COMP9517 Project – Individual

ID: z5140893

Name: Chengze Du

1. Introduction and Background

The aim of the individual task is to segment the optic disc from the provided retinal images. The dataset is from Indian Diabetic Retinopathy Image Dataset (IDRiD) which includes 54 images and the corresponding ground-truth segmentation images. The shape of the images are 2848x4288x3. There three major stages in this task: pre-processing, processing and post-processing. In pre-processing, we split color channel, remove noise and apply image contrast enhancement. The core processing method of the task is mainly based on fuzzy c-means algorithm and morphological operations. The post-processing is primarily contour detection. For the result, we use dice loss to evaluate the task.

2. Method

The method used in my task mainly refers to *An automated region-of-interest segmentation for optic disc extraction.* The stages are: (1) Retinal image pre-processing. (2) Fuzzy c-means binarization (processing). (3) Contour detection and Region-of-Interest(ROI) filled (post-processing).

(1) Retinal image pre-processing

Firstly, I split the color channels from the retinal original image, and choose the red channel layer for following processing image because the optic disc in red channel layer has better contrast than that in the gray level, blue channel layer and green channel layer. Shown as Figure 1.

Secondly, I use Contrast Limited Adaptive Histogram Equalization(CLAHE) to increase the contrast of the image. Then, I use the 15x15 median filter to remove the noises.

(2) Fuzzy c-means binarization (processing)

Since the optic disc is the brightest area in the retinal image, we use fuzzy c-means to cluster the pixel points according to their brightness values.

The principle of fuzzy c-means is: by quantifying the similarity between a point and every central points, the degree of membership between the data point and centers of clusters is graded by a factor number between 0 and 1. If the factor number between a point and a central point is bigger, this point is more similar as this cluster.

In this task, I assign 25 clusters which means the degrees of brightness are separated as 25 levels. After clustering all the pixel points, I find the brightest cluster and binarize the pixel values. I set the pixel points of the brightest level as 255 and set all the other pixel points as 0.

Thus I get the brightest area on the retinal image. Still, because there may be some retinopathy areas or other bright areas existed, the morphological opening needs to be applied to remove these noisy areas. As a result, the left area is the optic disc.

(3) Contour detection and Region-of-Interest(ROI) filled (post-processing).

After get the optic disc area, I can detect the contour of the area, and filled as red to achieve the same effect as the ground truth.

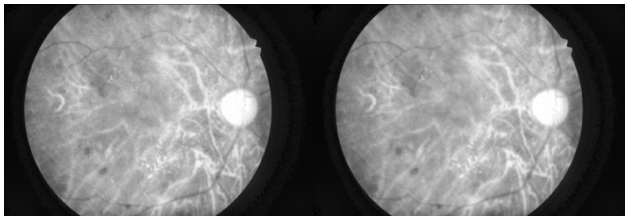
As for drawing the contours, the shape of the normal optic disc is similar to ellipse, so I fit an ellipse to the optic disc area. Another manner is to directly draw the approximate contour shape of the optic disc area considering the retinopathy.

3. Experimental setup

In the specific experiments, I did extra image transformation such as resizing and thresholding etc. The general processes are same as those mentioned in *Section 2 Method*.

(1)Retinal image pre-processing

Firstly, I extract the red channel layer shown as Figure 1.d. Secondly, I use CLAHE on it. Then, apply the 15x15 median filter to remove the salt and pepper noises. Shown as Figure 2.



(a) After CLAHE **(b) After 9x9 median filtering**

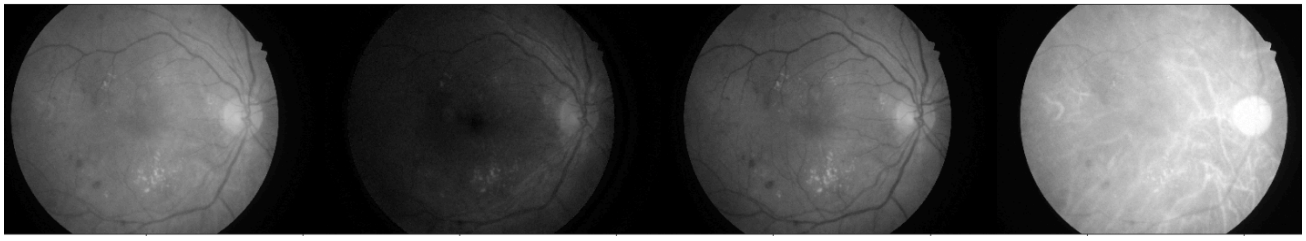
Figure 2

(2) Fuzzy c-means binarization (processing).

Firstly, we have to resize the image from size 2848x4288 to 89x134 shown as Figure 3, because the original image size is too large to apply fuzzy c-means cluster function.

Secondly, import 'skfuzzy' library and apply fuzzy c-means binarization on the image. Shown as Figure 4.a. Thirdly, use morphological opening to remove small noise area. Shown as Figure 4.b.

Finally, resize the image to the original size (Shown as Figure 4.c) and use thresholding to increase contrast (Shown as Figure 4.d).



(a) Grey level of original image **(b) Grey level of blue channel layer** **(c) Grey level of green channel layer** **(d) Grey level of red channel layer**

Figure 1

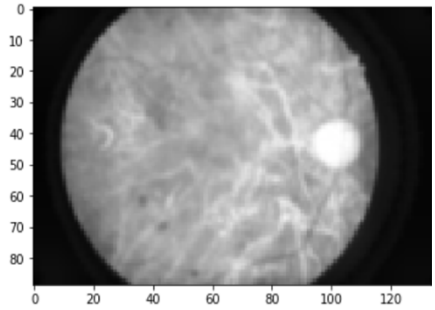
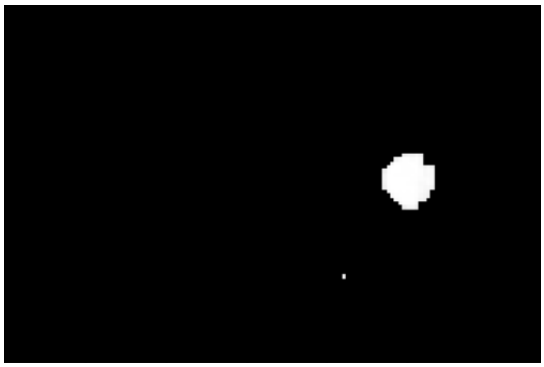
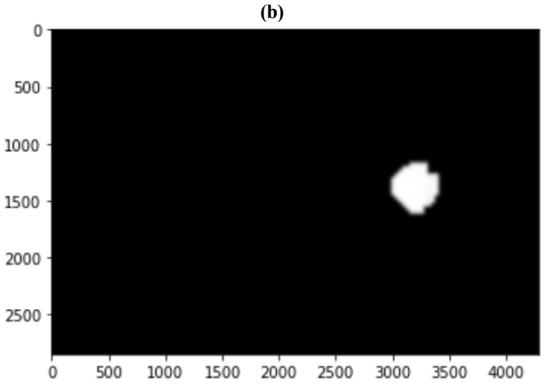


Figure 3: 89x134 image after reducing the size



(a)

(b)



(c)

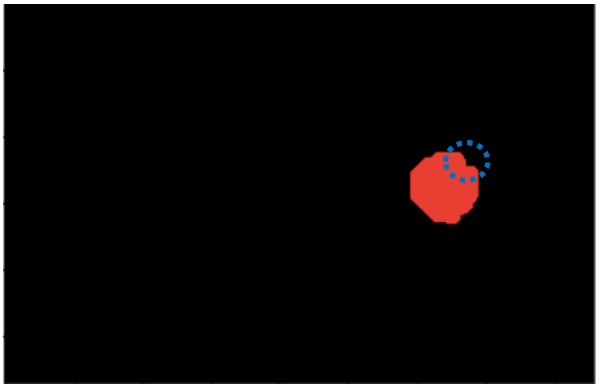
(d)

Figure 4: (a) After fuzzy c-means binarization (b) After morphological opening (c) Resize to the original size (d) After thresholding.

(3) Contour detection and Region-of-Interest(ROI) filled (post-processing).

To fill the optic disc area with red, I choose 'cv2.filled' to achieve the result when drawing the contour.

One manner is to draw an approximate contour shape of the optic disc area. (Shown as Figure 5.a). Another manner is to fit an ellipse to the optic disc area (Shown as Figure 5.b). While the ground truth image is shown as Figure 5.c.



(a)

(b)

(c)

Figure 5: (a) Approximate contour shape of the optic disc area (b) Ellipse fitting to the optic disc area (c) Ground truth image

(4) Evaluation

I use Jaccard index (Jaccard, 1908) to evaluate my results. It represents the proportion of overlapping area between the segmented OD (A) and the ground truth (B). the basic principle is:

$$J(A,B) = \frac{|A \cap B|}{|A \cup B|}$$

As I use two manners to achieve the result, the corresponding evaluations are shown in Figure 6. As we can see, even though the approximate contour shape is irregular, it may

get higher accuracy. We can choose a manner according to real needs.

However, the Jaccard index is not enough for evaluation because the background area is predominantly large. Therefore, I also introduce F1 score to get a fair measurement. (Shown as Figure 6).

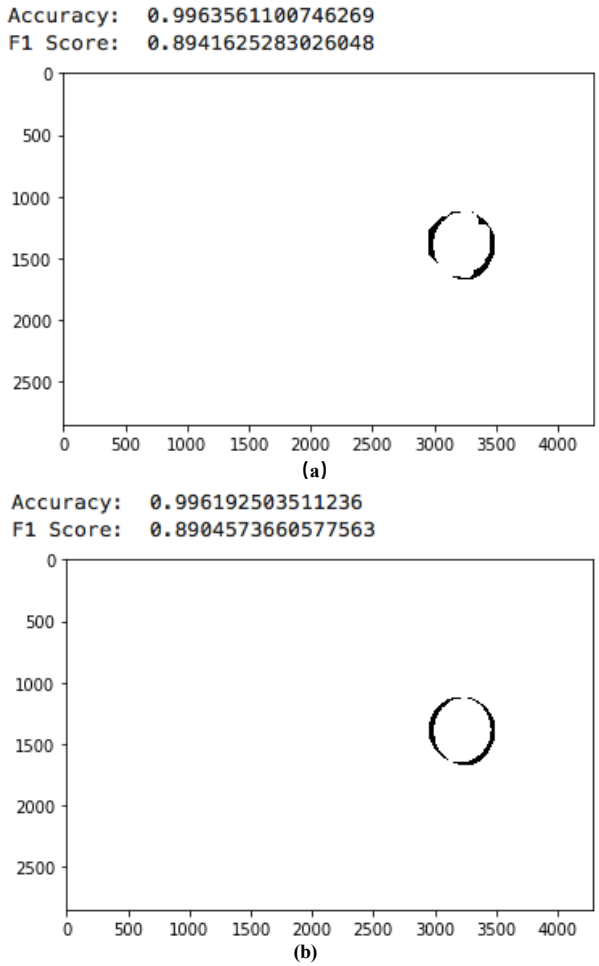


Figure 6: (a) Accuracy and comparison visual result of approximate contour shape of the optic disc area. (b) Accuracy and comparison visual result of ellipse fitting to the optic disc area .

4. Results, Discussion and Future Work

The visual result is shown in Figure 6. Even though it generally has a good performance, there are still some aspects needed to be improved and fixed.

Firstly, when dealing with big size images, we have to reduce the size of the image. In this process, the image loses information. Secondly, the dark vessels through the optic disc area harm the brightness and this causes optic disc area lost after fuzzy c-means clustering. Such as the area signed by the blue circle in Figure 5.a.

To fix it, we may use dilation to make up the lost area. Also, we can change the number of clusters in the process of fuzzy c-means or change the thresholding when doing binarization. Moreover, we can improve the brightness of the optic disc area which are influenced by the dark vessels before the processing.

Another aspect needs to notice is that, in some image, the lesion areas or other bright areas may be large. Therefore, morphological opening method cannot remove these noisy area. In these cases, we need to remove it manually and then do the processing and post processing, such as the image shown in Figure 7. Some of the example results are shown as below.

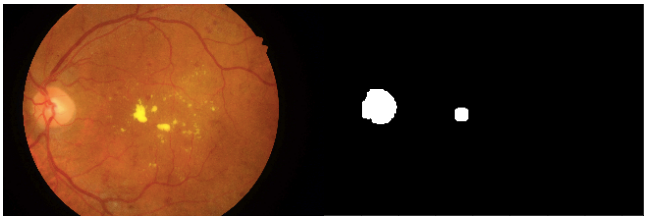


Figure 7: Left is original image of 'IDRiD_04.jpg'. Right is the image after postprocessing.

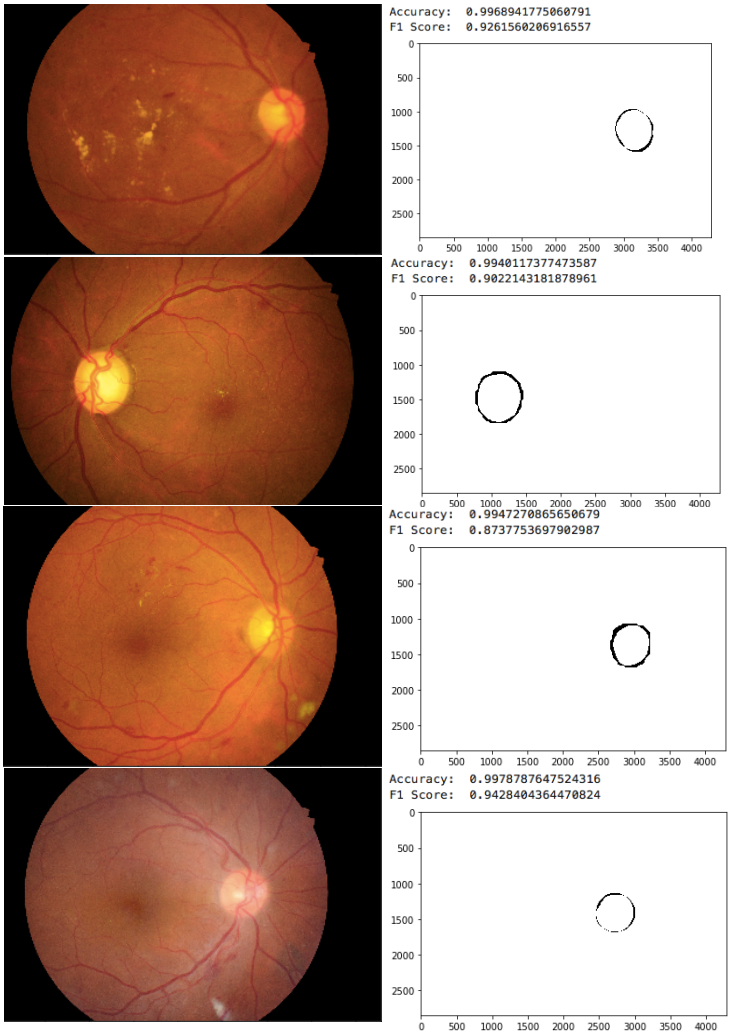


Figure 8: Example results.

Reference

[1] Jasem Almotiri and Khaled Elleithy, Abdelrahman Elleithy, "An automated region-of-interest segmentation for optic disc extraction."

[2] J. Almotiri, K. Elleithy, and A. Elleithy, "Retinal Vessels Segmentation Techniques and Algorithms: A Survey," Applied Sciences, vol. 8, p. 155, 2018.

[3] C. L. Srinidhi, P. Aparna, and J. Rajan, "Recent advancements in retinal vessel segmentation," Journal of medical systems, vol. 41, p. 70, 2017.

[4] Arturo Aquino*, Manuel Emilio Gegúndez-Arias, and Diego Marín, "Detecting the optic disc boundary in digital fundus images using morphological, edge detection, and feature extraction techniques," IEEE transactions on medical imaging, vol. 29, NO. 11, November 2010.