**Enhancing Ocular Disease Diagnosis, blood vessel segmentation, and vessel diameter estimation using an advanced deep learning approach**


## ABSTRACT

Artificial intelligence (AI) based on deep learning (DL) is an emerging technology widely adopted in image recognition, speech recognition, and natural language processing. Deep learning is in the beginning stage of impacting healthcare, mostly in the field of ophthalmology. Various deep learning tools and pre-trained models we have implemented such as EfficientNetV2S, ResNet50, and DenseNet121 can achieve optimal accuracy in detecting diseases like cataracts, glaucoma, and diabetic retinopathy. Other ophthalmological diseases including ischemia, retinopathy of prematurity, age-related macular degeneration, arterial hypertension, and cardiovascular diseases can be further detected by expert doctors from blood vessel segmented imaging and vessel diameter estimation implemented in the project. And farther denotes future challenges and path forward in the field of ophthalmology.


### Method with System Diagram/Design Complexity

In the first stage, Deep learning pre-trained models such as EfficientNetV2S, ResNet50, and DenseNet121 are used to diagnose cataracts, glaucoma, and diabetic retinopathy, which required data collection, data splitting, data processing, training, hyperparameter tuning, and testing. The second stage, fundus blood vessel segmentation, and diameter estimation are done to further help doctors diagnose diseases such as ischemia, retinopathy of prematurity, age-related macular degeneration, arterial hypertension, and cardiovascular diseases. This required 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. Background estimation and subtraction, skeletonization, k-means clustering, and noise reduction are also used for diameter estimation.

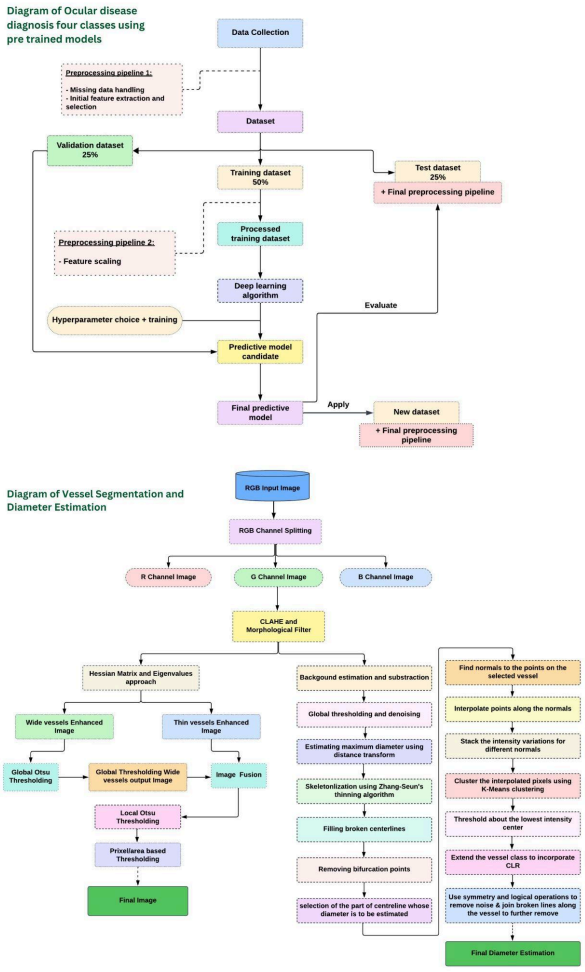


**Figure:** Diagram of Ocular Disease Diagnosis: Four-Class Classification with Pre-Trained Models and Vessel Segmentation and Diameter Estimation

**Novelty of Project**

- We combined a clustering algorithm with symmetry exploitation for vessel diameter estimation, which offers a unique approach to extracting additional information about vessel diameter.
- We used retinal vessel segmentation methods that focused solely on separating vessels from backgrounds.
- Then, we achieved the best accuracy from four pre-trained models using four classes.

**Impact on society/environment**

This project improves early diagnosis and treatment of ocular diseases, potentially reducing blindness rates. Early diagnosis can lead to cost saving and reduce the need of expensive tools required for diagnosis as well as reduce diagnosis cost. A deep learning approach can also reduce the requirements of tools and materials, contributing to medical waste and less carbon footprint.

**Business Model/Feasibility/Financial Scalability Plan**

Instead of using an ophthalmoscope for fundus images, we can train and test models with high-quality mobile phone images. As well as, Implement the diagnosis of cataracts, glaucoma, and diabetic retinopathy along with blood vessel segmentation (training with vast segmented fundus images segmented by expert doctors and performing symmetry exploitation) and diameter estimation in a single software, website, or an app. We can make it available for all. As well as earn revenue from it.

**Conclusion**

Our experiment provides an innovative approach to analyzing ocular images with great promise for the medical field. Improved efficiency and early disease diagnosis can be achieved by combining diameter estimate and vessel segmentation. Future work will be focused on enhancing the model and integrating these features into a web-based system aimed at real-life usage.