# Project Statement 1: VeinScope – Tear Vein Pattern Analysis for Early Disease Mapping


## Group_No. 39

### Team Members:


| | | | |
|---|---|---|---|
| Aryan Kashyap | B22004 | Animesh Kumar Jha | B22086 |
| Aditya Kumar Mishra | B22030 | Aditya Sharma | B22083 |
| Kavya Dhiman | B22110 | Aditya Kmar Singh | B22255 |

## 1. Introduction

VeinScope is a novel system developed to analyze tear vein patterns from close-up eye images to potentially map them to early health indicators. By combining deep learning-based segmentation with image processing, the project aims to deliver precise vein detection and highlight correlations between vascular patterns and physiological health parameters. This is a team project aimed at both building a functional pipeline and deploying it as a real-time mobile/web application.

## 2. Problem Statement

Develop a system that captures or processes close-up eye images, extracts tear vein patterns, and maps them to potential health indicators. The project uses image analysis and ML/DL methods to:

- Segment vein structures
- Quantify pattern features
- Map features to risk or condition scores

## 3. Dataset

The primary dataset used is the SBVPI (Sclera Blood Vessels, Periocular, and Iris) Dataset. It contains 1,858 high-resolution RGB eye images from 55 subjects. Each sample comes annotated for scleral vasculature, iris, pupil, and periocular regions.

Reference: https://sclera.fri.uni-lj.si/datasets.html

## 4. Methodology

### 4.1 Image Preprocessing

The preprocessing step enhances the visibility of vein structures using various techniques such as:

- CLAHE (Contrast Limited Adaptive Histogram Equalization)
- Green channel extraction and grayscale contrast
- ROI cropping to isolate the inner eye (tear region)

### 4.2 Segmentation Pipeline

The segmentation phase is split into two stages using a DeepLabV3+ architecture with a ResNet34 backbone.

- Stage 1: Identifies and segments the sclera.
- Stage 2: Further segments fine blood vessels within the scleral mask.

Emphasis was placed on preserving thin structures and ensuring vein continuity.

### 4.3 Feature Extraction

Using morphological analysis and contour tracking, the following features are extracted:

- Vein Length: Estimated via skeletonization.
- Curviness: Measured using local curvature metrics.
- Density: Computed as the ratio of vein to scleral area.

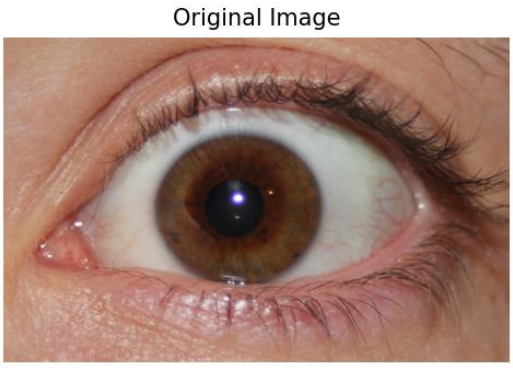
### 4.4 Mapping to Health Indicators

Based on literature and medical heuristics, features were mapped to possible health risks like dehydration, liver stress, and fatigue. Although this mapping is exploratory and may need clinical validation, clustering and heuristic rules were used to demonstrate proof-of-concept.

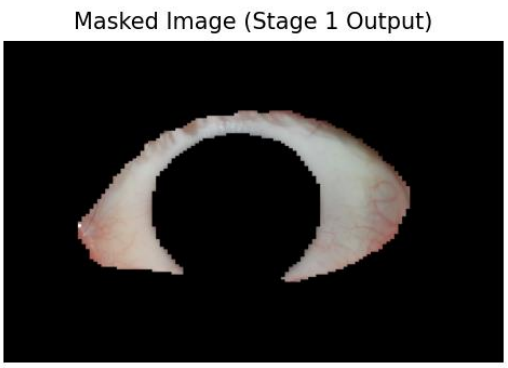
## 5. Implementation Output

The four main stages of the image pipeline are as follows:

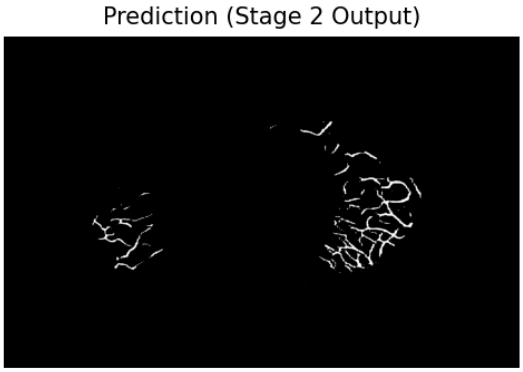
**Original Image**




**Masked Image (Stage 1 Output)**




**Prediction (Stage 2 Output)**




**Overlay of predicted veins**

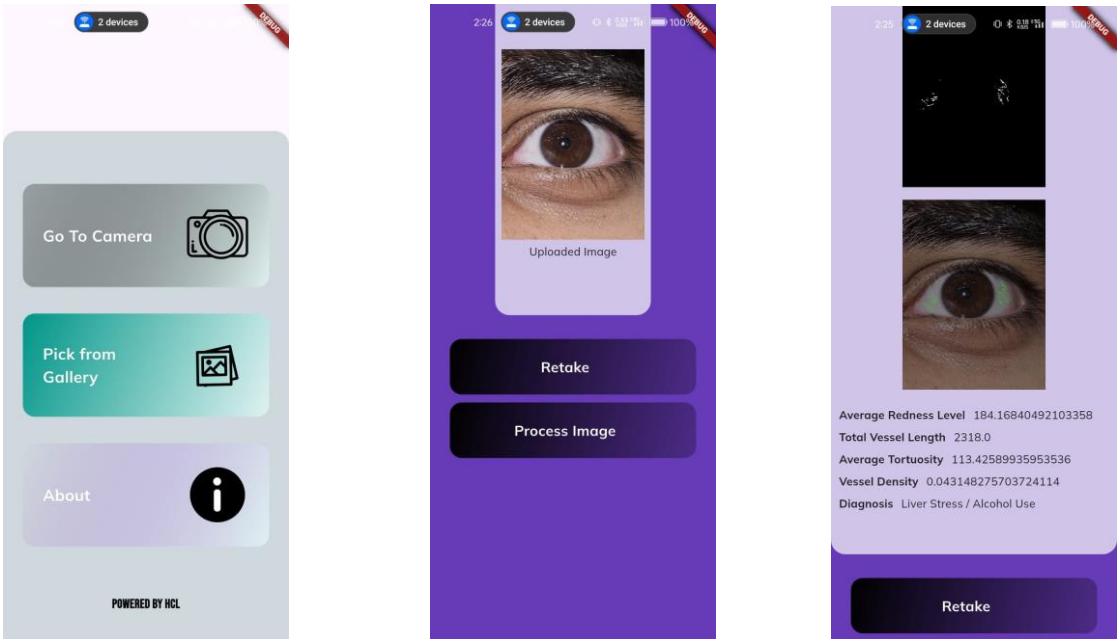
## 6. Evaluation

We evaluated the system using both qualitative and quantitative metrics:

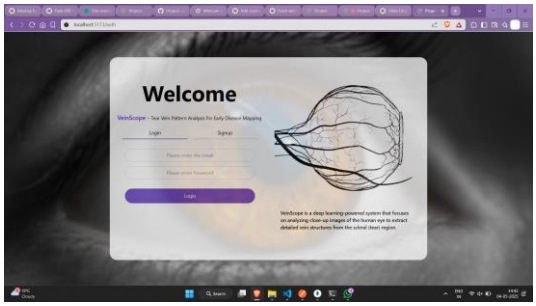
- - Dice Score: Used to evaluate how well the predicted segmentation matches the ground truth, with higher values indicating better overlap.
- - SSIM: Focuses on the structural similarity between two images, taking into account luminance, contrast, and texture.
- PSNR: A metric for evaluating the quality of reconstructed images, where a higher value indicates better quality, particularly in terms of preserving details.
- MSE: A numerical measure of the difference between predicted and true values, where lower values indicate better prediction accuracy. x

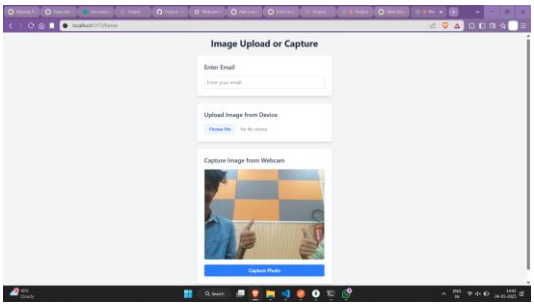
## 7 Deployment and Application

We developed a real-time Android application and a web-based interface that capture live images, process them using our trained model, and display the resulting scleral mask and vein pattern. This demonstrates the feasibility of deploying our model in practical, real-world settings.




**Some Screenshots of our App**




**Some Screenshots of our website**

## 8. Limitations

Despite promising results, there are a few limitations to be addressed in future work:

- - Lower performance on brown and black eyes due to training primarily on images of white individuals
- - Inaccurate results for low-resolution or poorly lit images
- - Requires close-up, clear images for best results.

## 9. Conclusion

VeinScope demonstrates a robust and scalable approach to tear vein segmentation and early health pattern mapping. Despite current limitations, the solution shows promise for non-invasive diagnostic support and real-time health monitoring.

## 10. Team and Contributions

This was a collaborative team project. Team members contributed in the following areas:

- - Model Training & Segmentation Pipeline
- - Dataset Preparation and Annotation
- - Real-time App and Web Interface Deployment
- - Evaluation and Report Writing