R&D PROJECT

# Hemoglobin Level Estimation from Photographic images

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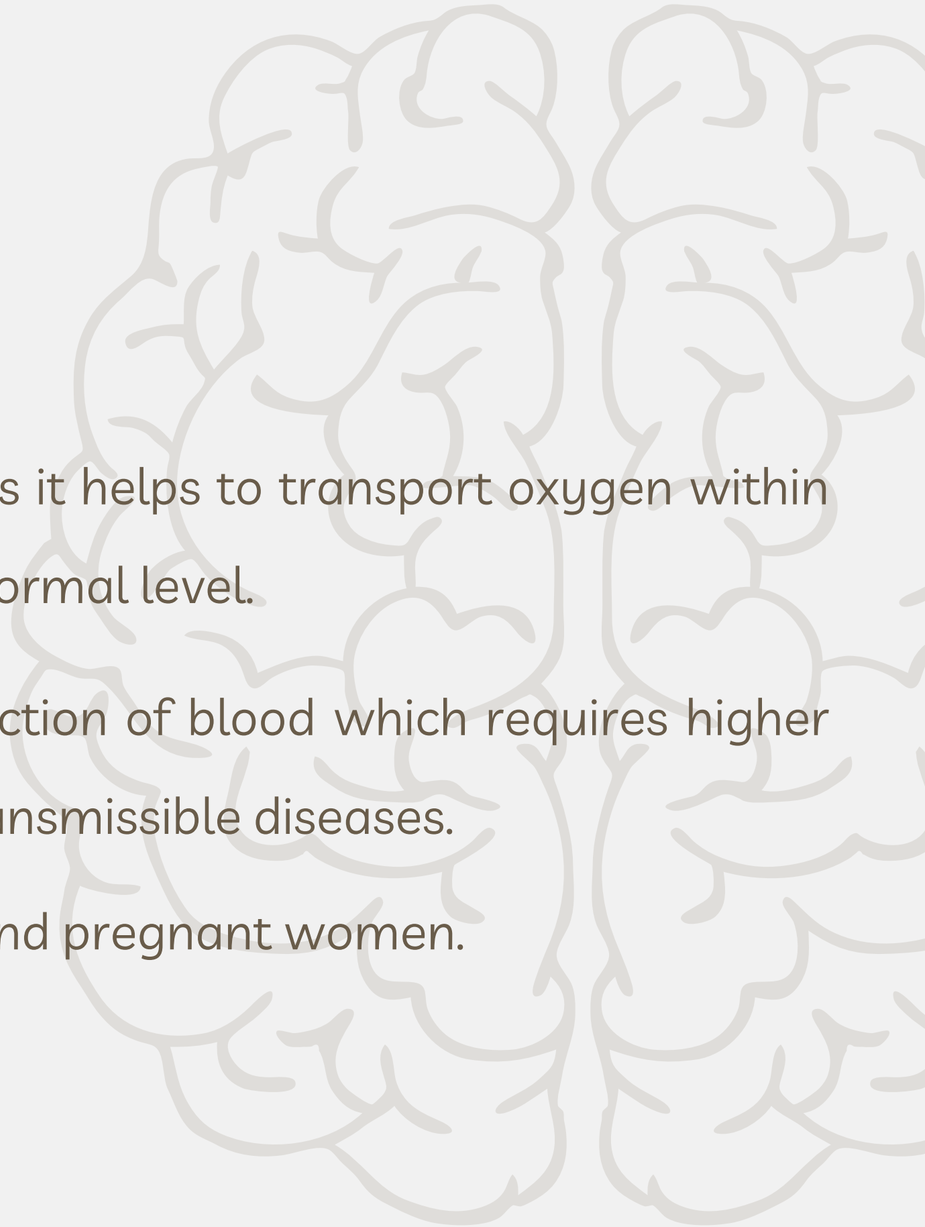
# Background



- Haemoglobin is very crucial for proper function of bodily organs as it helps to transport oxygen within the body. Anemia develops when haemoglobin level drops below normal level.
- Traditional methods to detect Anemia clinically depends on extraction of blood which requires higher labor, is expensive, time consuming and exposes people to blood transmissible diseases.
- Even use of this invasive method is discouraged in infants, elderly, and pregnant women.

# Why ML approach?

- **Non-invasive Nature:**
  - ML-based approaches rely on analyzing medical images making them non-invasive & comfortable
- **Cost Effectiveness:**
  - Once developed, ML-based systems can significantly reduce the cost of diagnosis
- **Efficiency & Scalability:**
  - They can be deployed on devices like smartphones, making them accessible in rural areas
- **Accuracy & Early Detection:**
  - ML models can detect subtle changes in medical images that might not be evident to human observers

# Literature Review

R&D PROJECT

**01** Comparative Study Between Decision Tree, SVM & KNN to Predict Anaemic Condition

**02** Anemia Detection Using a Full Embedded Mobile Application with YOLO Algorithm

**03** An intelligent non-invasive system for automated diagnosis of anemia exploiting a novel dataset

# Literature Review

R&D PROJECT

04 Detection of iron deficiency anemia by medical images: a comparative study of machine learning algorithms

05 Anaemia detection based on sclera and blood vessel colour estimation

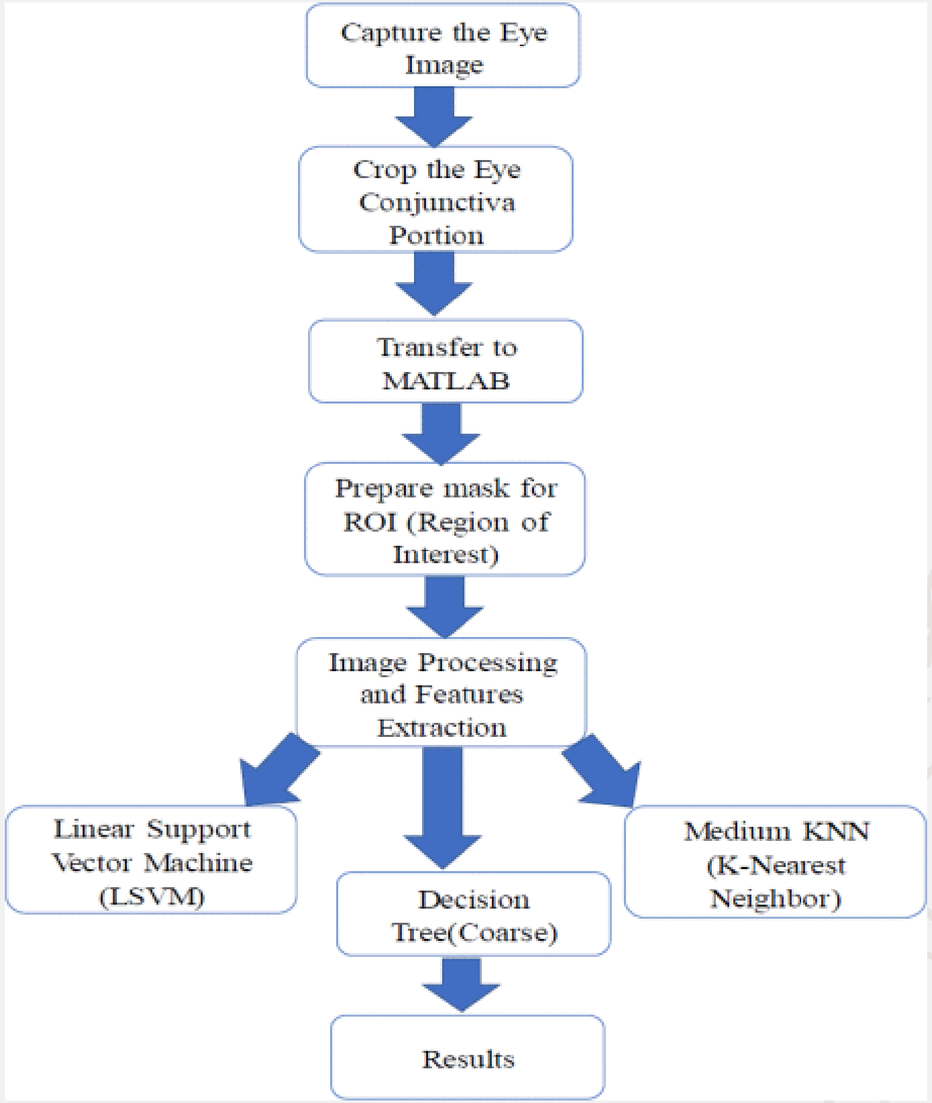
06 Computer Aided Detection of Anemia-like Pallor

# 01

# Comparative Study Between Decision Tree, SVM & KNN to Predict Anaemic Condition

LINK

## Methodology



# 01

# Comparative Study Between Decision Tree, SVM & KNN to Predict Anaemic Condition

LINK

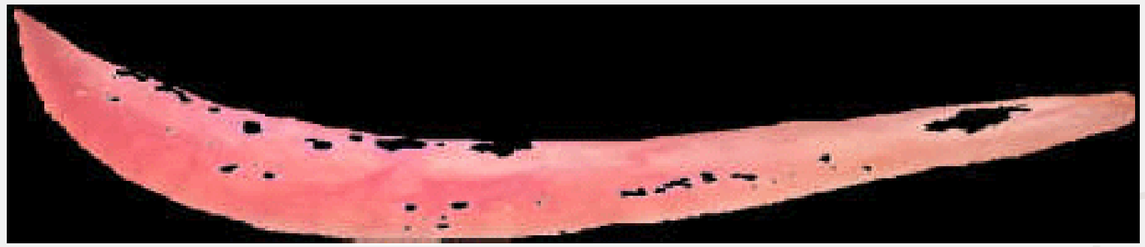
- Capture the Eye Conjunctiva Image and Crop the Eye Conjunctiva Portion

# 01

# Comparative Study Between Decision Tree, SVM & KNN to Predict Anaemic Condition

LINK

- Prepare Mask for Region of Interest Using Matlab Image Thresholding App



# 01

# Comparative Study Between Decision Tree, SVM & KNN to Predict Anaemic Condition

LINK

- Image Processing and Feature Extraction

The percentage of red pixel=

$$\frac{Total\ red\ pixel}{Total\ Red\ pixel\ +\ Total\ Green\ pixel\ +\ Total\ blue\ Pixel} * 100$$

| Name | %Red Pixel | %Green Pixel | %Blue Pixel | Anemic Condition |
|---|---|---|---|---|
| Shahalam | 47.6372 | 26.7953 | 25.5675 | Non Anemic |
| Rumana | 45.0693 | 29.8506 | 25.0801 | Anemic |
| Ajmal | 46.7979 | 28.1768 | 25.0253 | Non Anemic |
| Haradhan | 42.2324 | 30.6757 | 27.0919 | Anemic |
| Nujhat | 43.1425 | 30.289 | 26.5686 | Anemic |
| Noor | 42.5314 | 30.9742 | 26.4944 | Anemic |

# 01

# Comparative Study Between Decision Tree, SVM & KNN to Predict Anaemic Condition

LINK

- Results:

| MODEL | ACCURACY |
|---|---|
| ***DECISION TREE*** | ***82.6%*** |
| ***SVM*** | ***73.9%*** |
| ***KNN*** | ***73.9%*** |

# 02

# Anemia Detection Using a Full Embedded Mobile Application with YOLO Algorithm

LINK

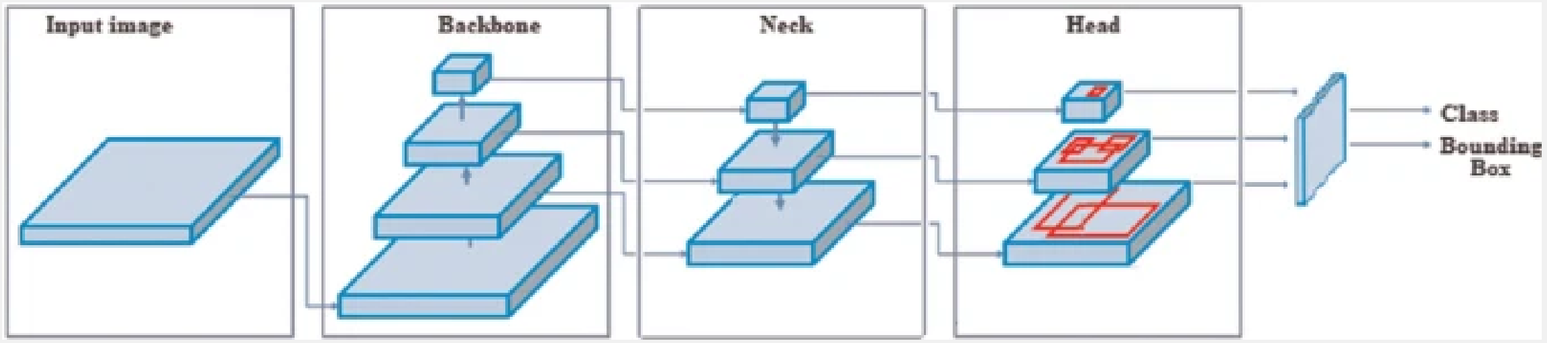
- **Dataset:**
  - 457 images, 121 to the Anemia class and 336 to the non-anemia
- **Pre-processing:**
  - The image was cropped to 1600x1600 pixels around the conjunctiva
- **Data Augmentation:**
  - To equalize the number of images in each classes existing ones were slightly modified by applying flipping and rotation

# 02

# Anemia Detection Using a Full Embedded Mobile Application with YOLO Algorithm

LINK

- YOLO v5 architecture is used for classification




- **Backbone**:  A convolutional neural network that aggregates and forms image features at different granularities
- **Neck**: A series of layers to mix and combine image features to pass them forward to prediction
- **Head**:  Consumes features from the neck and takes box and class prediction steps

# 02

# Anemia Detection Using a Full Embedded Mobile Application with YOLO Algorithm

LINK

- **Results in PC:**

| YOLO with preprocessing | |
|---|---|
| Sensitivity | 0.86 |
| Specificity | 0.95 |

| YOLO without preprocessing | |
|---|---|
| Sensitivity | 0.91 |
| Specificity | 0.95 |
| Accuracy | 93% |

# 02

# Anemia Detection Using a Full Embedded Mobile Application with YOLO Algorithm

LINK

- **Results in Mobile:**

| YOLO with preprocessing | |
|---|---|
| Sensitivity | 0.71 |
| Specificity | 0.89 |
| Accuracy | 80% |

# 03

## An intelligent non-invasive system for automated diagnosis of anemia exploiting a novel dataset

LINK

## DATASET

- **Novel Dataset:**
  - Eye conjunctiva photos from Indian and Italian patients.
  - Total: 218 images (116 Italian, 95 Indian).
  - Images segmented into palpebral and forniceal conjunctiva.
- **Key Attributes:**
  - Demographic data (age, gender) and Hb levels.
  - Captured with standardized lighting and distance.

# 03

# An intelligent non-invasive system for automated diagnosis of anemia exploiting a novel dataset

LINK

## FEATURE EXTRACTION

14 features are extracted

- **mean_r, mean_g , mean_b** : Intensity values of red green and blue pixel in ROI
- **mean_r−g** : distinction between the red and green components, which reflect blood characteristics
- **HHR ( high hue ratio )** : represents the proportion of pixels with high values in the hue component
- **Ent ( Entropy )** : entropy values can indicate different textures and blood-vessel distributions
- **B ( brightness )** : brightness given by the average grayscale of the image
- **Age**
- **Gender**

# 03

## An intelligent non-invasive system for automated diagnosis of anemia exploiting a novel dataset

LINK

## FEATURE EXTRACTION

Gray-Level Features for Blood Vessel Analysis

- **g1**: Difference between pixel intensity and the minimum intensity in the window.
- **g2**: Difference between the maximum intensity in the window and pixel intensity.
- **g3**: Difference between pixel intensity and the mean intensity in the window.
- **g4**: Standard deviation of pixel intensities in the window.
- **g5**: Pixel intensity of the center pixel.

Average these values across the entire ROI

# 03

# An intelligent non-invasive system for automated diagnosis of anemia exploiting a novel dataset

LINK

## MODELS

## 1. RUSboost

| METRIC | Whole conjunctiva | Palpebral conjunctiva |
|---|---|---|
| Accuracy | 0.83 ± 0.04 | 0.83 ± 0.04 |
| Sensitivity | 0.66 ± 0.16 | 0.69 ± 0.15 |
| Specificity | 0.87 ± 0.06 | 0.87 ± 0.06 |

# 03

## An intelligent non-invasive system for automated diagnosis of anemia exploiting a novel dataset

LINK

# MODELS

## 2. Random Forest

| METRIC | Whole conjunctiva | Palpebral conjunctiva |
|---|---|---|
| Accuracy | 0.85 ± 0.03 | 0.84 ± 0.03 |
| Sensitivity | 0.51 ± 0.16 | 0.49 ± 0.17 |
| Specificity | 0.93 ± 0.04 | 0.93 ± 0.05 |

# 03

# An intelligent non-invasive system for automated diagnosis of anemia exploiting a novel dataset

LINK

## MODELS

## 3. SVM

| METRIC | Whole conjunctiva | Palpebral conjunctiva |
|---|---|---|
| Accuracy | 0.86 ± 0.03 | 0.87 ± 0.03 |
| Sensitivity | 0.64 ± 0.12 | 0.62 ± 0.13 |
| Specificity | 0.91 ± 0.04 | 0.93 ± 0.03 |

# 03

# An intelligent non-invasive system for automated diagnosis of anemia exploiting a novel dataset

LINK

## MODELS

## 4. KNN

| METRIC | Whole conjunctiva | Palpebral conjunctiva |
|---|---|---|
| Accuracy | 0.83 ± 0.04 | 0.78 ± 0.04 |
| Sensitivity | 0.53 ± 0.13 | 0.46 ± 0.13 |
| Specificity | 0.90 ± 0.04 | 0.86 ± 0.05 |

# 03

# An intelligent non-invasive system for automated diagnosis of anemia exploiting a novel dataset

LINK

## MODELS

## 5. MobileNet-V2

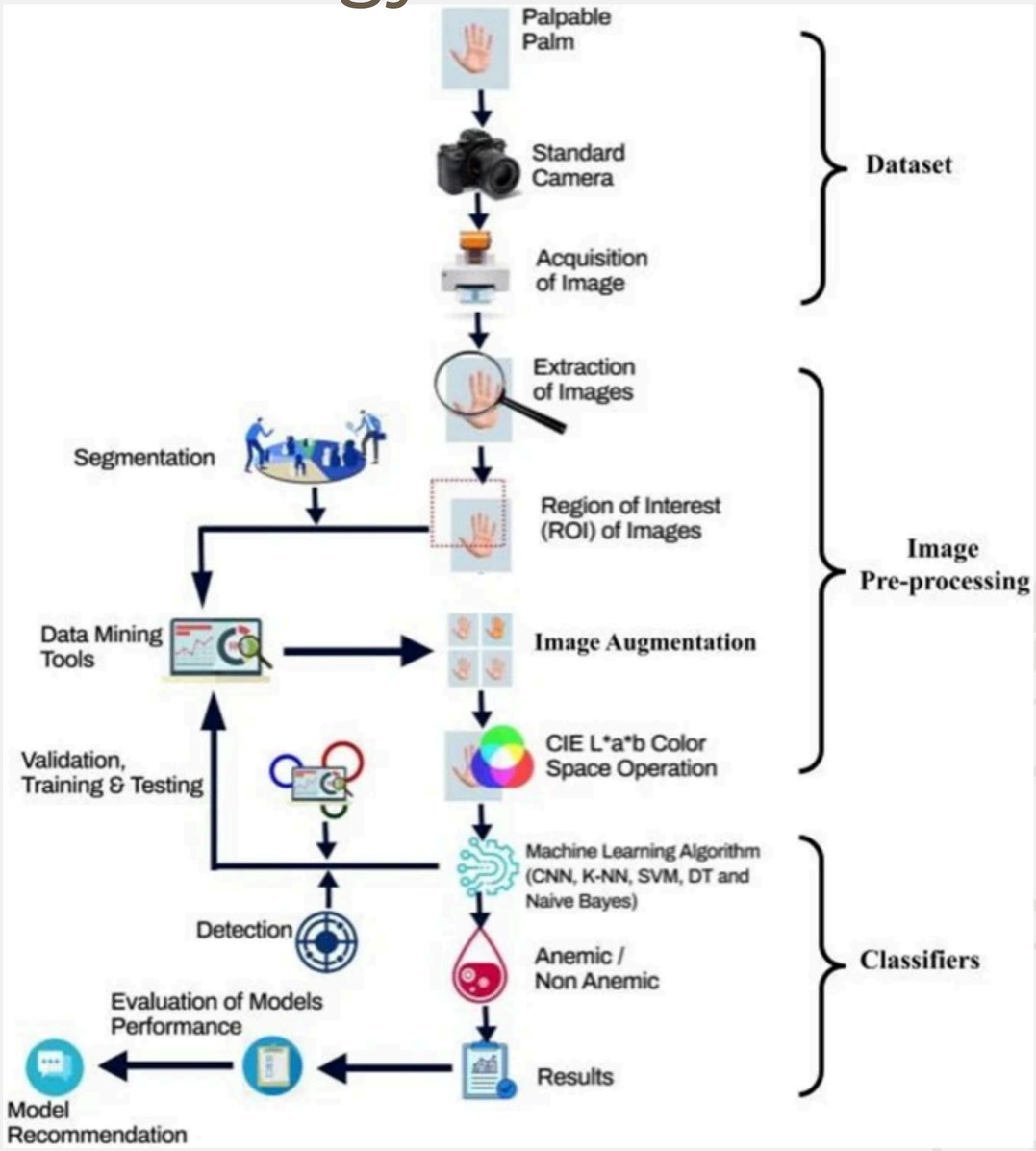
| METRIC | Whole conjunctiva | Palpebral conjunctiva |
|---|---|---|
| Accuracy | 0.82 ± 0.06 | 0.83 ± 0.06 |
| Sensitivity | 0.49 ± 0.21 | 0.52 ± 0.21 |
| Specificity | 0.90 ± 0.06 | 0.90 ± 0.06 |

# 04

## Detection of iron deficiency anemia by medical images: a comparative study of machine learning algorithms

LINK

# Methodology

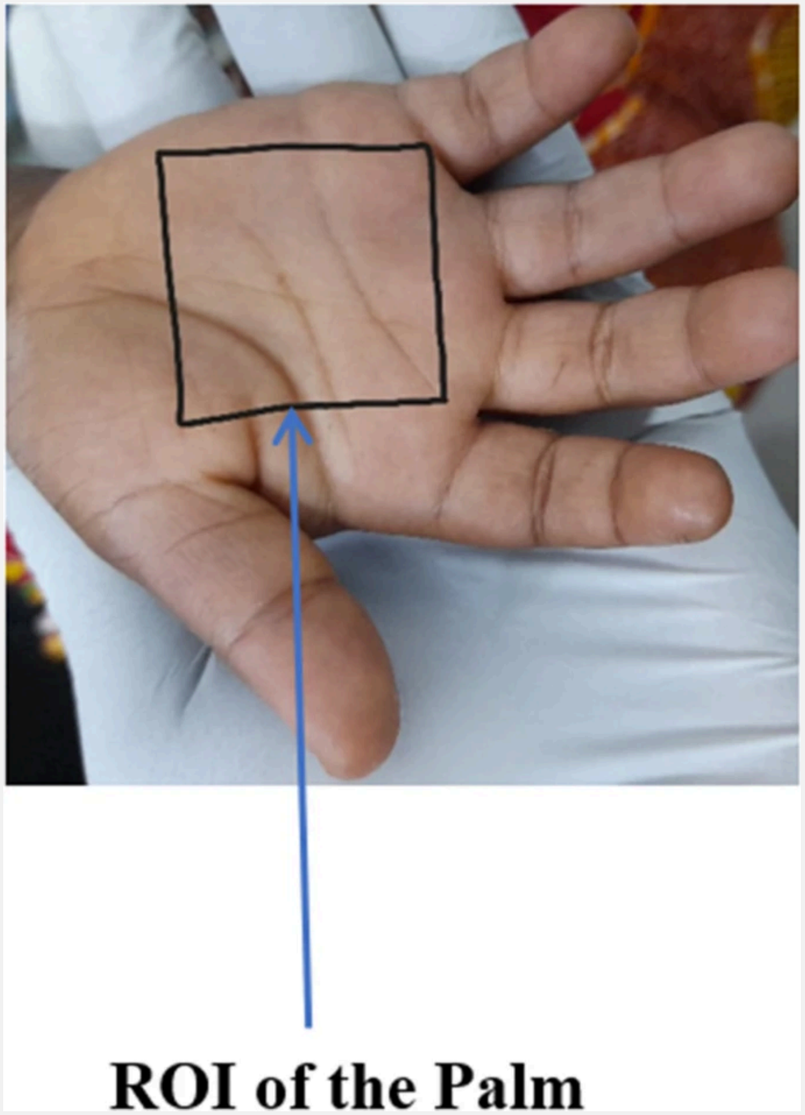


# 04

## Detection of iron deficiency anemia by medical images: a comparative study of machine learning algorithms

LINK

## DataSet



# 04

# Detection of iron deficiency anemia by medical images: a comparative study of machine learning algorithms

LINK

## Feature Extraction

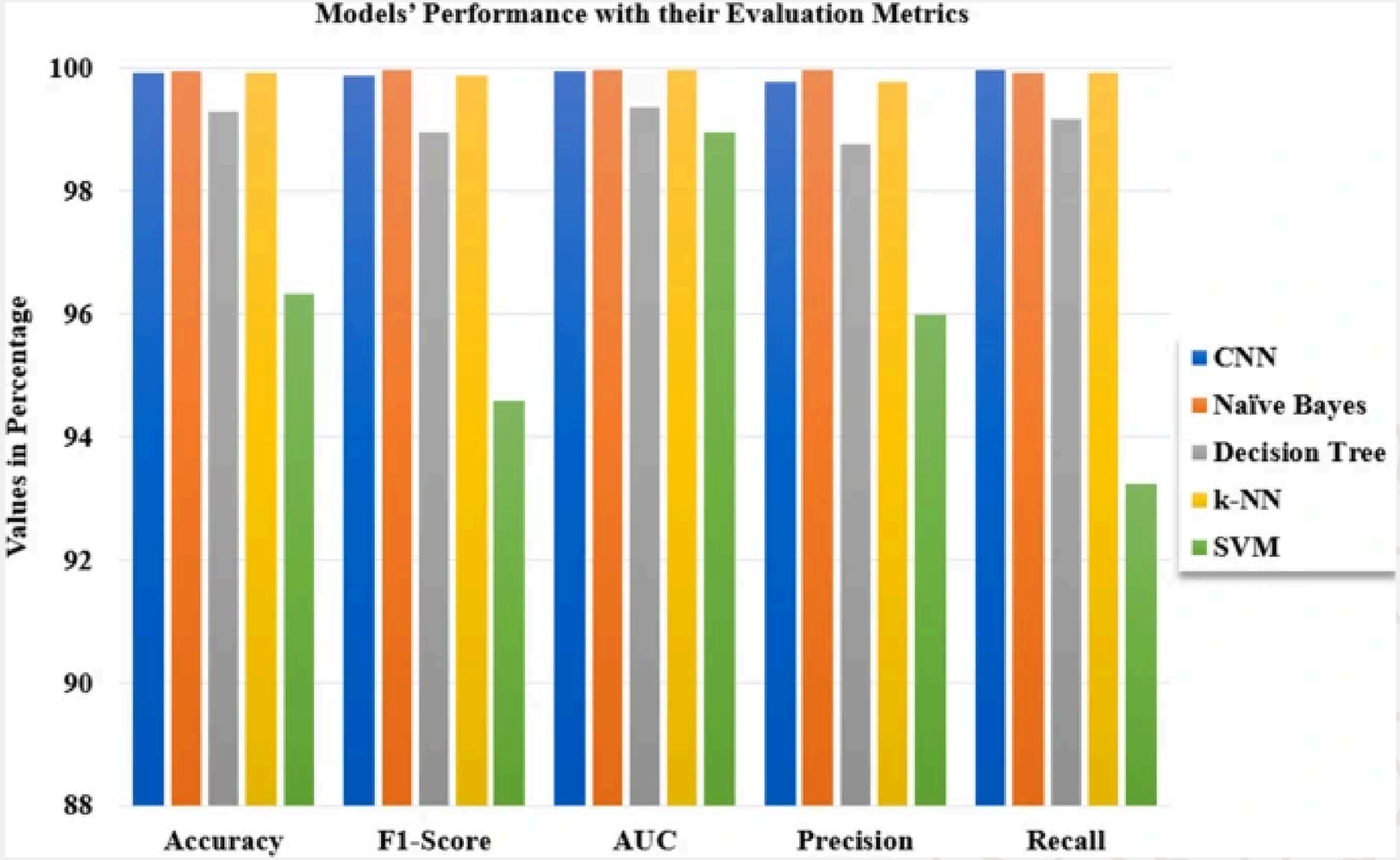
- Each image's ROI is converted to the CIE Lab* color space
- Visible colors are converted into a three-dimensional, device-independent space (L*, a*, b*).
- L* (Lightness): Ranges from 0 (black) to 100 (white).
- a* axis: Red (a* >0), Green (a* <0)
- b* axis: Yellow (b*>0), Blue (b*<0)

# 04

## Detection of iron deficiency anemia by medical images: a comparative study of machine learning algorithms

LINK

# Results

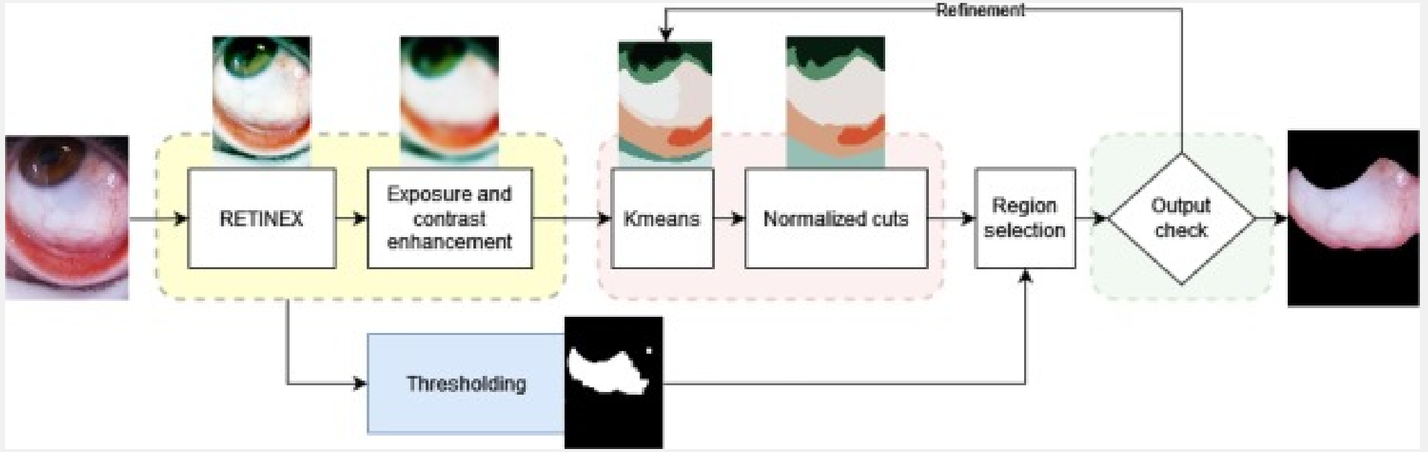


# 05

## Anaemia detection based on sclera and blood vessel colour estimation

LINK

# Sclera Segmentation




| Algorithm | Parameters | Precision | Recall | F1 | F2 |
|---|---|---|---|---|---|
| Nearest Neighbour | K=7, uniform weights | 87.0 | 78.0 | 79.8 | 78.4 |
| Random Forest | estimators=20, max features=auto, Gini criterion | 78.0 | 73.0 | 72.5 | 72.4 |
| Adaboost | Estimators=40 | 83.0 | 73.0 | 74.7 | 73.2 |
| Polynomial SVM | C=20, degree=3, gamma=auto | 74.6 | 90.1 | 80.1 | 86.4 |

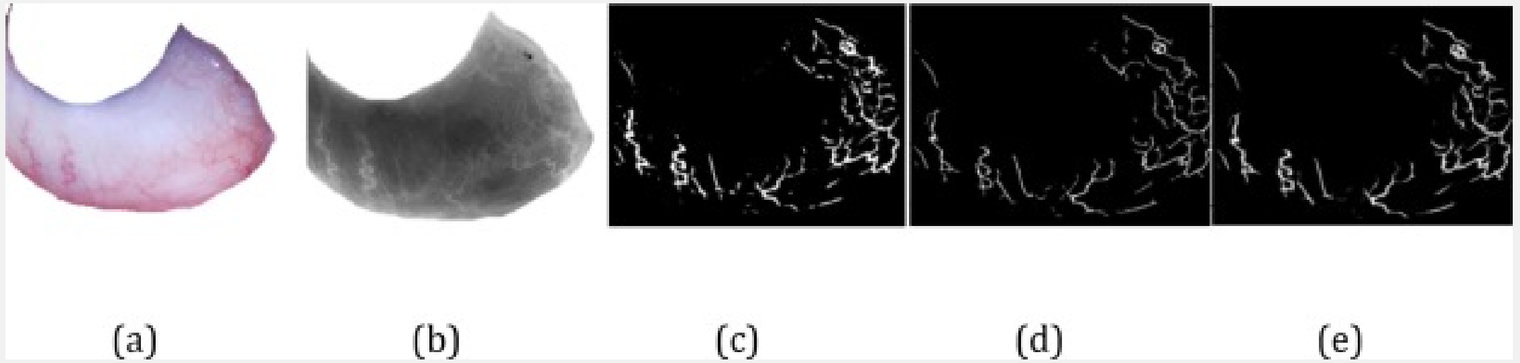
# 05

# Anaemia detection based on sclera and blood vessel colour estimation

LINK

## Vessel Detection

To identify blood vessels in the sclera, both a weighted line detection algorithm and a hidden Markov model (HMM) are used here



(a) (b) (c) (d) (e)

| Algorithm | Parameters | Precision | Recall | F1 | F2 |
|---|---|---|---|---|---|
| Nearest Neighbour | K=7, uniform weights | 92.0 | 77.0 | 82.6 | 78.9 |
| Random Forest | estimators=20, max features=log2, Gini criterion | 69.0 | 72.0 | 70.0 | 71.1 |
| Adaboost | Estimators=2 | 72.0 | 72.0 | 70.3 | 71.0 |
| Polynomial SVM | C=60, degree=4, gamma=auto | 57.6 | 95 | 71.4 | 83.8 |

# Pipeline

01

Data PreProcessing

- Resize
- Normalize
- Augment

02

Traditional ML way

- Feature Engg
- Ml model

03

Deep Learning Based Models

04

Optimization

# Future Research

## RECOMMENDATION FOR NEXT RESEARCH

- Need to read about YOLO and how it works

# Thank you