DIP PROJECT:

A Morphological Hessian Based Approach for Retinal Blood Vessels Segmentation and Denoising Using Region-Based Otsu Thresholding

Team Members:
Abhayram A Nair (2019102017), Btech. ECE
Aravind Narayanan (2019102014), Btech. ECE
Hemant Suresh (2019102016), Btech. ECE
Prayushi Mathur (2021701034), MS

Mentor:
Sai Manaswini Reddy Indupuru

Team: Society
Github: https://github.com/Digital-Image-Processing-IIITH/dip-project-society

Goals and Objectives

- The aim of this project is to find a less computational unsupervised automated technique with promising results for the detection of retinal vasculature by using a morphological hessian-based approach and region-based Otsu thresholding.
- Obtaining vessel segmentation results by applying the proposed method.
- Analyzing the results using 4 performance criterion and computing an average value over 20 test images.

Dataset

STARE(STructured Analysis of the Retina) dataset:

- A full set of ~400 raw images in the STARE database.
- Blood vessel segmentation work included 40 labeled images
- We have used 20 images to perform the analysis.
- Reference Link: https://cecas.clemson.edu/~ahoover/stare/

Sample Input Images

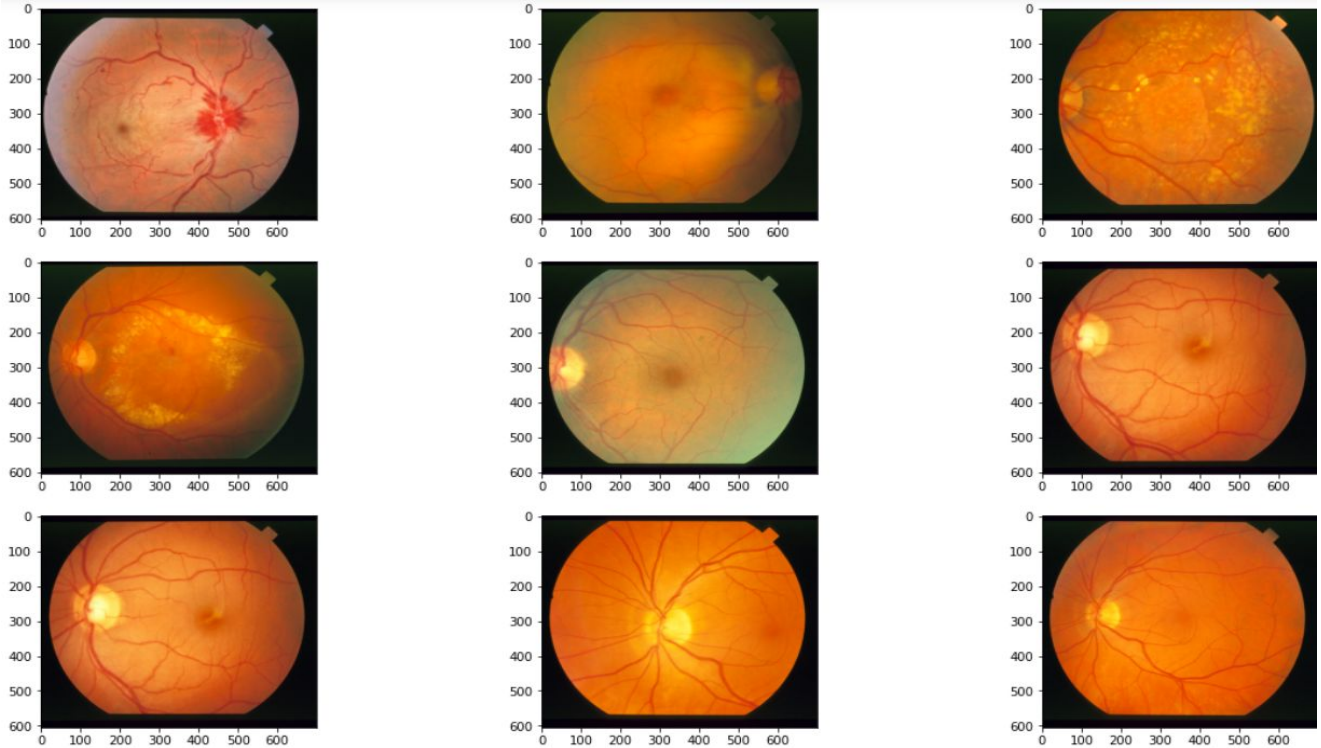
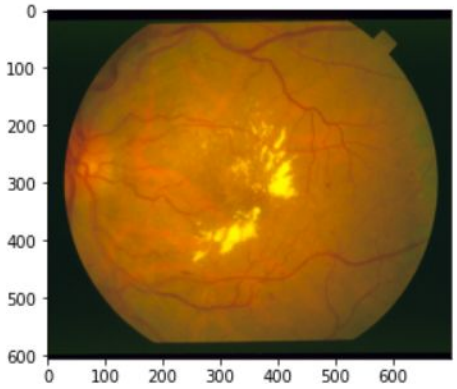
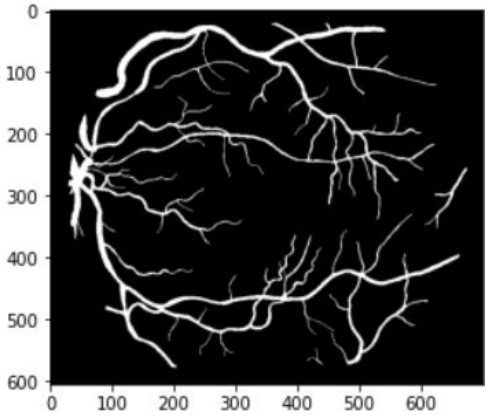


Image pairs



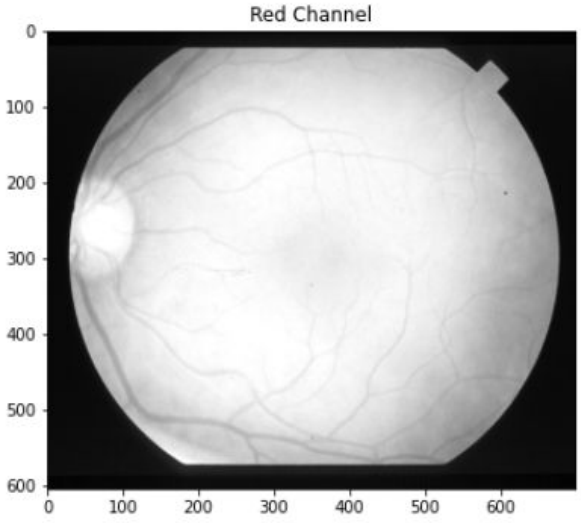
Input Image

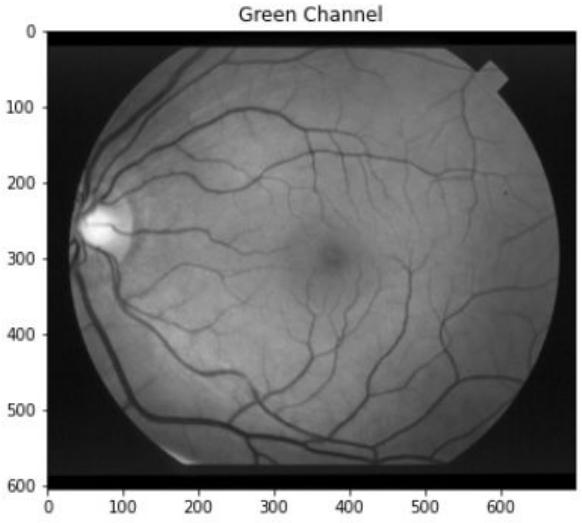


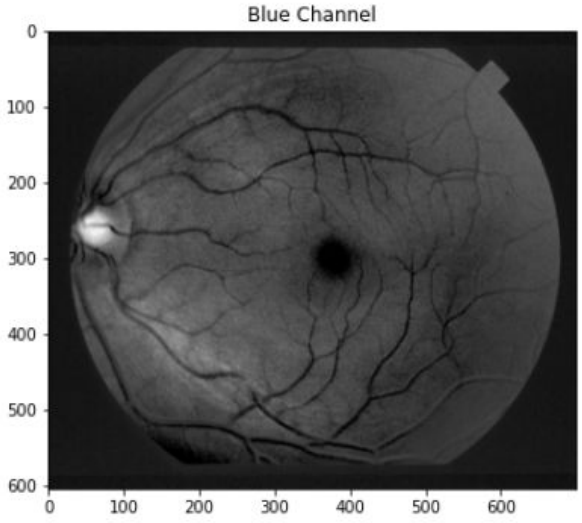
Hand labeled vessel network
provided by Valentina Kouznetsova

PREPROCESSING

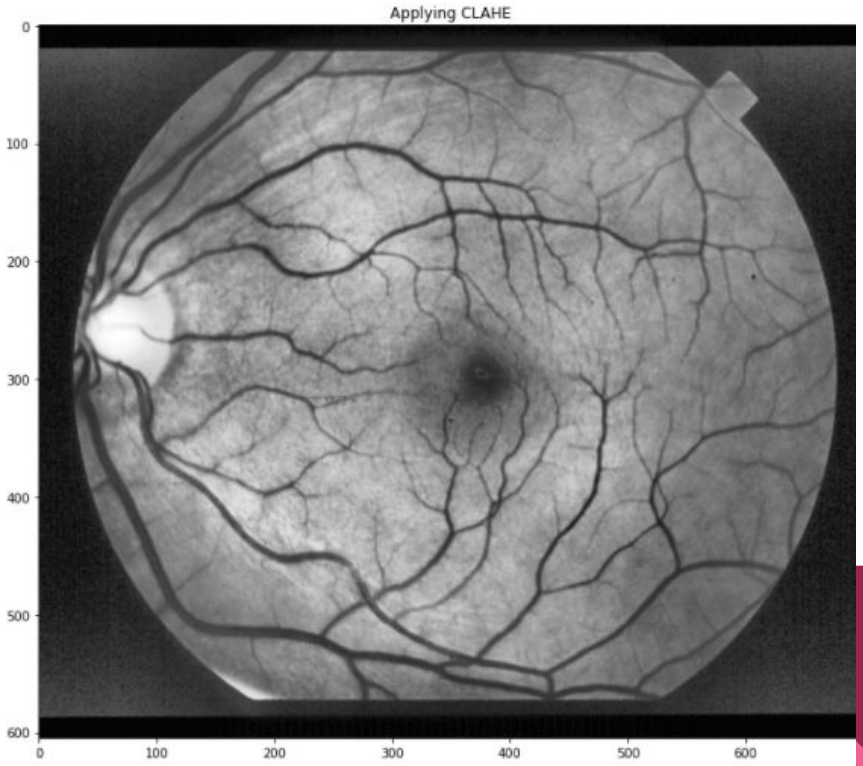
Step-1) RGB splitting







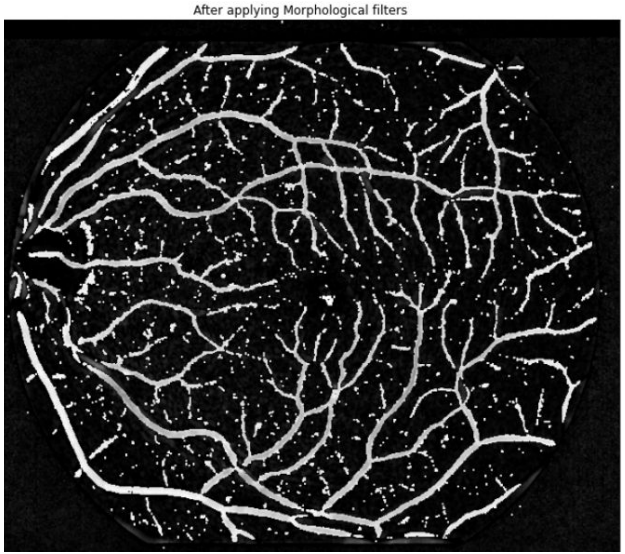
Step-2) G channel-> CLAHE



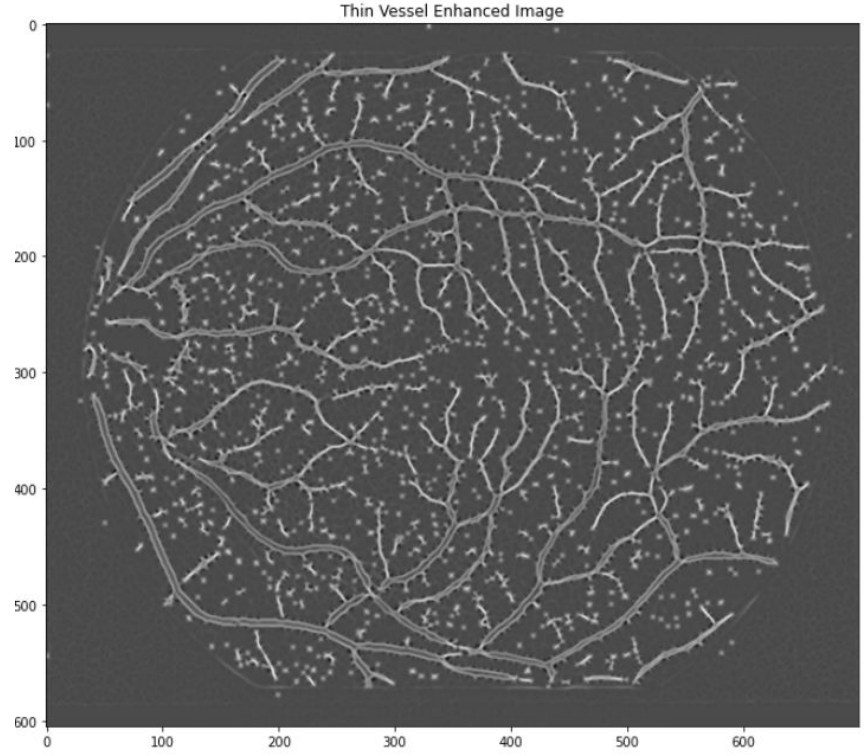
Step-3) Morphological filter

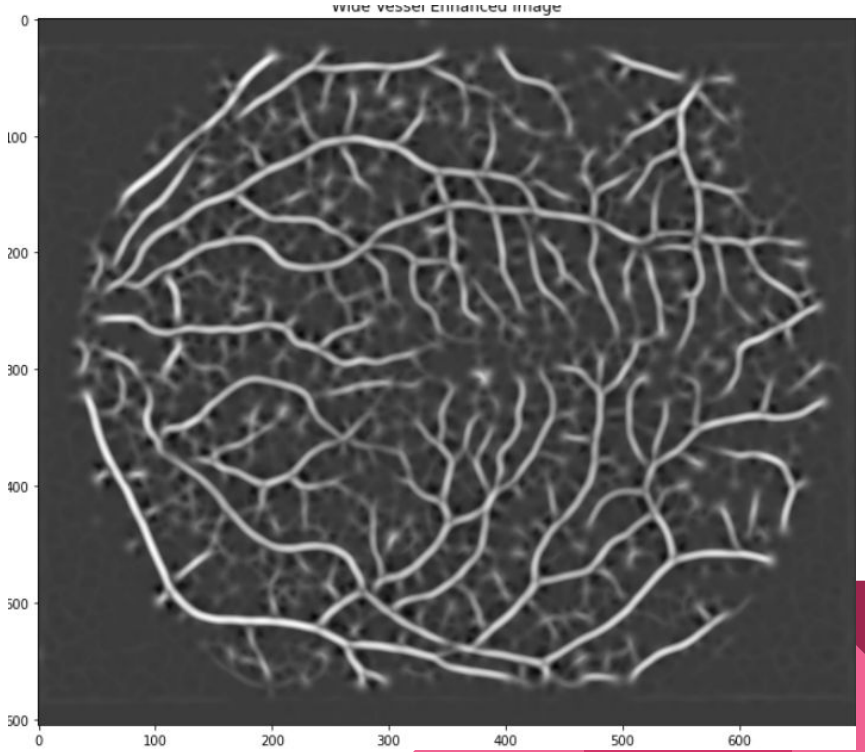
1. Modified Top Hat transform with a circular structuring element:

2. Erosion $TopHat = I - (I \cdot S_c) \circ S_o$



Step-4) Hessian Matrix



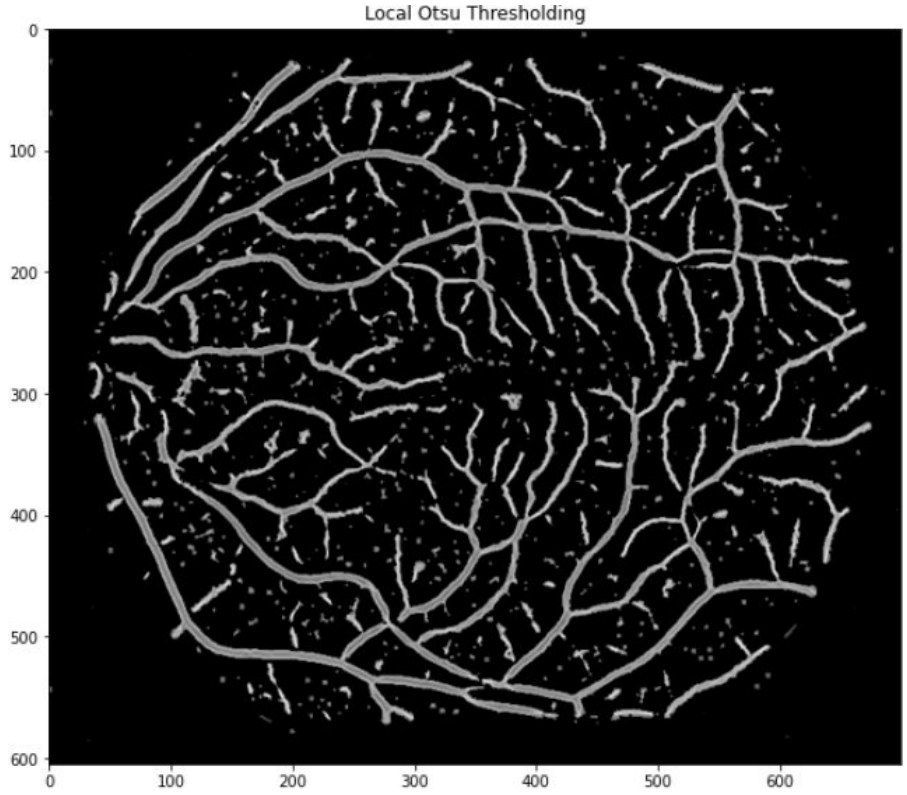


SEGMENTATION

Step-5)

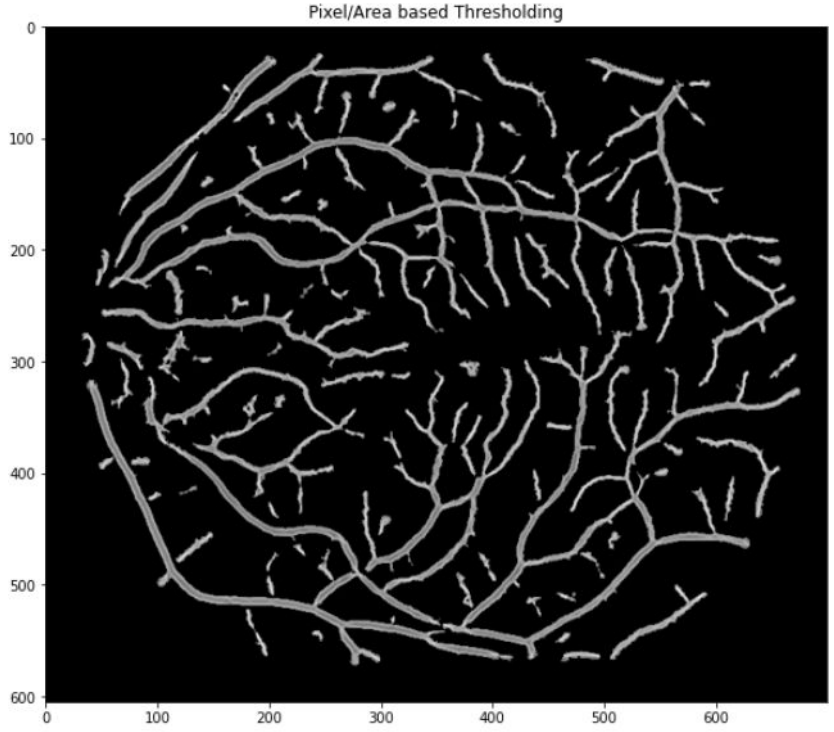
- Applying **global otsu thresholding** on wide vessels enhanced image to obtain global thresholding wide vessels output image.
- **Image fusion** of the global thresholded wide vessels output image and thin vessels enhanced image.
- Applying **local Otsu thresholding** on fused image.

Local Otsu thresholded image



POST PROCESSING

Step-6) Final output: Pixel/area based thresholding

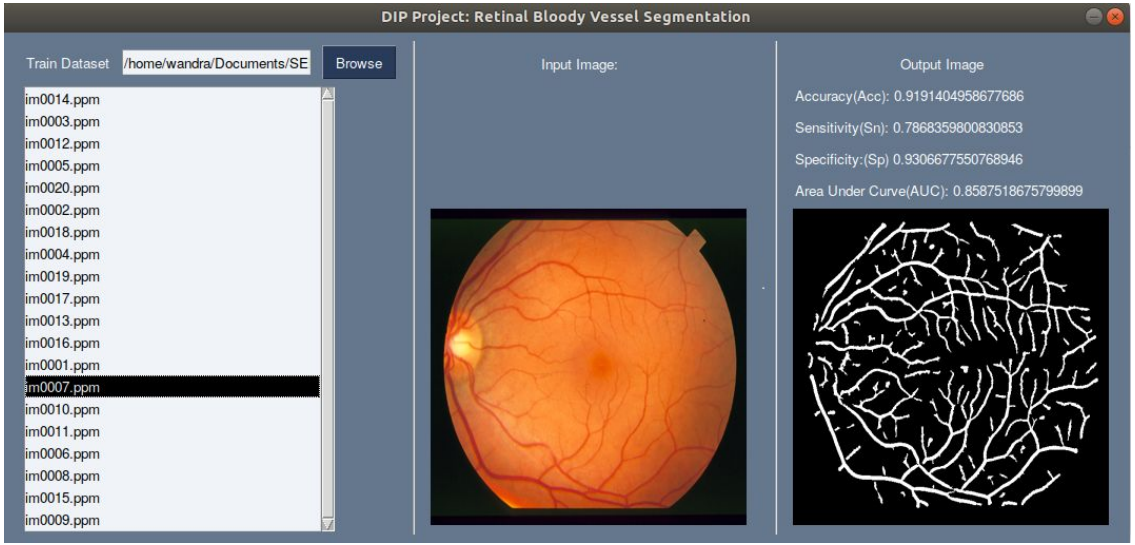


Graphical User Interface built for the project

GUI

Features of GUI:

1) Ability to select the image to be sent for Segmentation from the file manager.
2) Ability to view the input and output image.
3) Displays the performance of the image when compared with its ground truth image.
4) Framework used: PySimpleGUI, Tkinter



Performance Analysis

Accuracy Metrics

Four commonly used parameters to compare the performance are used

- **Accuracy:** shows the overall segmentation performance.
- **Sensitivity:** indicates effectiveness in detection of pixels with positive values
- **Specificity:** measure the detection of pixels with negative values.
- **Area Under the Curve:** the area under a Receiver Operating Characteristic (ROC) curve

$$\text{Accuracy (Acc)} = \frac{TP + TN}{TP + FP + TN + FN}$$

$$\text{Sensitivity (Sn)} = \frac{TP}{TP + FN}$$

$$\text{Specificity (Sp)} = \frac{TN}{TN + FP}$$

$$\text{Area Under Curve (AUC)} = \frac{Sn + Sp}{2}$$

Observations based on our implementation

Image No.	Acc	Sn	Sp	AUC
1	0.9155	0.7221	0.9322	0.8272
2	0.9427	0.7166	0.9588	0.8377
3	0.8910	0.8230	0.8953	0.8591
4	0.9481	0.6817	0.9695	0.8256
5	0.8996	0.7674	0.9127	0.8401
6	0.9174	0.8034	0.9260	0.8647
7	0.9191	0.7868	0.9306	0.8587
8	0.9365	0.8259	0.9454	0.8857
9	0.9273	0.7483	0.9426	0.8454
10	0.9058	0.7819	0.9167	0.8493
11	0.9288	0.7846	0.9398	0.8622
12	0.9335	0.8282	0.9423	0.8853
13	0.9324	0.7514	0.9501	0.8507
14	0.9329	0.7532	0.9508	0.8520
15	0.9396	0.7200	0.9603	0.8402
16	0.9391	0.6819	0.9684	0.8251
17	0.9398	0.7798	0.9555	0.8676
18	0.9668	0.7012	0.9810	0.8411
19	0.9508	0.7435	0.9601	0.8518
20	0.9352	0.7001	0.9520	0.8260
Average	**0.930095**	**0.75505**	**0.944505**	**0.849775**

Division of Labour

Division of Labour

Abhayram A Nair:
Segmentation, Posprocessing and Documentation

Aravind Narayanan:
GUI, demo, channel splitting, CLAHE and morphological filtering

Hemant Suresh:
Hessian matrix and Eigenvalues approach for Wide and Thin vessel enhanced image

Prayushi Mathur:
GUI ,Presentation, Documentation

THANK YOU