30 images, obtained by taking Mahalanobis and Euclidean distance metrics into account in line with brightness value thresholding [7].

In studies conducted with methods of circular Hough transform based adaptive histogram equalization, Canny edge detection algorithm, morphological operations and Circular Hough Transform, the success rates in optic disc detection were 98.4% on 1056 images [8], 98% on 54 images [9], 87.5% on 40 images [10], and 98.87% on 89 images [11], respectively. In a different study, matched filter and morphological operations were applied to retinal images, and optic disc detection was achieved with a 98.77% success rate on 81 images [12].

In this study, 3 different methods were applied on 120 images taken from the DIARETDB0 and DIARETDB1 databases, and the most successful image processing solution was used for detection of OD location.

2. Materials and Method

2.1. Materials

ImageRet project has published DIARETDB0 and DIARETDB1 public databases in 2007. Of the 120 fundus images taken from the DIARETDB0 and DIARETDB1 databases used in our study, 105 had DR signs, whereas 12 images had no DR sign. Retinal images had been obtained with the ZEISS FF 450 Plus fundus camera using 50° of view angle. The images are in PNG format, having a size of 1500x1152 pixels, and the reports, which had been created by four medical experts independently, are kept in an XML file [14]. An image taken from the database is shown in Figure 1.

Figure 1: The retina fundus image.

2.2. Method

In this study, three different solutions are proposed for the detection of the optic disc location. HSV color space transform, adaptive histogram equalization, Canny edge detection algorithm, and the Circular Hough Transform are the image processing methods used in these solutions.

The HSV (Hue, Saturation, Value) color space is one of the frequently preferred color spaces in image processing. It consists of transformation of the main colors in a non-linear fashion [15]. In the study, the retinal image is transferred to V channel of the HSV color space.

Adaptive histogram equalization is a local histogram-equalization algorithm used to solve the problem of noise in images having a dense distribution in a narrow region. In this algorithm, the image is divided into rectangular regions, and histogram equalization is applied to each region. After applying the histogram equalization process to the sub-regions of the base image, the sub-regions are combined through bilinear interpolation method to obtain enhanced image [16]. In the study, the HSV color space and adaptive histogram equalization methods are used to make the optic disc area have a more distinct appearance.

The Canny edge detection algorithm is a highly efficient algorithm for finding edges. The steps of this algorithm are as follows: first, the image is converted to gray level. The noises are cleaned by applying Gaussian filter on the gray-scaled image as in Equation 1 in order to make edge detection easier (σ: Smoothing coefficient).

$$F(x,y) = I(x,y) * G(x,y,\sigma) \quad (1)$$

The partial derivatives of the image obtained as the result of filtering are calculated as in the Equation 2, and gradient value of each point is found.

$$M(x,y) = |\nabla I(x,y)| = \sqrt{(\frac{\partial F(x,y)}{\partial x})^2 + (\frac{\partial F(x,y)}{\partial y})^2} \quad (2)$$

The non-maximum points are suppressed at the gradient values. In the last step of the algorithm, a threshold value is applied to *M(x,y)* and all points below the threshold value is set as the background in order to reduce the number of false edge points [17]. In the study, in order to be able to apply the Circular Hough Transform to the pre-processed retinal image, Canny edge detection algorithm is used to convert image into the binary (black and white) form.

For the Circular Hough Transform, any thresholding method is applied to the edges detected in order to obtain a new black-and-white image. Then, using an accumulator matrix, the values of points through which the circle passing in the polar plane is increased one by one. Values are assigned for all pixels in this way, and probable circles are determined [18]. In the study, OD location is detected by finding circles having a radius in the range of 95-105 pixels by applying the Circular Hough Transform. These algorithms and methods applied for these solutions are shown in Figure 2, Figure 3 and Figure 4.

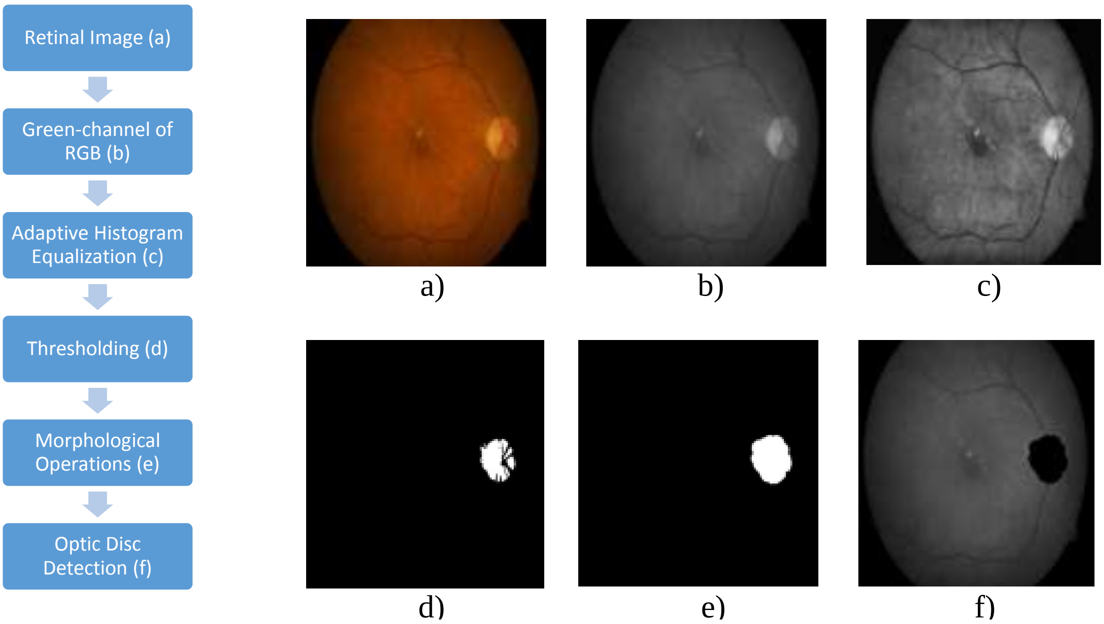

Figure 2: Optic disc detection algorithm with thresholding.

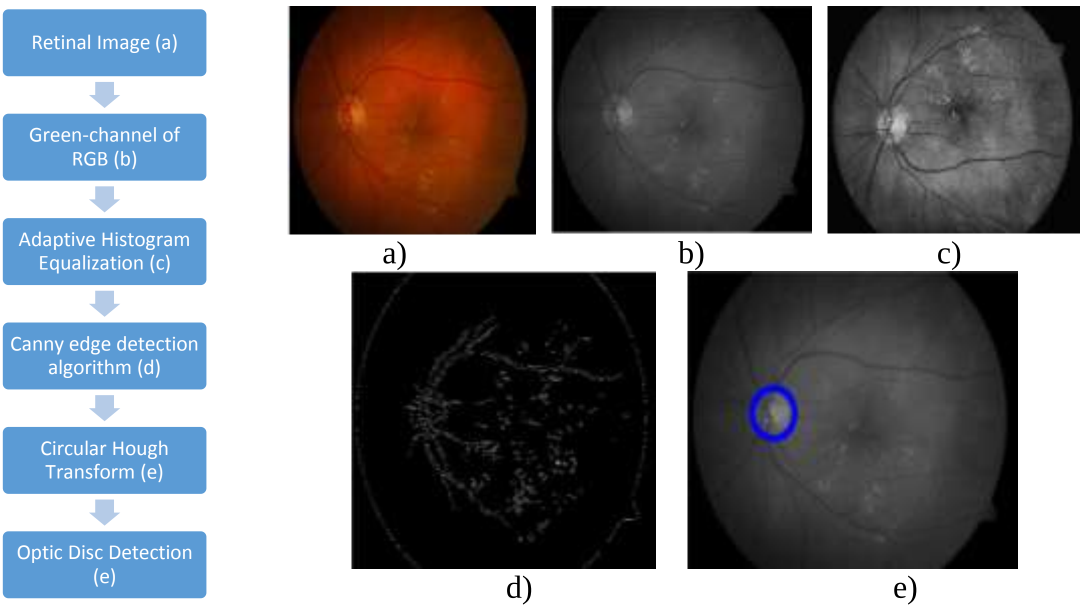

Figure 3: Optic disc detection algorithm using Circular Hough Transform.

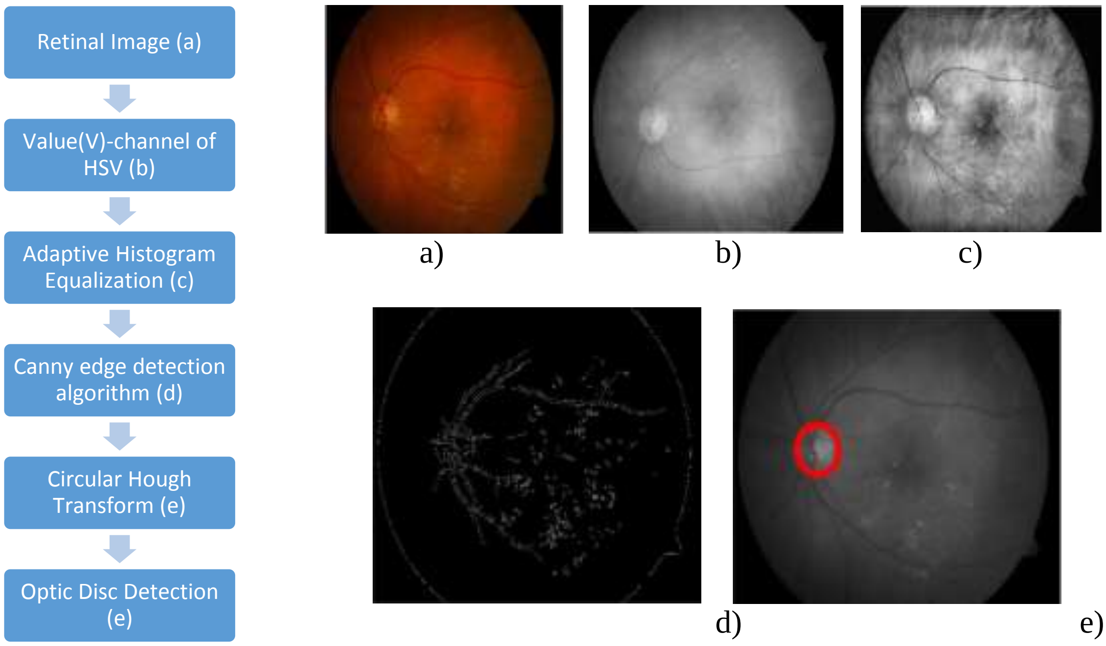

Figure 4: Optic disc detection algorithm using HSV color space and Circular Hough Transform.

As shown in Figure 2 and 3, switching to green-channel of RGB color space and adaptive histogram equalization was applied on the image as a pre-processing in both experimental trials. After the pre-processing, the first experiment used the thresholding method based on brightness value and area of the OD region. And, in the other experiment, circular Hough transform, which is a specific type of Hough transform method, was used since the OD area has a circular shape. In Figure 4, first the retinal image was transferred to the Value (V) channel of the HSV color space, and the circularity of the optic disc region was brought to the fore. After converting the image into the black-and-white form using the Canny edge detection algorithm, the circular Hough transform is applied to better detect the OD region.

As a result of the experimental studies conducted with the DIARETDB1 dataset, the HSV color space and circular Hough transform based solution proposal was observed to be more successful, and the results are given in Table 1.

Table 1: Comparison of the solutions.

Image Processing Methods	**TCC (%)**
Optic Disc Detection Algorithm with Thresholding	89.88
Optic Disc Detection Algorithm with Circular Hough Transform	98.87
Optic Disc Detection Algorithm with HSV Color Space and Circular Hough Transform	99.16

(TCC: Total Correct Classification)

As shown in Table 1, the HSV color space and circular Hough transform based solution proposal seems to be more successful. In this way, the confusion of diseased regions having the same features with the optic disc region will be prevented in the computer-aided diagnosis of retinal diseases. The results of the comparison of the proposed method with the studies in the literature are shown in Table 2.

Table 2: Comparison of the proposed method and the literature.

Author	**Year**	**Data of Number**	**TCC (%)**
Walter and Klein	1999	30	90.00
Fleming et al.	2007	1056	98.40
Treigys et al.	2008	54	98.00
Youssif et al.	2008	81	98.77
Nergiz et al.	2014	40	87.50
Adem et al.	2016	89	98.87
Proposed method	2016	120	99.16

As seen in Table 2, the proposed study has more successful results than the other studies in the literature.

3. Conclusion

In this study, we proposed a novel approach for detecting the optic disc location, which is the capable of avoiding the confusion with DR lesions. Switching to the Value (V) channel of the HSV color space, adaptive histogram equalization, Canny edge detection algorithm, and circular Hough transform was applied to the 120 retinal images, respectively. The retinal images taken from the DIARETDB0-1 database was preferred since it was used in other studies and offers an impartial assessment. Thanks to the proposed approach, the optic disc location was detected with 99.16% accuracy. In future studies, automatic detection of the lesions with higher success rates is intended by taking out the detected optic disc locations in the retinal images.

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