Outline

- Modeling Process
- Image Processing
- Feature Extraction
  - Blood vessels
  - Exudates
- Ensemble Learning
- Future steps
Retinopathy grades 0 and 1 are considered as class 0 (No-Retinopathy) and grades 2 and 3 as class 1 (Retinopathy).

Image Processing

Image-Texture Based Features

Blood Vessels and Exudates

Input Data

Ensemble Learning
Classify each image as retinopathy or not-retinopathy using multiple classifying algorithms

Number of features used: 58
- Enhance Fundus image
  - Extract green channel
  - Grayscale conversion
  - Image processing techniques
Blood Vessels Extraction

Filtering Process

Noise Removal
Exudates Extraction

Original Color Image → Extracted Green Channel → Contrast Enhancement - Adaptive Histogram Equalization → Labeled ‘Exudates’

Binary Mask using thresholding → Smoothing – Gaussian Filtering
Ensemble Learning

- Construct a set of classifiers for input images
- Predict retinopathy grade of previously unseen images by aggregating predictions made by multiple classifiers (e.g. by using weighted voting)
## Classification Results

<table>
<thead>
<tr>
<th>Metrics</th>
<th>Formula</th>
<th>Value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accuracy</strong></td>
<td>Correctly Identified Cases / Total Number of Cases</td>
<td>74.42</td>
</tr>
<tr>
<td><strong>Sensitivity</strong></td>
<td>Correctly Identified Retinopathy Cases / Total Retinopathy Cases</td>
<td>77.60</td>
</tr>
<tr>
<td><strong>Specificity</strong></td>
<td>Correctly Identified No-Retinopathy Cases / Total No-Retinopathy Cases</td>
<td>70.59</td>
</tr>
<tr>
<td><strong>Positive Predictive Value</strong></td>
<td>Correctly Identified Retinopathy Cases / Total Identified Retinopathy Cases</td>
<td>76.24</td>
</tr>
<tr>
<td><strong>Negative Predictive Value</strong></td>
<td>Correctly No- Identified Retinopathy Cases / Total No- Identified Retinopathy Cases</td>
<td>72.57</td>
</tr>
</tbody>
</table>
Classification Results: ROC Curve

Area Under ROC Curve

82.48%

The bigger the area under ROC curve, the better!
Correctly Classified Images

**No Retinopathy**  
(95.69 % confidence)  
Truth: Retinopathy Grade 0 (No-Retinopathy)

**Retinopathy**  
(95.70 % confidence)  
Truth: Retinopathy Grade 3 (Retinopathy)
Misclassified Images

No Retinopathy
(83.75 % confidence)
Truth : Retinopathy Grade 2 (Retinopathy)

Retinopathy
(95.50 % confidence)
Truth : Retinopathy Grade 0 (No-Retinopathy)
Future Work

Image processing & Feature computation
- Improvements in blood vessels extraction, exudates extraction, etc.
- Features based on hemorrhages, macula, optical disk, etc.

Feature selection
- Optimize features used for classification

Model selection & Ensemble Learning
- Model tuning
- Different techniques of ensemble learning

Further Analysis
- Trying the model on different dataset / Addition of new images as input
- Similar analysis for multiclass problem
- Change in threshold for categorizing as retinopathy