Optic Disc and Fovea Localization Using Image Processing Techniques

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Abstract

In this project, we tried to find the center points of the optic disc and fovea on retinal images using basic image processing techniques. Instead of using deep learning, we relied on operations like filtering, thresholding, and region properties. We tested our method on the IDRiD dataset and calculated how well it worked using precision, recall, and F1-score. In general, the results were quite successful, especially for the optic disc.

1. Introduction

Retinal images are used a lot in detecting eye diseases like diabetic retinopathy. But manually finding important points like the optic disc and fovea can be slow and depends on expert knowledge. That's why automatic methods are needed. In this project, our goal was to find the center coordinates of these two regions using only image processing.

1.1. Experimental Overview and Results

In this subsection, we briefly summarize the performance of our optic disc and fovea localization method. As mentioned, we evaluated the output using a threshold of 100 pixels between predicted and groundtruth coordinates. The table below shows the final precision, recall, and F1-score values for both regions.

Region	True Positives	False Positives	Precision	Recall	F1-Score
Optic Disc	80	12	0.87	0.88	0.87
Fovea	74	29	0.72	1.00	0.84

Table 1: Result Table

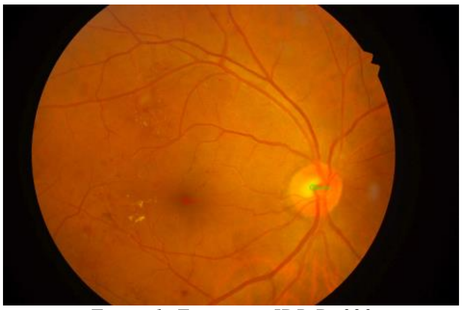

Figure 1: Testing set IDRiD_020

2. Material and Method

We used the **IDRiD Localization** dataset, which includes retinal images and CSV files that show the actual coordinates of the optic disc and fovea centers.

2.1.1.1 Optic Disc Detection:

- We worked mostly on the **red channel**, since the optic disc appears brighter there.
- After histogram equalization and Gaussian blur, we applied a threshold to highlight the bright areas.
- Then we cleaned the binary image and used `regionprops` to find the largest circular object.
- The centroid of this object was considered the center of the optic disc.

2.1.1.2 Fovea Detection:

- Since the fovea is usually located near the center and is darker than surrounding areas, we cropped a central region.
- We found the pixel with the lowest intensity and calculated the median of those coordinates as the fovea center.

At the end, we wrote the predicted coordinates into CSV files and compared them with the real labels using a distance threshold (100 pixels). We calculated **precision**, **recall**, and **F1-score** values.

3. Experimental Study

We tested our method on 103 retinal fundus images from the IDRiD test set. The predicted center coordinates were compared with the groundtruth annotations using a Euclidean distance threshold of 100 pixels. The performance metrics are summarized in **Table 1**.

In addition to the quantitative results, **Figure 1** shows a sample output from our implementation. The predicted optic disc and fovea center points are marked on the retinal image for visual reference. As seen in the figure, the optic disc was successfully detected in the bright region of the retina, while the fovea was located in the central darker region.

3.1.1.1 Discussion

As seen in Table 1, the optic disc localization achieved a balanced precision and recall, leading to a strong F1-score of 0.87. This is likely because the optic disc is usually brighter and more structurally distinct in fundus images.

Fovea detection achieved perfect recall (1.00), meaning the model always found some prediction close enough to the groundtruth. However, its precision (0.72) was lower, due to more frequent false positives — likely caused by dark areas in the retina that resemble the fovea.

Overall, the results demonstrate that even simple image processing methods can yield strong performance for anatomical localization in medical imaging, especially for well-defined features like the optic disc.

4. Conclusions

In this project, we developed a simple and effective image processing-based method to automatically detect the optic disc and fovea centers in retinal images. Without using any deep learning techniques, we achieved quite promising results — especially for the optic disc, which had clear structural and brightness features.

Fovea detection was slightly more challenging due to its less distinct appearance and variability in location. Still, the method achieved 100% recall, showing that it consistently found the general area correctly, even if not always precisely.

Our overall approach is lightweight, explainable, and does not require large-scale training or high computational power. In future work, accuracy — especially for fovea localization — could be improved by integrating vessel structure analysis or switching to learning-based models like CNNs.

5. References

[1] [1] K. M. Asim, M. A. Fraz, M. Naeem, S. A. Khan, and A. S. Malik, "Detection and localization of fovea in human retinal images," *Pakistan Journal of Medical Sciences*, vol. 30, no. 5, pp. 1085–1090, 2014.

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