Benchmarking Automatic Segmentation of Retinal Vascular Structure

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1 Objective

The purpose of this project is to benchmark a deep-learning U-Net method against a non-deep-learning method for the segmentation of blood vessels in retina fundus images.

2 Background

Retina fundus images are often used during the diagnosis and monitoring of disease progression for eye diseases such as diabetic retinopathy [1]. In these images, the distribution and morphology of the blood vessels are frequently indicative of the severity of the disease. However, the inspection of such images can be time-consuming. This process can be made more efficient by using computer-aided diagnostics and automating the inspection of blood vessels in these images. Benchmarking is an important process to choose the best method for segmenting the fundus image. Deep-learning methods for the segmentation of bioimages have become increasingly popular [2], however, for simpler segmentation tasks there still exist faster, non-deep learning methods which perform fairly accurately. Hence benchmarking is necessary to quantify the pros and cons of each method.

3 Methods

3.1 U-Net

The U-Net structure for convolutional neural networks for deep learning was proposed by Ronneberger, Fischer & Brox [3] in 2015 for the purposes of biomedical image segmentation. The U-Net structure uses consecutive convolution and max-pooling steps in the contracting path, followed by consecutive steps of up-sampling and convolution in the expanding path. For this method, we will be using the U-Net provided by Ronneberger et al. (2015) and will train the model on our retina dataset.

3.2 Ridge-based morphological operators and classifier

Ridge-based detection methods have been used frequently in vessel detection in retina images due to the similarity of these vessels to curved lines. These include methods proposed by Staal et al. (2004) [4] and Li et al. (2009) [5]. These segmentation methods are often coupled with a classifier – either a K-means, K-Nearest Neighbor classifier, or a manually chosen threshold to obtain a segmented mask. For this method, we will be attempting to write the code on Python using the above cited papers as reference.

4 Datasets

- Digital Retinal Images for Vessel Extraction (DRIVE): 20 fundus 2D images with labels

- STructured Analysis of the Retina (STARE): 20 fundus 2D images with labels
- Child Heart and Health Study in England (CHASE): 28 fundus 2D images with labels [6]

5 Benchmarking metrics

1. Computational requirements. How much CPU or RAM does each method require to run both the training and test datasets?
2. Speed. How long will each model take to run the test and training datasets?
3. Model evaluation. The model will be evaluated on the Accuracy, Sensitivity, Specificity, Precision, Recall and the Receiver Operating Characteristic (ROC) curve and the area under the ROC curve.

6 Timeline

Table 1: Timeline

Deadline	Milestone
End October	Establish code for Method 2 and train model for Method 1
Mid November	Benchmark Methods 1 and 2 using stated metrics
End November	Prepare Project Report and Presentation

References

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[3] Ronneberger, O., Fischer, P., Brox, T. (2015) “U-Net: Convolutional Networks for Biomedical Image Segmentation”. arXiv, Doi: 10.48550/ARXIV.1505.04597

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