Volume 4, Issue 5, May 2014 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

Optic Disc Segmentation Based On Watershed Transform

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Abstract— ***The retinal fundus photograph is widely used in the diagnosis and treatment of various eye diseases such as diabetic retinopathy and glaucoma. Medical image analysis and processing has great significance in the field of medicine. Segmentation in eye imaging provides an important role for calculating the geometric shape and size of optic disc and anterior segment and abnormal growth of any region in the eye. It automatically and precisely calculates the values of place, position and area of the contour and structural part of the image required by ophthalmologists.An efficient detection of optic disc (OD) in colour retinal images is a significant task in an automated retinal image analysis system. Most of the algorithms developed for OD detection are especially applicable to normal and healthy retinal images. It is a challenging task to detect OD in all types of retinal images, that is, normal, healthy images as well as abnormal, that is, images affected due to disease. This paper discusses to automatically segment the optic disc from a fundus image. For the detection of the optic disc, first step is to find the position approximately. Then find the exact contours by means of the watershed transformation. The method for the extraction of the optic disc contour is mainly based on mathematical morphology along with thresholding and watershed transform.***

Keywords— WATERSHED,OPTIC DISC,PCA,RETINAL,DIGITAL FUNDUS IMAGES

I. INTRODUCTION

Image segmentation is the first step of image analysis, which is an essential and critical technology of image analysis. Digital photography of the retina is widely used for screening of patients suffering from sight threatening diseases such as Diabetic retinopathy and Glaucoma. The timely diagnosis and referral for management of these diseases can prevent 98% of severe visual loss [1]. The shortage of the trained personnel in many countries leads to the need for automatic retinal image analysis system. Reliable and efficient automatic detection of normal features like optic disc, blood vessels and fovea in the retinal images are significant tasks in an automatic screening system. In colour fundus photograph shown in Figure 1.1.optic disc appears as a bright spot of circular or elliptical shape, interrupted by the outgoing vessels. It can be seen that optic nerves and vessels emerge into the retina through optic disc. It is situated on the nasal side of the macula and it does not contain any photoreceptor. Therefore it is also called the blind spot[1].

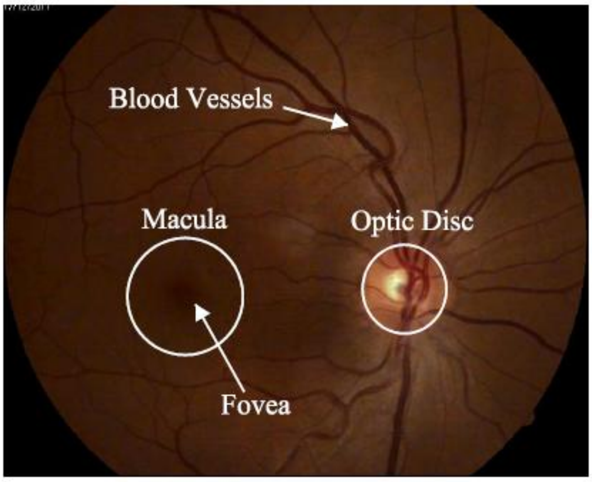


Fig. 1 Retinal Fundus Image With Main Anatomical Structures [1].

An important prerequisite for automation is the accurate localization of the main anatomical features in the image. An accurate and efficient detection of these structures is a significant task in an automated retinal image analysis system. Once these locations are known, a frame of reference can be established in the image.[1] The OD localization is important for many reasons. Optic disc detection is required as a prerequisite for the subsequent stages in many methods applied for identification of the pathological structures in retinal images. For example, in blood vessel tracking approaches the position of vessels in the neighbourhood of optic disc is used as seeds for vessel tracking. In macula localization the approximate distance between optic disc and the macula is used as a prior knowledge for locating the macula [2]. In case of diabetic retinopathy lesions identification removing the false positive optic disc region leads to improved lesion diagnosis performance. The attributes of optic disc is similar to attributes of hard exudates in terms of colour and brightness. Therefore it is located and removed during the hard exudates detection process, thereby avoiding false positives[1][6].

II. Overview Of State Of Art state

The available works related to OD processing in eye fundus color images can be grouped into two distinct categories that are location and segmentation methods. Location methods are based on finding the OD centre and segmentation algorithms on estimating its contour. Location methods are usually focused on the fact that all retinal vessels originate from the OD and follow a parabolic path or that the OD is the brightest component on the fundus. Among segmentation methods, several approaches must be stressed: templated-based algorithms , deformable models and morphological techniques. Most of algorithms based on mathematical morphology detect the OD by means of watershed transformation, generally through marker-controlled watershed, although different authors propose the use of different markers[2][3].

III. Methodology

The method studied in this paper is mainly based on mathematical morphology although includes a principal component analysis (PCA) in the preprocessing stage. The main steps of the method are the following as shown in Fig 2:

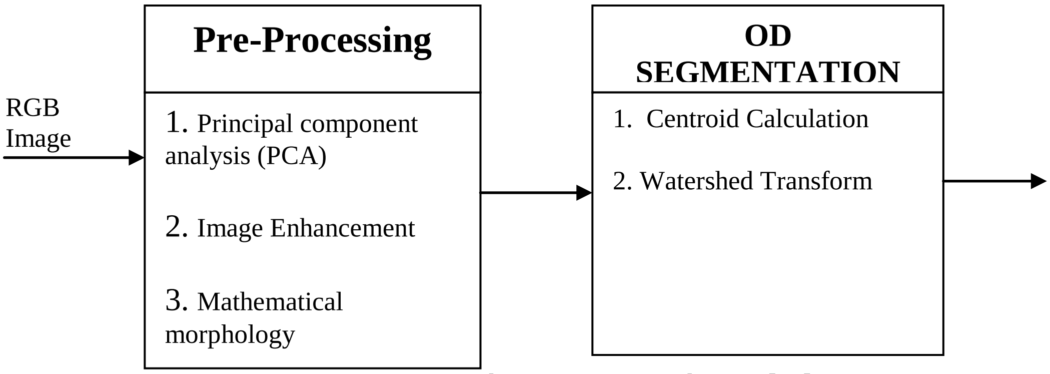


Fig. 2. Optic disc segmentation diagram[13].

First, the PCA is applied on the RGB fundus image in order to obtain a grey image in which the different structures of the retina, such as vessels and OD, are differentiated more clearly to get a more accurate detection of the OD. This stage is very important since it largely determines the final result. Then, the vessels are removed through morphology technique to make the segmentation task easier. Next, a variant of the watershed transformation, the stochastic watershed transformation, followed to a stratified watershed, are implemented on a region of the original image. Finally, it must be discriminated which of the obtained watershed regions belong to the optic disc and which ones are not. A geodesic transformation and a further threshold are used to achieve that purpose. The algorithm is fully automatic, so process is speeded up and user intervention is avoided making it completely transparent. Moreover, the method provides robustness in each processing step. First, it is independent of the database thanks to using PCA. Secondly, it employs the grey-image centroid as initial seed so that not only the pixel intensity is taken into account. Thirdly, it makes use of the stochastic watershed in order to avoid sub-segmentation problems related to classical watershed transformation[13].

A. **Pre-processing:**

1). Principal component analysis (PCA): It can also be used to localize optic disk. PCA can extract the common characteristics among the training images. These common characteristics are then used to detect the similar object in an input image. PCA will only be employed to the candidate regions to reduce the computation time. The central idea of PCA is to reduce the dimensionality of a data set consisting of a number of interrelated variables, while retaining as much as possible of the variation present in the data set. This is achieved by transforming to a new set of variables, the principal components (PCs), which are uncorrelated, and ordered so that the first few retain most of the variations present in all of the original variables [8][13].

Fig 3: (a) Original image, (b) Gray-scale image obtained by PCA[13]

2). Image enhancement: The non uniform illumination of this grey image is also corrected and its contrast is increased through a local transformation[13].Certain filters can also be used to enhance the appearance of image.

*3) Mathematical morphology:*It is a non-linear image processing methodology based on minimum and maximum operations whose aim is to extract relevant structures of an image. By applying a morphological closing on the grey-scale image obtained by the PCA algorithm, the blood vessels that are within the OD are removed, which facilitates its detection. Gray scale mathematical morphology provides a tool for extracting geometric information from gray scale images. A structuring element is used to build an image operator whose output depends on whether or not this element fits inside a given image. Shape and size of the structuring element is chosen in accordance with the segmentation task. The two fundamental morphological operations are dilation and erosion. The opening of an image is defined as erosion followed by dilation. It tends to smooth the small-scale bright structures in an image. The closing of an image is defined as dilation followed by erosion that tends to smooth the small-scale dark structures in an image. As closing only eliminate image details smaller than the structuring element used[9]. The structuring element is selected such that it covers all possible vascular structures, at the same time preserving the edge of optic disc[9].

B.OD Segmentation

The detection and segmentation of accurate boundary of the optic disc is important for the detection and diagnosis of Glaucoma where the variation in the shape and size of the optic disk is used to detect and measure the severity of disease. Difficulty in finding the optic disc boundary is due to its highly variable appearance in retinal images. Classical segmentation algorithms such as edge detection, thresholding, and region grow are not enough to accurately find boundary of the optic disc as they do not incorporate the edge smoothness and continuity properties.automatic optic disc boundary is detected by fitting an implicit active contour based on geometric model as reported in [7].

1). Centroid calculation:The location methodology obtains a pixel [called Optic Disc Pixel (ODP)] that belongs to the OD. It comprises three independent detection methods. Each method obtains its own OD candidate pixel. The final ODP is selected by taking into account the three previous candidate pixels and their location with respect to their average point (centroid). For this, a voting procedure comprising the following cases is applied.

• If the three OD candidate pixels are close to the centroid (closer than one-fifth of the image, maximum OD diameter estimation): the selected ODP is the centroid[2].

• If only two candidates are close to the centroid: the selected ODP is the average point in these two referred pixels.

• Otherwise, the selected ODP is the candidate pixel obtained with the most reliable method.

The methods used can be:

Maximum Difference Method: The OD usually appears as a bright region in eye fundus images. Moreover, the vascular tree formed by the ”dark” blood vessels emerges in the disc. This is why the maximum variation of the gray levels usually occurs within the OD. This maximum is used by this method to select its OD pixel[2].

Maximum Variance Method: This method is based on the same properties as the previous one. It calculates the statistical variance for every pixel by using a 71 ×71 centered window

Low-Pass Filter Method: The OD pixel of this method is the maximum gray-level pixel in a low-pass filtered image[2].

2). Stochastic watershed transform:The watershed transformation [9] is a segmentation technique for grey-scale images. This algorithm is a powerful segmentation method whenever the minima of the image represent the objects of interest and the maxima are the separation boundaries between objects. Due to this fact, the input image of this method is usually a gradient image. As mentioned above, the segmentation method makes use of the stochastic watershed.

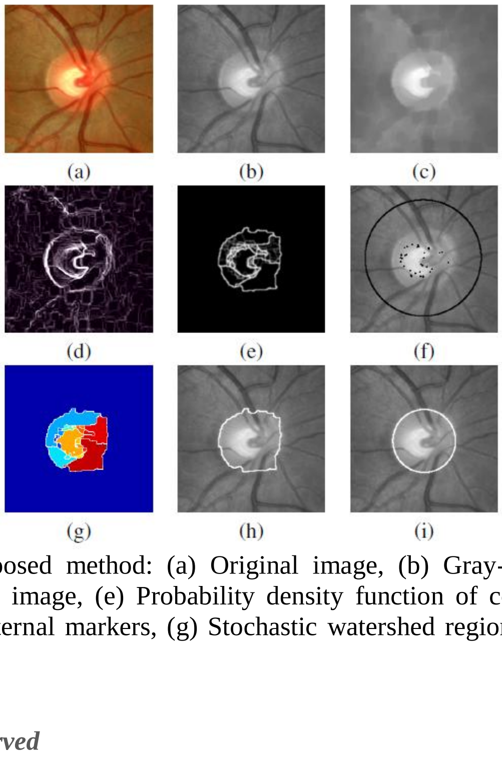
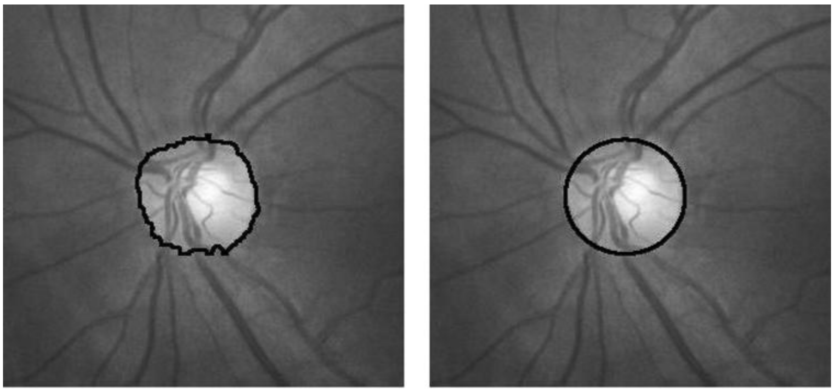


Fig.4 Different stages of the proposed method: (a) Original image, (b) Gray-scale image obtained by PCA, (c) Morphological closing, (d) Gradient image, (e) Probability density function of contours using 5 simulations and 50 internal markers, (f) Internal and external markers, (g) Stochastic watershed regions, (h) Stochastic watershed contour and (i) Circular approximation[3].

This transformation uses random markers to build a probability density function of contours, according to which is then segmented by volumic watershed for defining the most significant regions. However, in the marker definition not only internal markers (that specify what is the object of interest) are needed, but also an external marker which limits the area to be segmented.a[10][11][12][3].All the above steps are represented in figure 3.

C. Postprocessing

Once the region of interest has been obtained, the result must be fitted to eliminate false contours, which are detected due generally to the blood vessels that pass through the OD. The inpainting technique was performed to remove most of them, as previously mentioned, however some irregularities can still be appreciated in the final region contour Fig. 5(a).



(a) (b)

Fig. 5. Postprocessing. (a) Contour of the obtained region. (b) Circular approximation of the OD contour[13].

IV. CONCLUSION

In this paper, efficient methods for the segmentation of optic disc localization, boundary detection in colour retinal images are described. The optic disc and the vessels belong to the main features in the human eye, their detection is indispensable to understanding ocular fundus images. From a fundus image, the discussed method is able to automatically locate the OD. This method tries to make easier the early detection of diseases related to the fundus. On the other hand, improvements achieved by the stochastic watershed is also highlighted. As for future lines, the optic cup will also be detected. Its goal will be to measure the cup-to-disc (C/D) ratio so that it can be used for glaucoma diagnosis. A high C/D ratio will indicate that a fundus is suspicious of glaucoma[3]. Localization of disc is important as it has to be masked during the exudates detection and its position is used in the location of macula. The method used for the extraction of the optic disc contour is based on a variant of the watershed transformation, the stochastic watershed [3].

ACKNOWLEDGMENT

The authors would like to thank the authors of references for acquiring the materials and resources needed to conduct the present study.

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