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A dynamic approach for optic disc localization in retinal images

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ABSTRACT

Reliable and accurate localization of optic disc is most important for retinal image analysis. In this project we localize Optic Discs in retinal images based on directional models i.e., global and local directional model. Using these models, the main vessels are molded and turned by using two parabolas with one vertex and different parameters, characterize the local vessel convergence in the OD as well as shape, size and brightness of the OD. The method proposed for the localization of the OD contour is based on mathematical morphology along with principle component analysis (PCA). The purpose of using PCA is to obtain the gray scale image that accurately represents the original RGB image. By using global model and local directional model we can efficiently and reliably localize the OD in retinal images.

Keywords: Global directional model, local directional model, OD localization, retinal image, Optimal parabola, vessel extraction.

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I. INTRODUCTION

The optic disc (OD) is the entry point of blood vessels in the retina. An OD appears as circular and bright yellowish object in normal fundus images. OD localization is important for retinal image analysis and for fundus diseases. For eg,, the localization of the Optic Disc is helpful for detecting other important structures of retina, e.g., the fovea and vessels in the eye and many sight-threatening lesions of the retina, e.g., exudates and drusen. OD localization is the prerequisite step of OD segmentation which can provide much diagnostic information of eye diseases associated with the OD, e.g., glaucoma papilledema, of the disc (NVD), and hypertensive retinopathy etc. Although ODs have some well-defined features in normal fundus images, OD localization is still very challenging in abnormal fundus images. The lesion is much brighter than the Optic Disc and often mistakenly detected as an Optic Disc. The OD is too faint to be seen. The local techniques mainly consider general features of optic disc, e.g., the appearance of the ODs and the local vessel pattern within ODs, etc. These techniques perform well in normal fundus images, but often fail in abnormal images because retinal pathologies or images artifacts may alter the appearance of ODs or may have same appearance to ODs. To overcome this problem, some techniques have been stated for OD localization depended on the anatomical e.g., fuzzy convergence of vessel binary segmentations, vessels' orientation match filter and entropy of vessel orientations. These techniques detected the densest parts in the type on the amount of vessels as the OD. However, crossing vessels, clustered dark lesson and the gaps between bright lesions may contact with their performance. To take benefit of different general characterizes and have combined the local appearance prior and the local vessel prior of ODs to find the location. However, because of all of the general features are easily impaired by pathologies and image artifacts, local techniques may not reliably localize Optic Discs in abnormal images.

In fast few decades, automated OD location has been appropriately investigated. The existing techniques are distinguished in 3 parts: local techniques, global techniques and hybrid techniques.

II. METHODOLOGY

The method consist of three main phases-

1. Retinal images
2. Global directional model
3. Local directional model
4. Optic disc localization

A. **Retinal images-**

During the analysis of retinal images, the most important pre-processing step is the detection and localization of OD. The localization of OD is based on two major assumptions:

(1) OD is the brightest region

(2) OD is the main origin point of retinal vasculatures.

Fig. 1 retinal Image

The position of OD is the main entry point in retinal blood vessels network. The main point is defined as the location where several retinal blood vessels are converged. Normalize the brightness of the images after determining the location of OD after. The position of OD was found at the brightest region in the retinal image. The position of OD is the center of cross sectional parabola.

Defining a global directional model for retinal blood vessels requires the definition on the whole image of a function which represents the preferential direction in any retinal image of a vessel presented at entry point. Vector is the set of parameters defining the model and its positioning and thus it will include the OD coordinates. By visual inspection of retinal fundus images, it appears that a common vascular pattern is present among images: the main vessels originating from the OD and follow a specific path that can be called geometrically modeled two parabolas, with a common shared vertex inside the OD. The definition of the directional model can therefore be based on this assumption. If we consider a Cartesian coordinate system, these parabolas can be considered as the geometrical locus In order to completely define the model, it is necessary to express the preferential direction also outside of the parabolic geometrical locus. Anatomical knowledge shows that vessels spreads when moving away from the ODs and branch vessels tend to diverge from the main vessel. In particular, vessels inside the parabolas quickly bend toward the macula in the that region (Specifically, the relationship between the vascular structure, optic disk and fovea is modeled as a parabolic structure of the OD at the head of the parabola and the fovea located in line with the OD in the region closed by the parabola. The shape of the OD being roughly oval is another information used for its detection.

A new method, pyramidal decomposition is used for OD detection and with a candidate region which potentially include the fovea being determined using its relative position with respect to the Optic Disc. Information from the vessel tree structure, extracted using a modified active shape model, and OD located with principal component analysis (PCA) are used in. Parabola is fit to find out the main arcade of the vessel structure from which OD and macula regions are located.

Fig. 2 Optimal Parabola

B. **Global directional model-**

Originating at the OD, the blood vessel network follows a similar pattern in different fundus images. First, the main vessels move away from the OD, some of which diverge into the temporal region, while the others diverge into the nasal region. Second, the main blood vessels in the same side can be roughly regarded as a parabolic curve, and the vertex of the curves fall into the area of the Optic Disc. Third, branches of the main vessels within the temporal region quickly move toward the fovea, while the inward deflection of branches in the other region is much slower. A global directional model can be built to describe these characteristics. Since the blood vessel network is the most predominant and stable structure in a fundus image, the global model based on the vessel network is robust to pathologies and image artifacts.

1. Bi-Parabola Directional Model (BPDM)-

A global directional model, named the bi-parabola directional model (BPDM), is proposed to describe the direction of the entire vessel network. The BPDM firstly deals with the main vessels by using two parabolas with the following three assumptions:

- The two parabolas always share a common vertex in the Optic Disc

- The opening angles of the two parabolas are same

- The two parabolas share a horizontal symmetry axis.

Then the expected direction of each point in the blood vessel network is determined by its distance to the parabolas.

2. Relaxed Bi-Parabola Directional Model(R-BPDM)-

To rotate the shared axis of the shared axis of the parabolas and center their vertex at the assumed OD center.

C. **Local directional model-**

The retinal vessels enter into the eye through the OD, hence these vessels appears to be conversed in the OD region. Furthermore, an optic disc usually deals with the bright region with a round shape in a fundus image. These two local characteristics of an optic disc can be reflected by the vessel direction and the gradient direction of the Optic Disc region. To compute the gradient vector fields of ODs, in this project, a morphological operation is firstly used to remove the interference of the blood vessels and the gradient direction field of the Optic Disc region without the vessel. Both the directions of the vessels inside the OD and the gradient on the Optic Disc boundary coverage towards the OD center.

To model these two local characteristics, a local circular support is first defined by equations. Although this shows that the round and bright object but without local convergence, the proposed local model can effectively localize the true OD. In addition, the OD of the failure case of the global model, local model can successfully localize and detect the OD.

D. **Optic disc localization-**

The OD localization is done by using these two models i.e. Global directional model and Local directional model. It is based on three assumptions-

An OD is the main entry point of the entire vessel network.

1. The middle center of an Optic Disc is convergence point of the vessels.
2. An OD appearance as a round and bright object in fundus images.

These characteristics can be described and stated by using the directions of vessels or the directions of the gradients OD regions.

III. ALGORITHM

1. Start
2. Take input retinal image.
3. Complement the input image and apply dilation and opening operation.
4. Take double precision of difference image of input and complemented image and apply morphological operations on it.
5. Invert that images and take difference between input image and gray scale image.
6. Apply morphological operations on it such as dilation and erosion.
7. Extract the blood vessels by mathematical morphology.
8. Apply the opening operation on the disc shape of the input image.
9. After applying morphological operations, take ROI and pass through high pass filter.
10. Apply CLAHE process and equalize the histogram of the filtered image.
11. Take the fundus image from vessel extracted image.
12. Finally localize the optic disc in retinal images using various models.
13. Stop

IV. RESULT AND DISCUSSION

Firstly, we have taken retinal image as input image which is RGB image

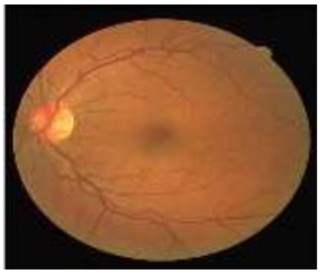

Fig. 3 Input retinal image

We converted input image into gray scale image so that it can occupy less space and then taken the complement of it. We got this image by taking dilation and opening operations as shown in figure 4.

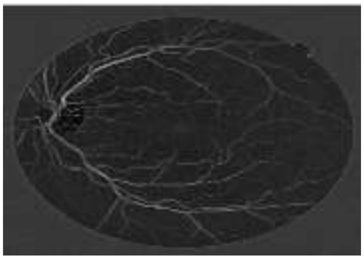

Fig. 4 Gray Scale Image

We have taken the double precision of gray scale image for increasing its size for applying all the operations as shown in figure 5.

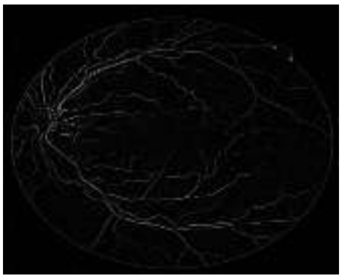

Fig. 5. Double precision image

We have performed the opening and dilation operation on figure 6. We got blood vessels faint. Dilation is used so that blood vessels are expanded and background is shrinked and opening is always followed by dilation.

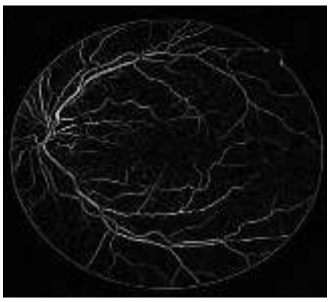

Fig. 6 Vessel expansion

Here, we have performed the closing and erosion operation on figure 7. Erosion is used so that blood vessels are shrinked and background is expanded and closing is always followed by erosion.

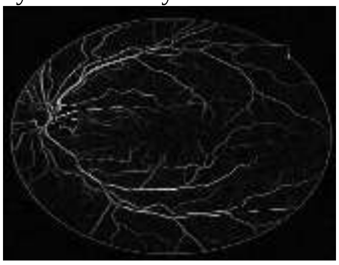

Fig. 7 Background expansion

At last, we are getting the image having extracted blood vessels by applying morphological operations. The main blood vessels are extracted which are important and which contain information for localizing optic disc as shown in figure 8.

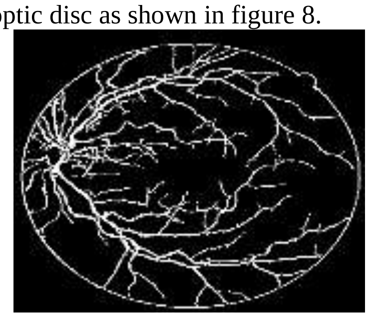

Fig. 8 Vessel Extraction by Mathematical Morphology

After vessel extraction, we applied opening operation on disc shape of input image. We can only detect location of the optic disc and other part is blur as shown in fig 9.

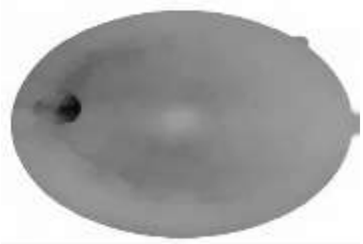

Fig. 9 Morphological opening

After applying all morphological operation, we have taken the ROI of input image and passed through high pass filter for removing noise present in it as shown in fig 10.

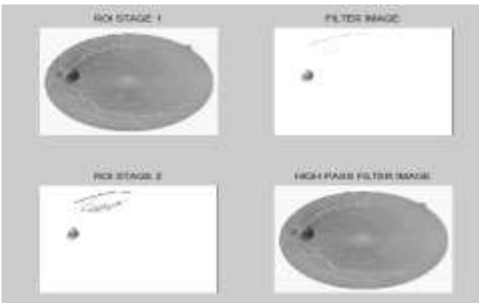

Fig 10. Filtering process

After applying CLAHE process we got image as shown in fig. 11. In this image we have equalized the histogram of filtered image. Only main vessels are extracted and remaining vessels are blur.

Fig. 11 CLAHE image

We have taken the fundus image from vessel extracted image. The fundus image is mainly for identifying diseases present in it as shown in fig. 12.

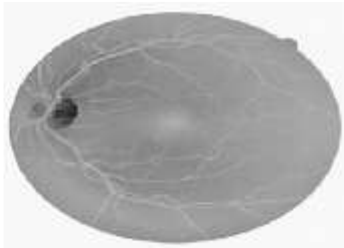

Fig. 12 Fundus image

By taking double size of fundus image, increasing size of image and we got final optic disc localized image. Here we localized the optic disc as shown in fig. 13.

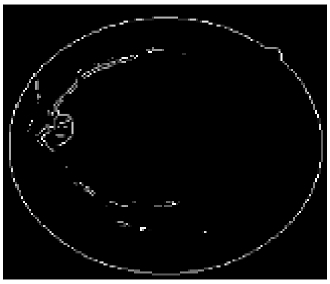

Fig. 13 OD localization

V. Conclusion

By using global directional model (R-BPDM) and local directional model (DDM) we segmented and localized the Optic Disc in retinal images. As well as we have used several morphological processes on it. The global model, which shows the relationship between ODs and entire vessel networks, is robust to pathologies and image artifacts. The local model can well characterize the shape, brightness and vessel convergence of ODs, which is an effective compliment of the global model. In future we can increase its accuracy and diseases can be removed.

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