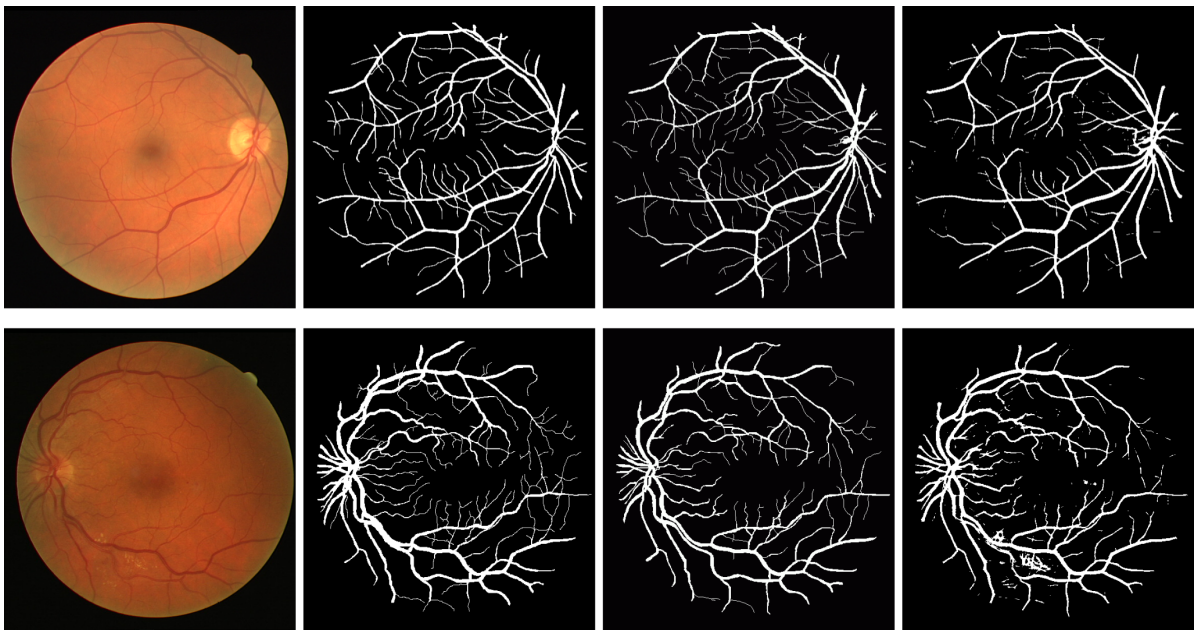
Digital Image Processing
Project ID - 27

Project Proposal

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



GitHub link: Link

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Main Goals of the project

Diabetic Retinopathy is a type of eye disease caused due to high blood sugar levels from diabetes. It causes changes to the blood vessels in the retina. It can cause the blood vessels to leak fluid, swell or bleed which results in vision changes or blindness at the last stage. Therefore, it needs to be detected at an earlier stage. The main goal of this project is as follows:

1. Implementation of a less computational unsupervised automated technique with promising results for detection of retinal vasculature by using morphological hessian-based approach and region-based Otsu threshold.
2. Obtaining vessel segmentation results by applying the proposed method.
3. Analyzing the results on different databases and doing a comparison study of different methods performing the same task.

Problem Definition

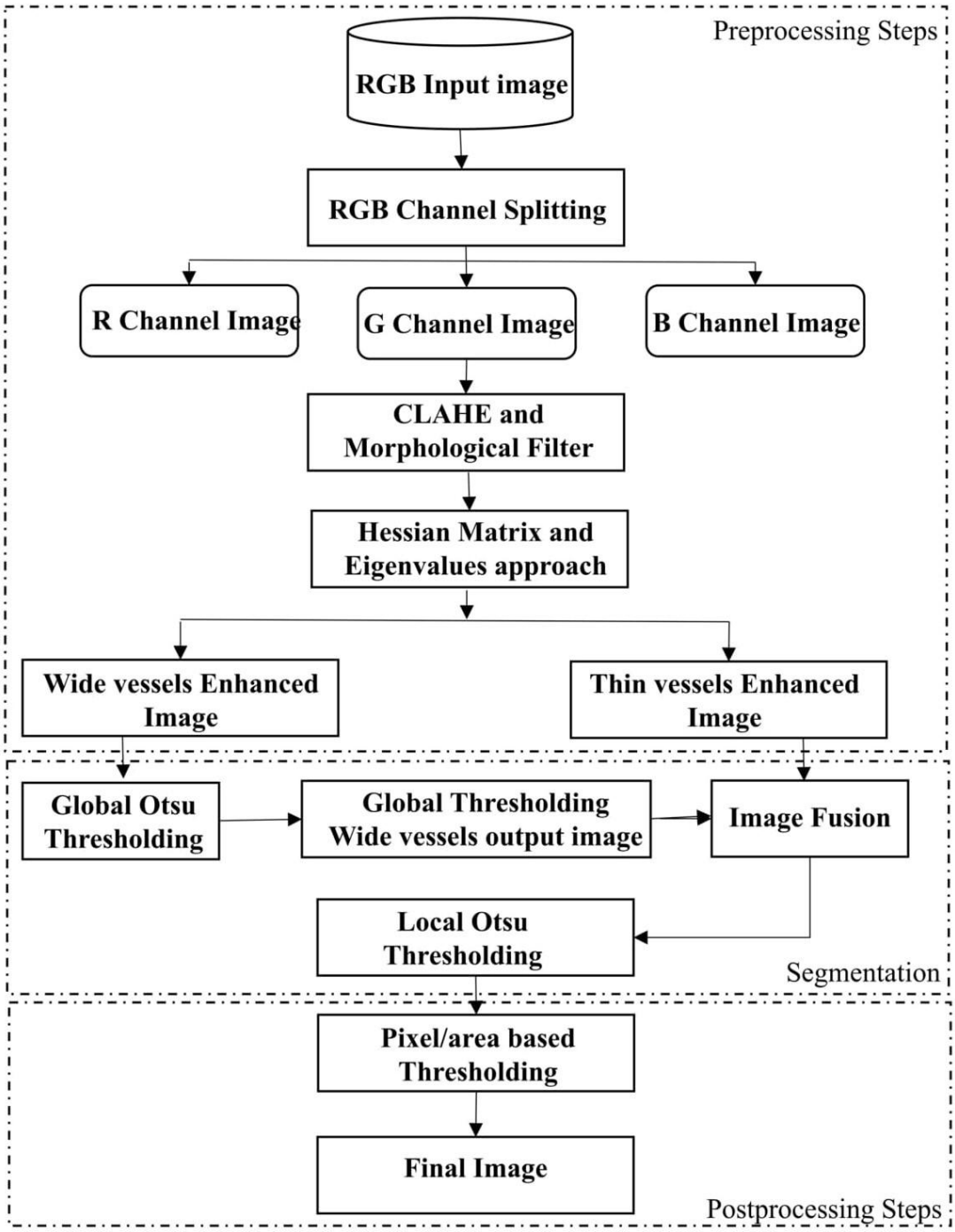
The current method of Retinal Blood Vessel Segmentation, Diabetic Retinopathy (DR) harms our retinal blood vessels causing a visual deficiency.
The aim of this project is to find a less computational unsupervised automated technique with promising results for the detection of retinal vasculature by using a morphological hessian-based approach and region-based Otsu thresholding.

Proposed Procedure

We aim to use specifically the Green Channel image from the input RGB image for processing:

1. Contrast Limited Adaptive Histogram Equalization (CLAHE) and Morphological Filters are used for blood vessel contrast enhancement and removal of low-frequency noise/geometrical objects respectively.
2. Hessian Matrix and Eigenvalues transformations are applied in a modified form at 2 different scales to extract wide and thin blood vessels in the enhanced image respectively.
3. Global and local Otsu Thresholding are utilized in a modified way to classify vessel and non-vessel pixels from wide and thin vessel enhanced images respectively.
4. Pixel/Area-based Thresholding is used for eliminating background noise and undesired/erroneous segments. The final image is outputted in binary form with vessel pixels valued at ‘1’ and non-vessel pixels valued at ‘0’.

A block diagram of the proposed technique has been given below.



Project Milestones and Expected Timeline:

Expected Timeline	Project Milestone
13th November	• Finish a thorough reading of the paper along with formalizing the algorithms, helper functions needed. • Data augmentation to directly import into the segmentation pipeline.
16th November	Complete pre-processing steps of the procedure.
21st November	Complete segmentation steps of the procedure.
25th November	• Complete post-processing steps of the procedure. • Tabulate and compare the accuracy levels with theoretical values.
29th November	• Build the GUI that can input the initial image and display the segmented output. • Make the final project PPT.

Expected Deliverables / Project Results

- A working method for segmentation as described in the paper
- Binary output images segment the image into “vessel” pixels and “non-vessel” pixels with relatively high accuracy
- Modular code with separated functions performing individual tasks for each of the three steps - the pre-processing, segmentation, and post-processing steps.
- Comparison of different performance evaluation criteria between our implementation and the ones discussed in the paper in tabular form
- A GUI which allows for uploading images and provides a segmented output on a given image
- Links to input and output images in ZIP folders, a List of dependencies required to run the code, and instructions to run the code in a README.md file
- Presentation and demo of our project

Dataset:

There are two major datasets that we plan to make use of in the project. Both of these are openly accessible and their ground truth data has been precisely marked by the experts.

- **STARE(STructured Analysis of the Retina) dataset:**
    - A full set of ~400 raw images in the STARE database.
    - Blood vessel segmentation work included 40 hand-labeled images, our results, and a demo.
    - Optic nerve detection work includes 80 images with ground truth and our results.
    - **Link:** https://cecas.clemson.edu/~ahoover/stare/
- **DRIVE (Digital Retinal Images for Vessel Extraction) Dataset:**
    - It consists of a total of JPEG 40 color fundus images; including 7 abnormal pathology cases.
    - The images were obtained from a diabetic retinopathy screening program in the Netherlands. The images were acquired using Canon CR5 non-mydriatic 3CCD camera with FOV equal to 45 degrees.
    - Each image resolution is 584*565 pixels with eight bits per color channel (3 channels).
    - **Link:** https://www.dropbox.com/sh/z4hbbzqai0ilqht/AAARqnQhjq3wQcSVFNR__6xNa?dl=0