Enhancing Ocular Disease Diagnosis, Blood Vessel Segmentation, and Vessel Diameter Estimation Using Advanced Deep Learning

Members:

Md. Marop Hossain	2013982042
Md. Zunayed Islam Pranto	1921609642
Tasnia Tasnim	1912533642

Faculty Advisor:

Dr. Mohammed Ashrafuzzaman Khan
Assistant Professor
ECE Department

Abstract :

The eye is an essential sensory organ in humans that enables vision by responding to light. Many people in Bangladesh suffer from nearsightedness and vision loss due to eye diseases. These issues are often overlooked as people are more focused on securing their financial stability, which is influenced by poverty and illiteracy within the population. In our project, we have used advanced deep-learning techniques to revolutionize healthcare, especially in the field of ophthalmology. We have successfully integrated deep learning tools and pre-trained models such as EfficientNetV2S, ResNet50, DenseNet121, and ResNeXt50 to achieve optimal accuracy in detecting cataracts, glaucoma, and diabetic retinopathy. Furthermore, our project involves the detection of various ophthalmological diseases, including ischemia, retinopathy of prematurity, age-related macular degeneration, arterial hypertension, and cardiovascular diseases, through blood vessel segmented imaging and vessel diameter estimation, interpreted by expert doctors.

Objective :

- In the context of Bangladesh, where most hospitals lack advanced equipment for Ocular disease diagnosis. This project will enable ophthalmologists to diagnose most of the Ocular disease just with the help of an ophthalmoscope and a basic Computer.
- Create a system that is easy to use and accessible to healthcare professionals, so that they can quickly and accurately diagnose Ocular diseases.
- Improve Healthcare Accessibility, Provide a cost-effective and scalable solution to improve eye care accessibility in Bangladesh, addressing the needs of populations affected by poverty.
- Facilitate Real-time Diagnostics, Develop and deploy user-friendly applications for real-time disease detection in clinical and remote settings, enabling timely intervention and treatment.

Methodology :

- In the first stage, Deep learning pre-trained models such as EfficientNetV2S, ResNet50, DenseNet121, and ResNeXt50 are used to diagnose cataracts, glaucoma, and diabetic retinopathy. which required data collection, data splitting (Train 50%, Validation 25%, Test 25%), data pre-processing, Model training, hyperparameter tuning, and testing.

- The second stage for blood vessel segmentation, we have done data collection, RGB channel splitting, CLAHE and Morphological filtration, Hessian matrix and eigenvalue approach, Global thresholding, image fusion, and Pixel-based thresholding for final segmented images.

- In last stage for diameter estimation, we have done background estimation and subtraction, Global thresholding, estimating maximum diameter using distance transform, skeletonization using Zhang-Seun's thinning algorithm, k-means clustering, and noise reduction are also used for diameter estimation.

Datasets :

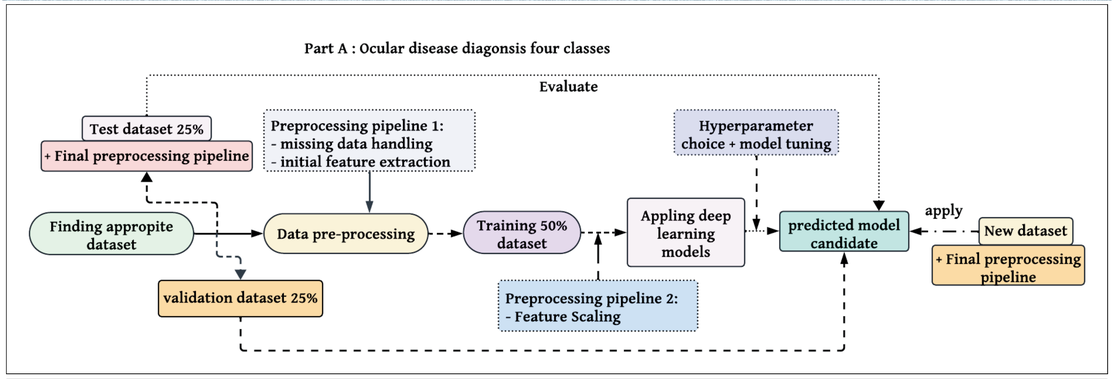
Dataset of Part A: (ODIR)

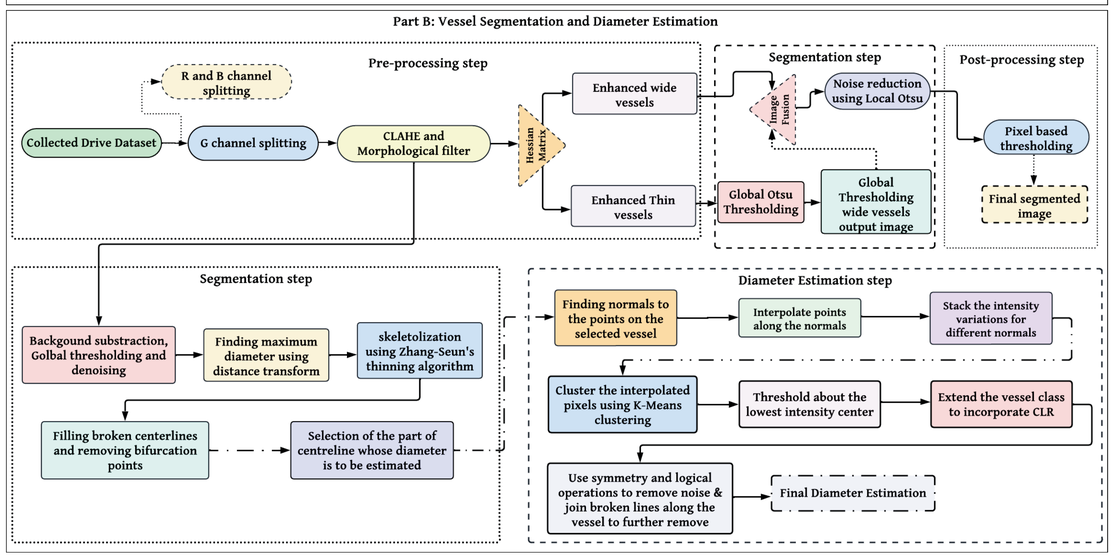
• Cataract	1038
• Diabetic Retinopathy	1098
• Glaucoma	1007
• Normal	1074

Dataset of Part B: (STARE)

• Abnormal Pathology	07
• Normal	13
• Segmented	20
• Total	40

System Diagram :

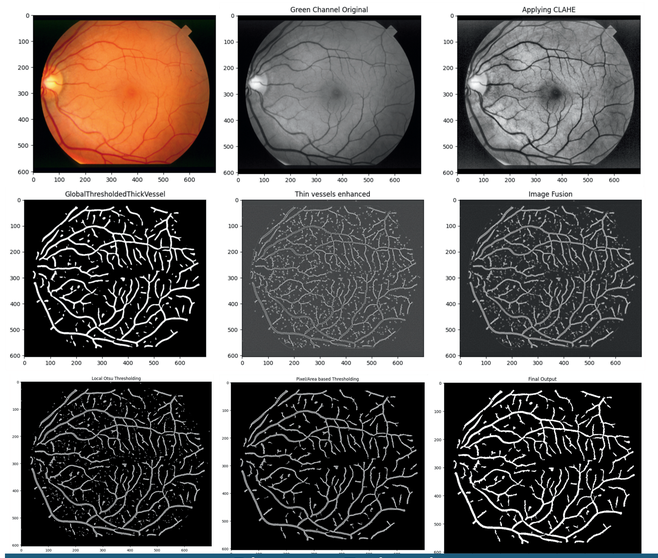




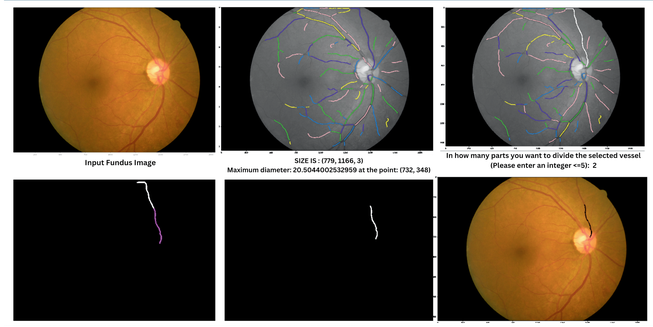
Results Part A: Ocular disease diagnosis four classes using pre-trained models

	Categorical accuracy	Validation categorical accuracy	AUC percentage difference	Accuracy percentage difference	Total testing image	Misclassified test image	Prediction accuracy on the test set
EfficientNetV2S	99.98%	98.58%	7.67%	1.42%	1057	23	97.82%
RestNet50	99.96%	98.39%	3.98%	1.56%	1057	32	96.98%
DenseNet121	99.16%	84.03%	2.79%	15.24%	1057	163	84.59%
ResNeXt50	94.35%	64.92%	11.11%	31.19%	1057	377	64.33%

Results Part B: Vessel segmentation



Diameter Estimation



Result Analysis :

- EfficientNetV2S: (Highest accuracy)
  - Categorical accuracy: 99.98%, Prediction accuracy: 97.82%
  - Fewest misclassified test images
- Segmentation and Diameter Estimation:
  - Highest accuracy of segmentation was 94.80%
  - Average Diameter estimated: 6.721
  - Median Diameter estimated: 7.00

Conclusion and future work :

- Our project uses advanced DL models to improve eye care in BD by segmenting vessels and calculating vessel diameters for ophthalmologists. The system is affordable and user-friendly, making it accessible to healthcare professionals in remote areas.
- Our goal is to provide timely and effective eye care to prevent vision loss and improve the quality of life for many people.
- In future, we can take eye images using a basic mobile phone for diagnosis, allowing people to monitor their eye health and detect abnormalities early for timely medical consultation.