uc3m | Universidad Carlos III de Madrid

Bachelor in Data Science and Engineering

Audio processing, Video processing and Computer vision

Lab 3 Report

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Introduction

During this lab we had to develop and improve an automatic image segmentation system for retina images, with the goal of accurately segmenting retinal blood vessels. The lab involves pre-processing, segmentation, and post-processing steps using non-machine learning-based techniques. The primary objectives are to enhance the performance of a baseline threshold-based segmentation method and to implement a clustering-based segmentation approach. The performance of the segmentation is evaluated using the Jaccard Index (IoU), comparing the predicted and ground-truth segmentation masks.

Experiments

Our baseline consists of a simple adaptive thresholding with a block size of 41 and pre-processed using CLAHE to increase the contrast. This method is not horrible. But as we can see in the images below it has some confusion detecting the vessels.

A simple way to improve this result is to instead of converting the image to gray-scale, just pick the green channel[1]. In that way the contrast of the vessels increases and it is easier to detect them, we can see it in the original image of the provided figure.

Next, we tried still trying to improve the contrasting between the vessels and the rest of the retina, so we decided to apply a Bottom-Hat filter[2], which consists of emphasizing small, dark objects on a bright background, which is the perfect case for our vessels. This was followed by an Otsu thresholding.

Then, as requested, we implemented a clustering segmentation method, but it does not really work well. Clustering seems not to be a very popular method in this problem, we could only find references to an algorithm called FCM clustering. In this algorithm each data point can belong to multiple clusters, but it was not worth to implement it.

Techniques	Intersection over the Union (IoU)
Baseline	0.38
Green channel	0.42
Green channel and bottom-hat filter	**0.53**
Clustering segmentation	0.12

Table 1: Result for main techniques

[1]Khandouzi et al., “Retinal Vessel Segmentation, a Review of Classic and Deep Methods.”
[2]Mehidi, Belkhiat, and Jabri, “A High Accuracy Segmentation Method for Retinal Blood Vessel Detection Based on Hybrid Filters and an Adaptive Thresholding.”

Proposed techniques

Now we will do a summary of the explored and proposed techniques, diving them by the part of the process we should be implementing them

Pre-processing

Filters, such as Gaussian and median filters, only made the results worse.

Green channel, that is, use only the green channel of the image, which really made the results better by incrementing the contrast of the vessels.

Contrast limited adaptive histogram equalization (CLAHE), has the goal of increasing the contrast between foreground and background, it works really well.

Bottom-hat filter, which focuses on emphasizing dark objects on a bright background, also really improved the result.

Segmentation

Adaptive thresholding is used to scan documents where we have uneven lightning, ensuring a more accurate segmentation of the goal object from the background. We used it when we had uneven lighting in the retina image.

Otsu Thresholding is a global thresholding technique which determines the optimal threshold for separating the foreground and background. In this case we used Otsu threshold after applying the bottom-hat filter since we did not have the uneven lighting problem.

Clustering segmentation, segments the image by assigning pixels to the nearest cluster. It was expected that this technique would not work that well, since it is a technique more thought for when we have “compact” objects, which is the completely opposite case of vessels.

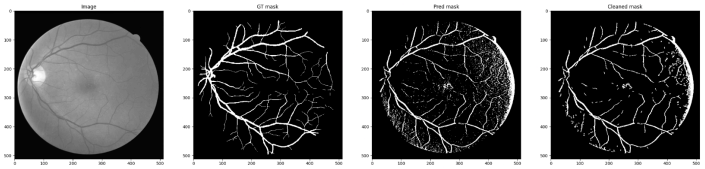
Post-processing

“Remove small objects” function improves the segmentation masks by removing noise, we can play with the min size and continuity parameters but there is really no difference.

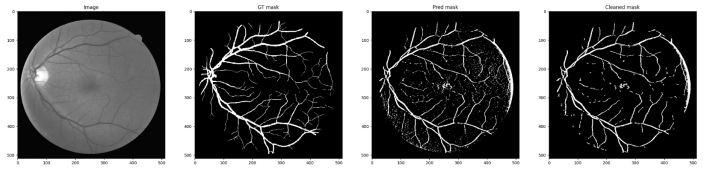
Closing morphological operations were explored, it was expected for it to join disconnected vessels, which is a common case as it can be seen, but it did not really provide a better result.

Annex: Images

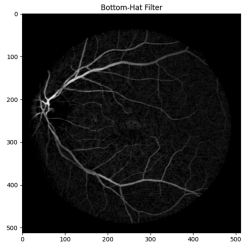
Baseline result



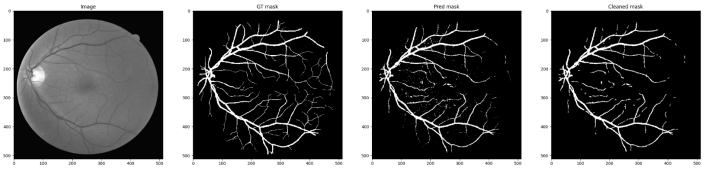
Green channel result



Original image after applying bottom-hat filter



Results of using the green channel and applying bottom-hat filter



Result of using clustering segmentation