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ABSTRACT. *This paper presents a method for automated localization and accurate segmentation of the optic disc. An intensity threshold is determined and select all the pixels whose intensities are greater than the threshold, by erosion the optic disc can be localized. By dilation and region filling, a minimum enclosing circle which can completely hold the optic disc is determined, within the circle, the vessels are eliminated by replacing the darker vessel pixels with brighter pixels. Define the intensity features of the optic disc boundary , and select the pixels according to the features, then the optic disc may be segmented. The experiment shows that compared to the active contour models, this method is more efficient and accurate on the boundary extraction of the optic disc.*

KEYWORDS: *Automated localization, Accurate segmentation, Intensity threshold, Minimum enclosing circle*

1. Introduction

The fundus images are used for diagnosis by trained clinicians to check for any abnormalities or any change in the retina. The information about the optic disc can be used to examine the severity of some diseases such as glaucoma. Its detection is prerequisite for the segmentation of other normal and pathological features.

A number of studies have reported on automated localization of optic discs; several studies have also reported on the segmentation of optic discs [1-14]. Walter and Klein [1] applied the watershed transformation to the gradient image based on the morphological operations. Lalonde et al.[2] used the Canny edge detector to detect optic disc edge, and by matching the edge map with a circular template the optic disc was segmented. The method of Li and Chutatape[3] is based on an active contour model, and it iteratively matching the landmark points on the disc edge. Osareh et al. [4] and Lowell et al. [5] used the active contour model to find the optimal points based on the external and internal energy of the image. Wong et al. [6] proposed a method based on the level-set technique, and used ellipse to fit the disc boundary. Abramoff et al. [7] employed a pixel classification method using the feature analysis and nearest neighbor algorithm, then group each pixel to rim, cup or background. Jaspreet Kaur et al. [8] and Siddalingaswamy P. C.[9] employed iterative thresholding method followed by connected component analysis to automatically localize the approximate center of the optic disc, then the geometric model based implicit active contour is employed to obtain accurate optic disc boundary. Hoover and Goldbaum used a ‘‘fuzzy convergence’’ algorithm to correctly identify the optic disk location in 89% of 81 images [10]. The method of Park et al [11] found the brightest pixels by employing the repeated thresholding technique, then used the roundness of the object to detect optic disk features, and then localized the optic disk by using the Hough transform.

Yet because of fuzzy boundaries, inconsistent image contrast or missed edge features, it is difficult to accurately localize and segment the optic disc. Based on the intensity and shape features, this paper proposed a method for the automated localization and segmentation of the optic disc, without human intervention, the optic disc may be segmented accurately and efficiently by the contour extraction, the contour can then be used to help the doctor for further analysis.

2. Appearance intensity threshold determination for optic disc localization

The optic disc is often the brightest object, ranging from white to yellow, is circular and of reasonably consistent size from patient to patient [12]. So the pixel whose intensity is brighter than the threshold is marked as candidate optic disc pixel. For the retinal images whose sizes are 640×480, the optic discs have more than

1000 but less than 10000 pixels. Clustered those pixels whose intensities are equal when divided by a certain histogram bin width which in this paper is 10, and sort the clusters according to the intensity. Start from the cluster with maximum intensity and check the number of pixels in it, if the number is less than 1000, then go to the next cluster in descending order of intensity until the number of pixels is between 1000 and 10000, and the intensity range of this cluster is determined as the threshold T . Those pixels whose intensities are brighter than the threshold are marked as candidate optic disc with a green color (0xff00ff00) as shown in Figure1.

Figure1. *Retinal image with candidate optic disc marked with green color*

As shown in Figure1, there are some regions marked with green color which are not real optic disc, to eliminate the false candidate pixels, morphological erosion is applied on them. Find all the start positions of the candidate regions, structure element *structElem* begins from these positions and tests all the candidate regions so as to find a region which can include it. Figure2 shows an instance of the localization result.

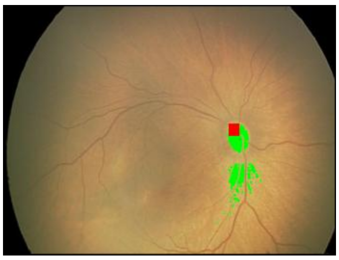

Figure2. *The result of automatic localization of the optic disc with a rectangle*

3. Dilate the optic disc region, determine the minimum enclosing circle

As shown in Figure2, the green pixels don't occupy the whole disc region, so further steps are needed to gather more optic disc pixels.

3.1 *Morphological dilation*

By region grouping, the optic disc pixels are collected together and marked in binary matrix M . The matrix is the same size as the retinal image, if the pixel on the image is colored by green, then the corresponding cell in the matrix is 1, otherwise 0. To find more optic disc pixels, double dilation was applied on M , The dilation result was shown in Figure3 with blue color, take all the x and y coordinates of dilated matrix M , and compute the average x and y as the coordinate of the center point $P(x, y)$ of the blue region.

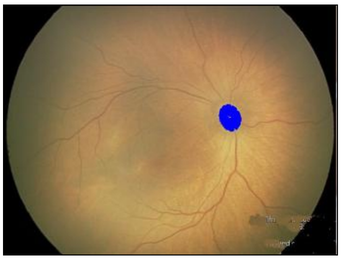

Figure3. *Dilation result of Figure2.*

3.2 *Determination of minimum enclosing circle*

Based on the normal size of optic disk, centered at P , a circle which can totally enclose the optic disc region can be determined. Analyze the intensity distribution of pixels in the circle, and define the intensity features of the pixels on the edge, and mark those pixels having edge features, then the segmentation is done. Two edge features are defined initially: the first is that its intensity is darker than the optic disc localization threshold T ; the second is at least one of its 8 neighbors belongs to the internal optic disc, i.e. the intensity is brighter than the threshold T . According to the two features, some pixels are selected which are used to compute their distances to the center point $pCenter$, and get the average distance $avgD$, set the radius of minimum enclosing circle to be $avgD + d$, where d is the incremental constant used to make the circle include all the optic disc pixels and exclude the false optic disc pixels. So the third feature of the edge pixel is that its distance D to $pCenter$ should satisfy $|D - avgD| \leq d$. D is calculated by equation (1). The determined edge result is shown in Figure4.

$$D = \sqrt{(p.x - pCenter.x)^2 + (p.y - pCenter.y)^2} \quad (1)$$

Figure4. *The optic disc edge results with the third feature added.*

4. Experiment and Conclusion

The automated localization and segmentation of the optic disc is implemented by JAVA, and it can accurately and efficiently get the contour of the optic disc, yet for the active contour model, to get the optic disc contour, an initial contour need to be drawn first, and because of the noise, vessel intervention etc., normally they cannot get to the accurate boundary, so compared to these methods, our algorithm is more accurate and efficient.

We test our method on DRIVE, DIARETDB1 and the infant retinal images, for segmentation, the method has good performance on the infant images whose optic discs have relatively weak vessel intervention, for those images with strong inside vessels, the method cannot segment all the optic disc, normally a large part the disc, so it needs further improvement which is our future work.

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