Optic disc segmentation using histogram matching

Zhiwei Wang

Abstract*— *The localization of the optic disc and its center plays an important role in most vessel segmentation algorithms. In this article, a template is used for localizing optics disc in retinal images by histogram matching. Optic discs of four retinal images in the IDRiD database are used to calculate the mean histograms for each color as the template. Then, a moving window is used to calculate the correlation. Finally, the most matching window is* extracted *and segmented. There are 54 original retinal images in JPG format from IDRiD database are used to evaluate the proposed algorithm.

***Index:* Optic disc, Retinal image, Histogram matching, IDRiD database**

I. Introduction and Background

RETINA is the innermost layer of the eye which can be visualized using adequate apparatus such as fundus camera [1]. Optic disc is the brightest region in the retinal image, and the blood vessels originate from its center [2]. Optic disc is a key reference for blood vessels segmentation [3], and diagnosing some diseases such as diabetes [4]. The inability to analyze the optic disc leads to the uneven illumination in retina images and their poor quality. Applying some preprocessing methods to retina images considerably improves the contrast, and illumination for further analysis tasks such as optic disc localization and vessel segmentation [5,6].

In this article, a template is used for localizing optics disc in retinal images by histogram matching. For this purpose, optic discs of four retinal images in the IDRiD database are used to calculate the mean histograms for each color as the template. Then, a moving window is used to calculate the correlation. Finally, the most matching window is extracted and segmented.

The rest of this article is organized as follows. “Method” section presents the optic disc localization and segmentation method. Then, “Experiment setup” section includes the steps of improving of this method. Furthermore, Experimental results are in “Results” section. Limitations and solutions are discussed in “Discussion” section. Finally, “Conclusion and future work” section is devoted to concluding remarks.

II. Method

As pathological regions exist in retina images, many methods for localizing optic disc are inaccurate [7,9]. Here, a robust method for localizing the center of optic disc in presence of pathological regions is used [1]. In this method, Histogram matching is used to find the optic disc region. The region with the highest matching value with the template is segmented to get the final result.

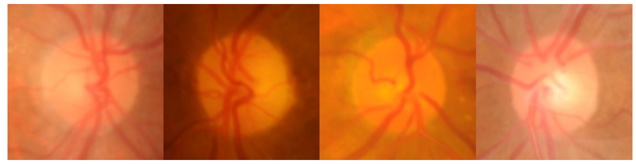

Fig. 1: Four extracted optic discs

A. Preprocessing

In this method, the original images are simply preprocessed, For reducing the running time, they are reduced to a quarter of their previous size. Meanwhile, a Gaussian Blur filter with the size of 31 × 31 pixels to retina images is used to decrease the effect of noise. Then, four optic discs images(400 × 400 pixels) which are shown in figure 1 are manually extracted to create a template. In the next step, color components (red, blue, and green) of each optic disc are divided to obtain the histogram of each color component. Finally, the mean histogram of each color component for all retinal image samples is calculated as the template [1]. Template matching

To get the region that best matches with the template, an 400 × 400 pixels window is moved through retinal image. Each moving window is divided to three channels (red, blue, and green) which are used to calculate the correlation between the histograms of them and its corresponding channel in template. For this purpose, correlation function is a normal method to obtain the similarity of the two histograms, which is expressed in the following equation:

$$c = \frac{1}{(1 + \sum_i (a_i - b_i)^2)} \tag{1}$$

where a and b are two histograms that should be calculated, and c is the result of the correlation. Therefore, if they are similar, the result would be very close to 1, else $c \ll 1$. Hence, the result is in the range of [0,1].

In this method[1], in order to reduce the influence of pathological regions and exudates in high-brightness regions, only pixels with intensity value less than 200 in the histogram will be calculated. This leads to the increased role of blood vessels in the optic disc for optic disc localization.

Because of the different contrast of each channel, each value(c_r, c_g, c_b) is assigned a weight(t_r, t_g, t_b) to compute the result of histograms matching:

$$c(i, j) = t_r * c_r + t_g * c_g + t_b * c_b \tag{2}$$

Green channel has the largest weight, because the contrast of green channel is higher than that of red and blue channels [11]. The red channel in retinal images always is noisy as hemorrhage. It leads to a decrease in accuracy of positioning. Therefore, the red channel has the least weight. The results show that $t_r = 0.5$, $t_g = 2$ and $t_b = 1$are the best weights for optic disc localization [1].

In figure 2, the window with the largest $c(i, j)$ in a retinal image will be used as the segmentation target.

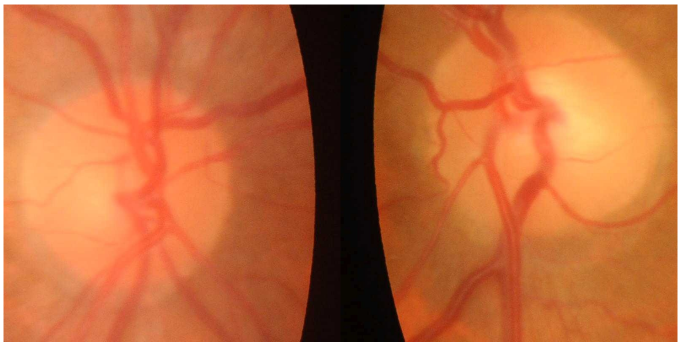

Fig. 2: Matching result for retina images in IDRiD database

B.Segmentation

Based on the optic disc image obtained in the previous step, many traditional image processing methods are used to obtain the final segmentation results. Before segmentation, the optic disc image is processed with two gaussian blur filters with size of 11 × 11 pixels to reduce the influence of blood vessels on segmentation. Furthermore, the blood vessels become very inconspicuous under the red channel. Hence, the red channel of the image is separated for thresholding, which will make the obtained result more accurate. The best threshold is 220. Finally, morphology methods are used to remove the noise to obtain final result.

III. EXPERIMENTAL SETUP

Experimental environment: Python3.6

Required libraries: module numpy, cv2, sklearn

A.The pixel value used for histogram matching

Since the brightnesses of the images in IDRiD database are different, the histogram composition of their three channels is quite different. In this method [1], only pixels with intensity value less than 200 are used to calculate the correlation. Due to the high brightness of optic disc, the calculation of pixels with high brightness is more important than that of pixels with low brightness. Therefore, removing some low intensity value pixels and adding some high-brightness pixels will improve the accuracy of histogram matching. As a result, the final range is determined as [60,240].

B.The weights of c_r, c_g and c_b

In this method, the role of blood vessels in histogram matching is enhanced. As the pixel values of blood vessels and hemorrhage are similar, the effect of noise in histogram matching is increased. Therefore, adjusting weights to avoid imaging effects is an important step. However, the test results find that $t_r = 0.5$, $t_g = 2$ and $t_b = 1$ still are the best weights.

C.Red channel segmentation threshold

Due to the different brightnesses of optic discs, the fixed threshold will reduce the accuracy of the results. As a result, In the following experiment, a formula for calculating the threshold which is related to the image's brightness is adopted, as follows:

$$Th = m_r * 1.47 - m_g * 1.18 + m_b * 0.8 \tag{3}$$

where m_r, m_g and m_b are the maximum pixel value in each channel. The weights are obtained by calculating the optimal segmentation threshold for several images. However, as it is segmentation only for the red channel of the image, the threshold calculation formula should only related to the pixel value within the red channel, as follows:

$$Th = m_r * 0.5 + 110 \tag{4}$$

This is the threshold calculation formula with highest accuracy of results.

D.Postprocessing

There are some exudates in the segmentation result due to their brightness is similar as optics discs. Morphology methods are used to remove them. However, the optic disc is also removed through the processing. As a result, the steps to use these methods become important. At first, two erosion filters with size of 21 × 21 pixels are used. The next is an opening filter with size of 91 × 91 pixels. Finally, images will be processed by a dilation filter with size of 21 × 21 pixels.

IV. RESULT

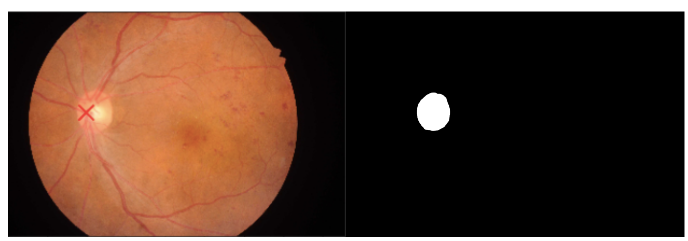

Fig. 3: Result of location and segmentation

Table 1: Evaluation Metric

Accuracy	0.991
Recall	0.535
Precision	0.754

In this method, a moving window is used to find and match the optic disc. According to the results, most optic discs of retinal images in the database can be accurately found, the success rate is 80%. In figure 3, the results of accurate location and segmentation are shown. Then, compare the segmentation result with the masks. As table1 shows that the average accuracy, precision and recall score are 90.01%, 53.54% and 75.43%, respectively. Obviously, for the pathological retinal images, the accuracy of this method is considerable.

V. Discussion

In figure 4, due to some limitations of this approach, some optic discs cannot be found and segmented well.

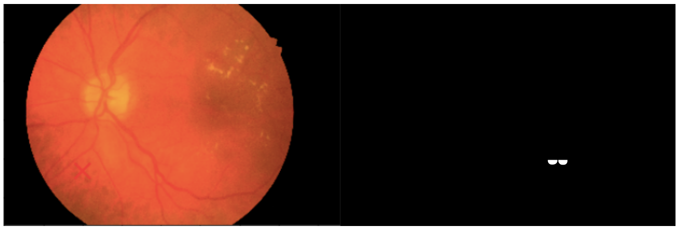

Fig. 4: Result of failed location and segmentation

A.Limitation

1.Failed matching. Due to the large color difference of the images in the database, the template used to match can not satisfy all the images.

2.The run time. The moving window needs to traverse the entire image to get the best matching area which leads to a long run time.

B.Solution

1.More complex preprocessing methods should be used to allow template to more accurately match more retinal images. Or use more pictures to make template. Some details are missing because the image has been compressed. The original size of image should be used. The results should be more accurate.

2.Some methods can be used to obtain candidate regions [1]. The probability of optic disc presence in these areas is more than other regions. Using candidate regions instead of the entire image greatly reduces the computation time.

VI. Conclusion and Future Work

In conclusion, the mean histograms of some optic discs in retinal images are used as template to locate the optic disc of retinal images. Most in the database can be accurately located and segmented. However, the optic discs of some images can not be positioned accurately, as different brightnesses and noises. In additional, some of the optic discs that have been located can't be well segmented due to the inaccurate threshold.

In future work, some methods can be used to improve the accuracy and decrease the run time. The center of the optic disc needs to be positioned more accurately as it is beneficial to medical research. Furthermore, It will play an important role in the research of human recognition in the future.

References

[1] Dehghani, Amin, Hamid Abrishami Moghaddam, and Mohammad-Shahram Moin. "Optic disc localization in retinal images using histogram matching." EURASIP Journal on Image and Video Processing 2012, no. 1 (2012): 19.

[2] VV Kumari, N Suriyanarayanan, Blood vessel extraction using wiener filter and morphological operation. Int. J. Comput. Sci. Emerg. Technol. 1(4), 7–10 (2010)

[3] Y Jiang, A Bainbridge-Smith, AB Morris, Blood vessel tracking in retinal images, in Proceedings of Image and Vision Computing, 2007, pp. 126–131

[4] R Abdel-Ghafar, T Morris, T Ritchings, I Wood, Detection and characterisation of the optic disk in glaucoma and diabetic retinopathy, in Proceedings of Medical Image Understanding and Analysis, 2004

[5] AA Youssif, AZ Ghalwash, AS Ghoneim, Comparative study of contrast enhancement and illumination equalization methods for retinal vasculature segmentation, in Cairo International Biomedical Engineering Conference (CIBEC), 2006

[6] AA Youssif, AZ Ghalwash, AS Ghoneim, A comparative evaluation of preprocessing methods for automatic detection of retinal anatomy, in Proceedings of the Fifth International Conference on Informatics and Systems (INFOS 07), 2007, pp. 24–30

[7] A Osareh, Automated identification of diabetic retinal exudates and the optic disc. Ph.D. dissertation (Department of Computer Science, Faculty of Engineering, University of Bristol, Bristol, UK, 2004)

[8] AA Youssif, AZ Ghalwash, AS Ghoneim, Optic disc detection from normalized digital fundus images by means of a vessels' direction matched filter. IEEE Trans. Med. Imag. 27, 11–18 (2008)

[9] H Li, O Chutatape, Automatic location of optic disc in retinal images, in Proceedings of the International Conference on Image Processing (ICIP), vol. 2, 2001, pp. 837–840

[10] RM Rangayyan, X Zhu, FJ Ayres, AL Ells, Detection of the optic nerve head in fundus images of the retina with Gabor filters and phase portrait analysis. J. Digit. Imag. 23(4), 438–453 (2010)

[11] A Osareh, B Shadgar, Automatic blood vessel segmentation in color images of retina. Iran. J. Sci. Technol. Trans. B: Engineering 33(B2), 191–206 (2009)