Automatic Localization of the Optic Disc in Retinal Images Using Top Hat Transform Algorithm

Rasik Dhoble
Dept.of Electronics and Telcom. Eng. 
YCCE
Nagpur, India
rasikd2@gmail.com

Nita Nimbarte
Dept. of Electronics & Telecom. Eng.
YCCE, 
Nagpur, India
nitangp@gmail.com

Sapana Dhanvijay
Dept Electronics Engineering
Priyadarshini Bhagwati College of Engineering, 
Nagpur, India
sapanaadhanvijay@gmail.com

Abstract—In Diabetic retinopathy, early detection as well as periodic screening helps in reducing the progress of disease and in preventing the subsequent loss of visual capability. The system extracts some retinal features, such as optic disc, retinal tissue for easier segmentation of dark spot lesions in the fundus images. To improve the detection optic disc in diabetic retinopathy image, a morphological top hat transform, bottom hat transform, combination of the two transform are proposed in this paper. The proposed algorithm is applied on the DIARETDB1_v_1_1 fundus color image dataset. Experimental results show that the performance of our method is effective to detect and remove the optic disc in retinal fundus image.

Keywords- Diabetic Retinopathy (DR), Optic Disc, Hemorrhages (HMs))

I. INTRODUCTION

Diabetes occurs when the level of glucose in the blood is higher than normal. Over several years diabetes can damage the blood vessels of the retina causing what is called diabetic retinopathy (DR) and is the major cause of poor vision [1]. Diabetic retinopathy is a serious complication of diabetes mellitus and a major cause of blindness all over the world. Diabetic retinopathy (DR) is a condition arises where the retina is damaged due to fluid leaking from the blood vessels in retina. As DR is a progressive disease, the longer a patient has untreated diabetes, the higher is his chances of progress towards potential blindness. Therefore, early detection as well as the periodic screening of DR helps in reducing the progressing of this disease and will be useful in preventing the subsequent loss of visual capability. Signs of diabetic retinopathy include red lesions such as microaneurysms (MAs), intraretinal hemorrhages (HMs) and bright lesions such as exudates (Exs), cotton wool spots. Red lesions are considered to be first clinically observable lesions depicting diabetic retinopathy. Therefore, their detection is essential for a prescreening system.

Hemorrhages are larger irregular ‘dot’ configuration very similar color components as retinal image background. Due to non-uniform illumination and contrast across retinal image, it becomes difficult to detect Hemorrhages precisely.

In the literature, a number of methods have been reported to address the problem of Hemorrhage detection in Diabetic Retinopathy (DR). In [2], author proposed a system consisting of a novel hybrid classifier for the detection of retinal lesions. He uses standard fundus image database. The proposed system consists of preprocessing, extraction of candidate lesions, feature set formulation, and classification. In [3] Dongbo Zhang, Xiong Li, Xinyu Shang, Yao Yi, Yaonan Wang applied algorithm to improve the robust performance to detect hemorrhage lesions in diabetic retinopathy image with a background estimation and vessel exclusion based algorithm. The author in [4] had developed several automated methods for detecting abnormalities in fundus images. They propose a new method for preprocessing and false positive elimination in the study based on hue saturation value (HSV) space, gamma correction etc. In study of paper [5], the blood vessel regions incorrectly detected as hemorrhages were eliminated by first examining the structure of the blood vessels and then evaluating the length-to-width ratio. The sensitivity of detecting hemorrhages in the fundus images was 85%. Meindert Niemeijer, Bram van Ginneken, Joes Staal, Maria S. A. Suttorp-Schulten, and Michael D. Abràmoff [6], proposed a novel red lesion detection method is based on a hybrid approach, combining prior works by Spencer et al. [7] and Frame et al [8] with two important new contributions. Yuji Hatanaka, Toshiaki Nakagawa, Yoshinori Hayashi, Takeshi Hara and Hiroshi Fujita [9] propose the algorithm that the brightness of the fundus image was changed by the nonlinear curve with brightness values of the hue saturation value (HSV) space. In [10] author proposes that after pre-processing, a morphological technique was used to segment red lesion candidates from the background and other

Fig. 1 – Human retina and NPDR: (a) normal retina along with main components (b) severe NPDR with red lesion and bright lesion
retinal structures. Then a rule-based classifier was used to discriminate actual red lesions from artifacts.

Marwan D. Saleh and C. Eswaran [12], proposed the system that extracts some retinal features, such as optic disc, retinal tissue for easier segmentation of dark spot lesions in the retinal fundus image. That is followed by the classification of the correctly segmented spots into MAs and HAs. Based on the number and location of MAs and HAs, the system quantifies the severity level of DR. Giri Babu Kande, T. Satya Savithri, and P. Venkata Subbaiah [13], applied pixel classification and mathematical morphology for detection of red lesion. The proposed system retains the computational simplicity with high sensitivity and reasonable specificity.

II. MATERIAL

The dataset used in this paper is the DIARETDB1_v_1_1 dataset [13]. It gives the relative study on various signs in DR. The dataset consists of a total of 89 color retinal images which is used for creating genuine clinical diagnoses.

III. METHODS FOR DETECTION OF OPTIC DISC

In this work input to the developed system is a color image of human retina, which is acquired by using a fundus camera. A database of DIARETDB1_v_1_1 color images compressed in PNG format was used in this work to test the accuracy of the proposed algorithms for optic disc detection and removal. This is open source database readily available online.

A. Preprocessing

Pre-processing is a crucial stage for preparing the fundus image for further process since image quality varies according to the conditions of acquisition. The image could be acquired under some undesired conditions, such as unevenly illuminated, noisy or low-contrasted images, which obviously influence the performance of segmentation algorithm. Hence the acquired RGB image has to undergo a sequence of preprocessing steps, which are Green-plane extraction, optic disc removal, and background normalization. For detecting red lesions, normally, the green channel of the color retinal image is employed as it shows the best red lesion/background contrast. But the red channel has the advantages of being brighter and distributed over a wider range of gray-level values, which results in less contrast between bright lesions and the retinal background.

Fig. 2 – Input image

The algorithm starts with resizing all input images to 600 × 800 pixels with JPEG format. In proposed algorithm, we consider Fig. 2 as input image. In RGB color image components green-channel provides maximum information among the image pixel values. As MAs and HAs are clearly distinct from the other retinal in green channel. But as we are removing the optic disc hence we here consider red channel in the input image with intensity \( f_R \). Thus, such conversion will decrease the computational time, as well as the storage space.

B. Optic Disc detection and removal

In pre-processing stage we focus on removing some retinal features, namely optic disc from the retinal fundus image. Optic disc (OD) in general has some characteristics such as high intensity, circular shape and constant size. Normally, some dark objects could appear inside the optic disc which may be incorrectly considered as hemorrhages (HAs). Therefore, optic disc removal will help to eliminate those confusing objects which may be falsely detected as HAs. Optic disc will always be present at middle region of the fundus image due to position of the fundus camera. Because of this the proposed method for optic disc removal starts with focusing on the middle third region of the red intensity image. Because of this the computational time required for processing the image reduces significantly and helps to get accurate results. Hence we cropped the input image to middle third region as shown in fig.3 (a) and then apply further methods.

Next, the image is processed with a median filter of size 11 × 11 pixels to fill up the thin blood vessel regions inside Optic Disc. The resulting image after applying median filter is shown in Fig. 3(b). Basically, the median filter replaces the value of the pixel \( f_R(a,b) \) by the median of all pixels in neighborhood of this pixel, as follows:

\[
    f_{\text{median}}(x,y) = \operatorname{median}\{f_R(a,b)\}_{(a,b) \in z_{x,y}}
\]

(1)

Where \( Z \) represents a neighborhood centered on location \( (x, y) \) in the image.

Then morphological top hat transform applied to enhance the contrast of the image. The resulting image with contrast enhancement is shown in Fig. 3(c). The top-hat transform
operation involves subtracting the result of performing a morphological opening on $f_{\text{median}}$ image from the image itself based on a given ball structuring element (SE) with 60 pixel radius.

$$T(f_{\text{median}}) = f_{\text{median}} - (f_{\text{median}} \circ SE) \quad (2)$$

The resulting image obtained from the previous process is low contrasted. Therefore, contrast stretching process [15] is applied to enhance the contrast. This process can be performed by specifying lower and upper limits of pixel intensity in image. Thus, the resulting image $f_{CE}$ obtained after contrast stretching is fig. 3(e).

The red intensity image $f_{CE}$ is then converted to a binary image using a binary threshold value $T = \max(f_{CE}) - 10$, as follows:

$$f_{\text{Bi}} = \begin{cases} 1 & \text{if } f_{CE}(x,y) \geq T \\ 0 & \text{otherwise} \end{cases} \quad (3)$$

In order to detect rough location of optic disc both morphological opening and closing operations are performed. Morphological opening is used for eliminating small objects. This is followed by closing operation to conglutinate the adjacent objects using a ‘flat’ structuring element i.e. we consider square of size $15 \times 15$ pixels. The resulting image is shown in Fig. 3(f).

As the accurate location of optic disc is being detected in the cropped image, we have to resize the cropped image to its original size. Padding zero process is used for resizing the cropped image. The resulting image obtained is then complemented to get the ‘mask’ of the region of optic disc. This mask is then cross-correlated with input image. Thus optic disc is successfully removed from the input image and image ready for further operation. This is shown in Fig. 3

![Fig. 4 - (a) Mask of rough location of optic disc (b) Complemented image (c) Input image with optic disc removal](image)

IV. RESULTS AND DISCUSSION

![Fig. 5 - The output mask obtained for (a) Red channel (b) Green channel](image)

We have used proposed algorithm for input fundus image with red channel and green channel extracted. The resultant output mask of location of optic disc is shown in fig. 4(a) for red channel Fig. 4(b) for green channel. It clearly shows that we get better result for red channel extraction.

The proposed algorithm developed here is tested on a set of retinal images of diaretdb_v_1_1 dataset. As given in figure 6(a) is the set of input images we used for the algorithm. And after applying proposed algorithm we obtained the output images in Fig. 6 (b)
This paper proposed algorithm for locating optic disc in retinal images and image with optic disc removed will be processed for Hemorrhage detection. It is an effective method to detect of optic disc in retinal images. Retinal images in the DIARETDB1_v_1_1 dataset are used to test the robustness of above algorithm. Reliant on the results that are obtained from the proposed algorithm it is seen that the optic disc is detected accurately.

REFERENCES