GROUP-16

Recognition of Ocular Diseases using Deep Learning Techniques

41153- Sameer Memon
41156- Soham Naik
41159- Kirti Palve
41165- Sejal Pekam

Guided By - Dr. B. A. Sonkamble

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Introduction

- Early fundus screening is an economical and effective way to prevent blindness caused by ophthalmic diseases.
- In the Indian context, this is significant because at least 1 in every 10 people suffer from diabetes.
- This also extends to the international context as 537 million people worldwide suffer from diabetes.
- Similar statistics come forward when we look at other ophthalmic diseases like cataract, glaucoma and hypertension.
- Hence, there needs to be an efficient solution to detect the presence of multiple eye diseases from the fundus images.
- This is where deep learning methods like image recognition and computer vision come into play.

Background

- The human eye fundus data has been around since 2021 and has primarily been used for cataract identification.
- A few other attempts were made with respect to binary classification which majorly considered the target disease label and grouped all the other labels into an 'others' category.This resulted in the final output being binary between the presence and absence of the target disease.
- Another roadblock is the fact that these attempts were mainly made on an aggregate of both eyes despite each eye having an individual label.

Motivation & Purpose

- According to World Health Organization (WHO) at present, at least 2.2 billion people around the world have vision impairments, of whom at least 1 billion have a vision impairment that could have been prevented.

- Ocular disease refers to any condition or disorder that interferes with the capacity of the eye to operate correctly. It can be challenging for doctors to identify eye disorders early enough using fundus pictures. Diagnosing ocular illnesses by manually is time-consuming and complicated.

- Therefore, an automated ocular disease detection system with computer-aided tools is necessary to detect various eye disorders using fundus pictures. It is possible to create such a system given the advancements in the field of deep learning and certain advanced image classification techniques.

- We plan to use these advanced image classification techniques to classify the presence of certain diseases by creating a machine learning pipieline on the dataset containing images of the fundus of the human eye.

Objectives

- Early detection: The primary objective of an ocular disease detection project is to identify and diagnose ocular diseases at an early stage.

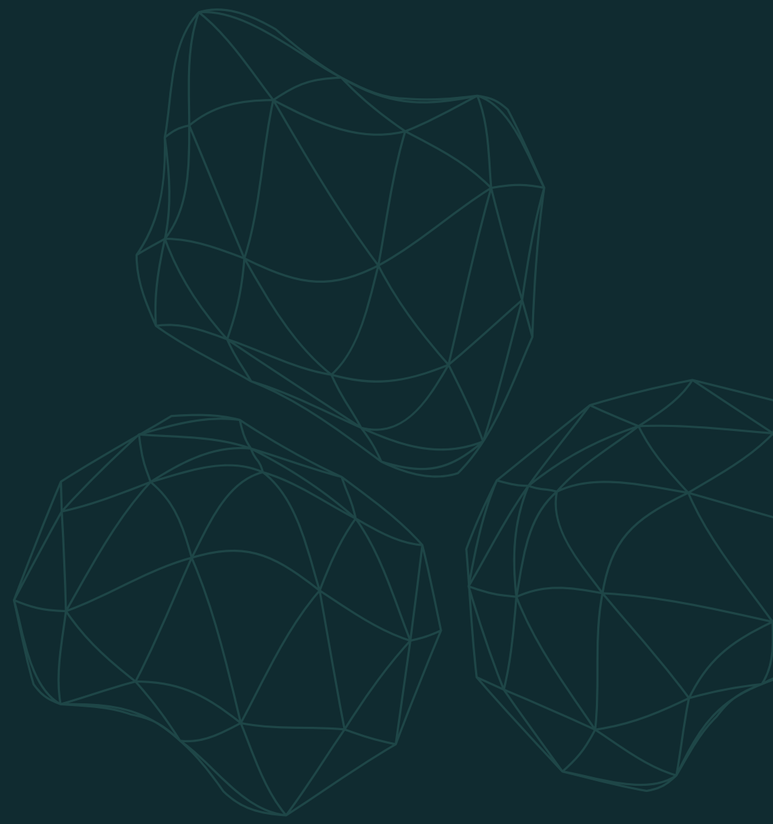
- Accuracy and reliability: Another objective is to develop a detection system or methodology that is accurate and reliable in identifying ocular diseases.

- Screening and prevention: Ocular disease detection projects often aim to develop screening programs or tools that can be used on a large scale to identify individuals at risk of developing ocular diseases.

- Automation and efficiency: Many ocular disease detection projects seek to automate the detection process, enabling faster and more efficient diagnosis.

Project Scope

Develop a pipeline for human fundus image processing which includes data preprocessing, dataset augmentation,development of a machine learning model and a progressive web application with a user-friendly interface.



Problem Statement

ODIR- To develop an automated pipieline for the recognition of ocular diseases such as Diabeteic Retinopathy, Glaucoma, Cataract and Hypertension by implementing deep learning algorithms on the dataset containing opthalmic images of the human eye fundus.

Review of Literature and Gap Identification

S. No.	Paper	Authors	Review	Gap
1.	A Benchmark of Ocular Disease Intelligent Recognition: One Shot for Multi-disease Detection, 2021 [1]	Ning Li, Tao Li, Chunyu Hu, Kai Wang and Hong Kang	To overcome problems with existing datasets a new dataset is introduced having 10,000 images from 5,000 patients with multiple modals for multiple diseases.	The dataset is skewed in favour of certain diseases which occur more often as the availability of data for such diseases is more.
2.	Deep Learning for Ocular Disease Recognition: An Inner-Class Balance, 2022 [2]	Md Shakib Khan,Nafisa Tafshir,Kazi Nabiul Alam,Abdur Rab Dhruba,Mohammad Monirujjaman Khan,Amani Abdulrahman Albraikan,and Faris A. Almalki	To overcome the skewness in data multiclass classification is converted to binary classification with balancing in the dataset.	Researchers can further also use GANs for the creation of datasets to overcome the skewness.
3.	Rethinking the Inception Architecture for Computer Vision, 2016 [3]	Christian Szegedy, Vincent Vanhoucke, Sergey Ioffe, Jonathon Shlens, Zbigniew Wojna	A common technique such as use of multiple layers in the neural network resulted in overfitting of models. Thus the use of Inception V1 was looked upon which uses multiple filters on the same level using a wider architecture rather than deeper.	Shallow networks are not as efficient in terms of oomputational accuracy and cost. The learning rate is also affected in the process.

Review of Literature and Gap Identification

S.No.	Paper	Authors	Review	Gap
4.	Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs, 2016 [4]	Varun Gulshan, PhD; Lily Peng, MD, PhD; Marc Coram, PhD	In this study, deep learning was used to train an algorithm to detect referable diabetic retinopathy and assess the performance of the algorithm on validation sets.	Further research is necessary to determine the feasibility of applying this algorithm in the clinical setting and to determine whether use of the algorithm could lead to improved care and outcomes compared with current ophthalmologic assessment.
5.	Automated detection of mild and multi-class diabetic eye diseases using deep learning, 2020. [5]	Rubina Sarki , Khandakar Ahmed , Hua Wang , Yanchun Zhang	Classification system considering mild multi class DED and multi class DED.	Doesn't support more complex and advantageous identification of multi-grade diseases.
6.	Ocular Diseases Diagnosis in Fundus Images using a Deep Learning: Approaches, tools and Performance evaluation, 2019 [6]	Yaroub Elloumi a,b,c, Mohamed Akila,*, Henda Boudegga	Presented an overview of DL-based methods for ocular pathology detection	The majority of DL-based methods are interested to a unique ocular pathology. However, the clinical context requires detecting several eventual diseases in the same screening, which correspond to a real challenge.

Review of Literature and Gap Identification

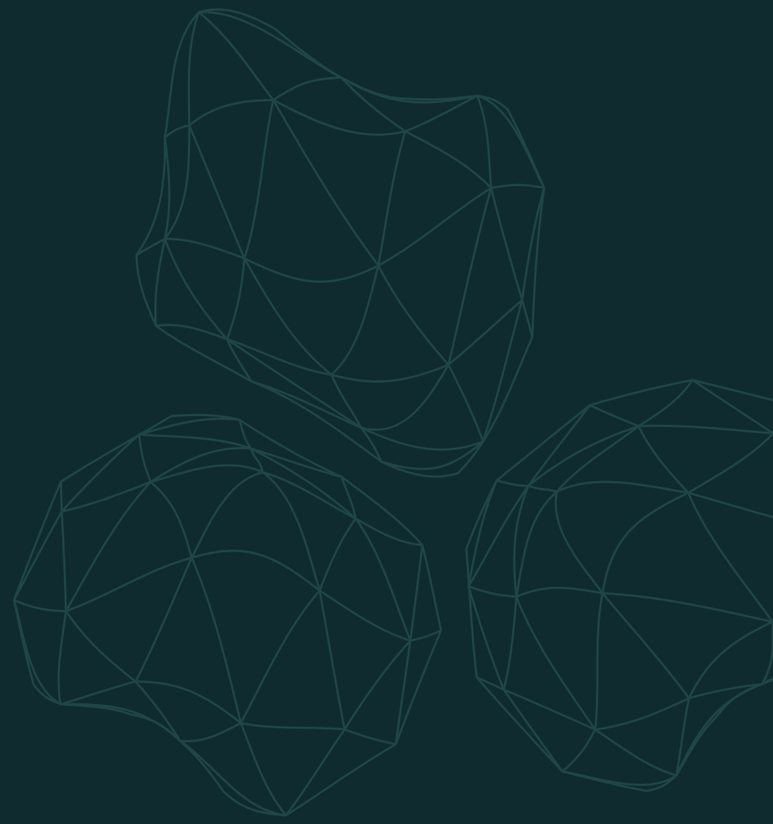
S.No.	Paper	Authors	Review	Gap
7.	Source and Camera Independent Ophthalmic Disease Recognition from Fundus Image Using Neural Network, 2019 [7]	Md. Tariqul Islam; Sheikh Asif Imran; Asiful Arefeen; Mahmudul Hasan; Celia Shahnaz	Developed model has achieved a cogent F-score of approx. 85%, Kappa score of 31% and an AUC value of 80.5 %.	Decent accuracy and loss have been maintained but there is a significant difference between validation accuracy (87.6%) and validation loss (55%).
8.	Ophthalmic Disease Detection via Deep Learning With a Novel Mixture Loss Function, 2021 [8]	Xiong Luo, Jianyuan Li, Maojian Chen, Xi Yang, Xiangjun Li	Authors presented a mixture of those two losses in deep neural network model to improve the recognition performance of classifier for biomedical data.	Due to loss function, it becomes sensitive to outliers.

Risks & Plans

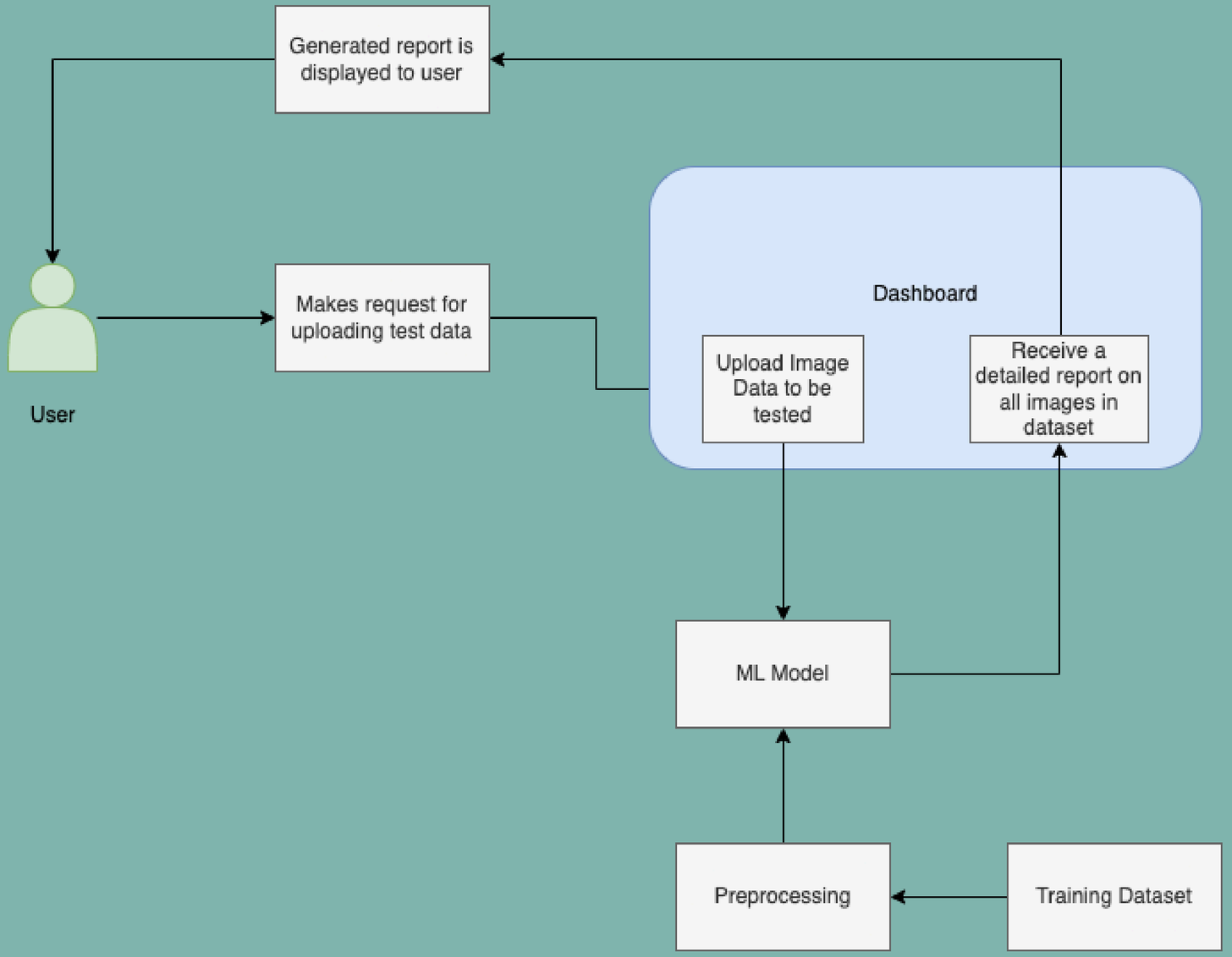
- The dataset is skewed towards cataract more than the other diseases. This may create a bias while training the model and hence the accuracy of other disease labels may be less.

- The images in the data are very big and have different image resolutions. Most images have sizes of around 2976x2976 or 2592x1728 pixels.

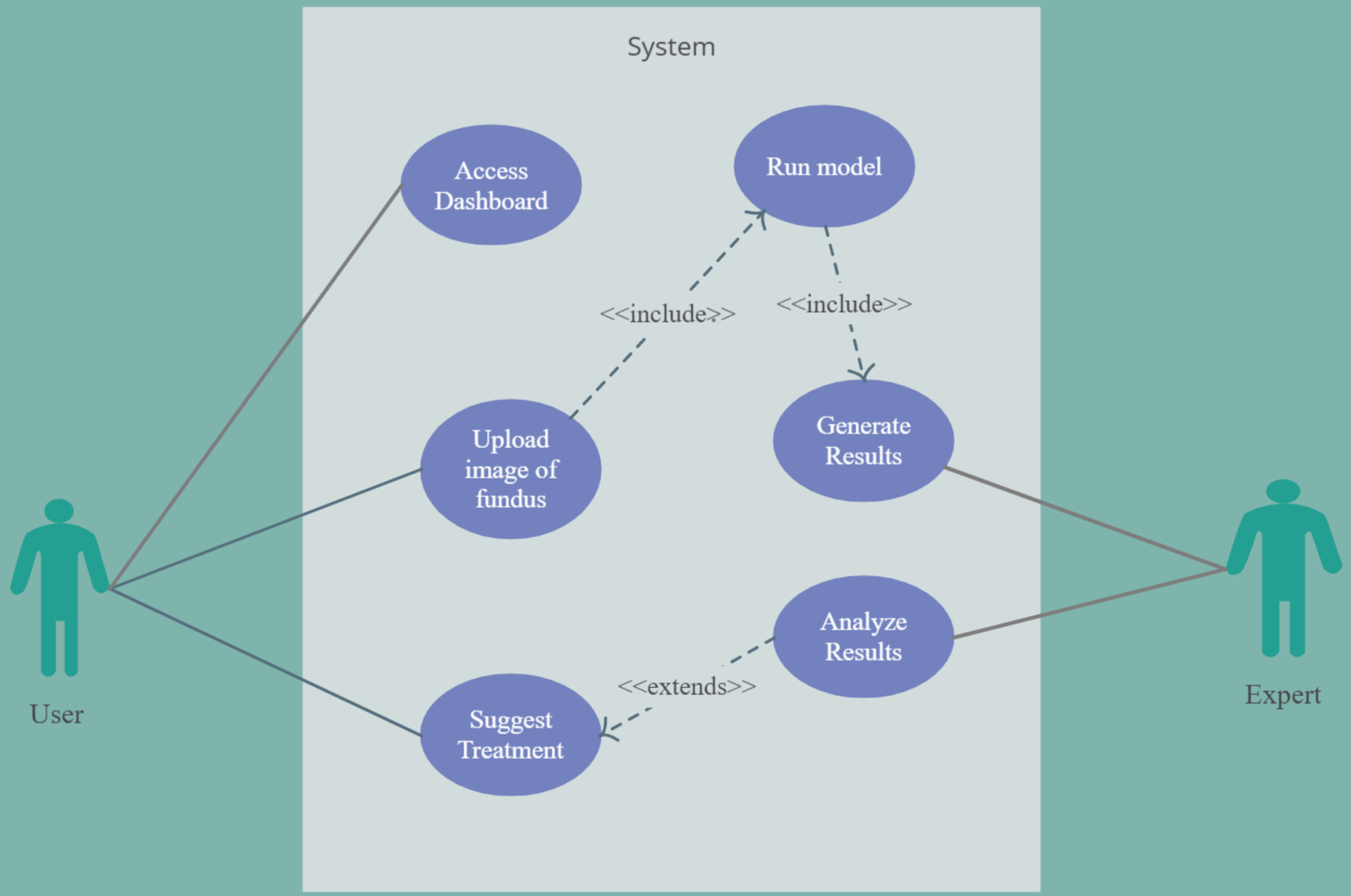
- Some of the images may be of low quality due to factors like lens dust or haziness.



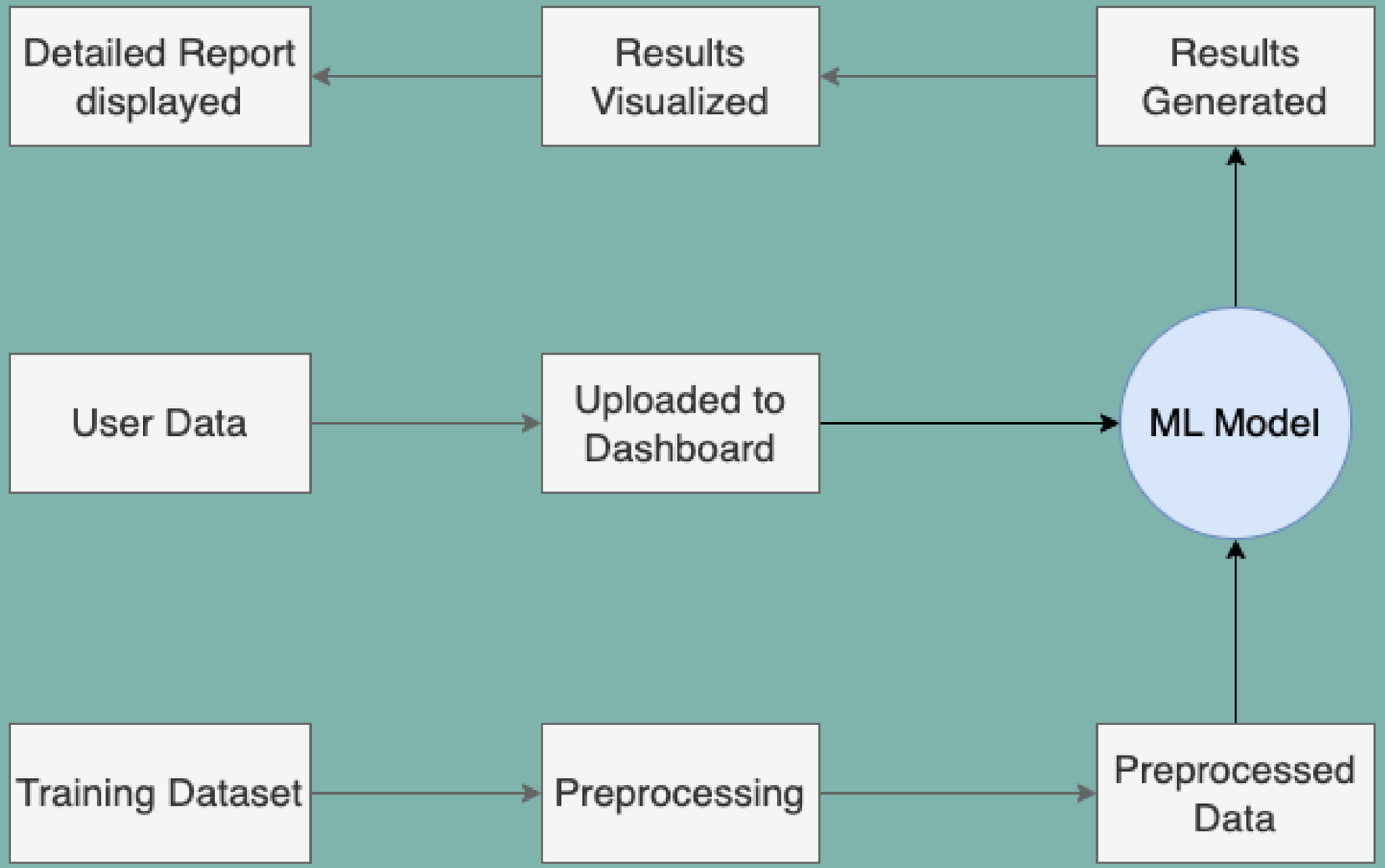
Architecture & Modules



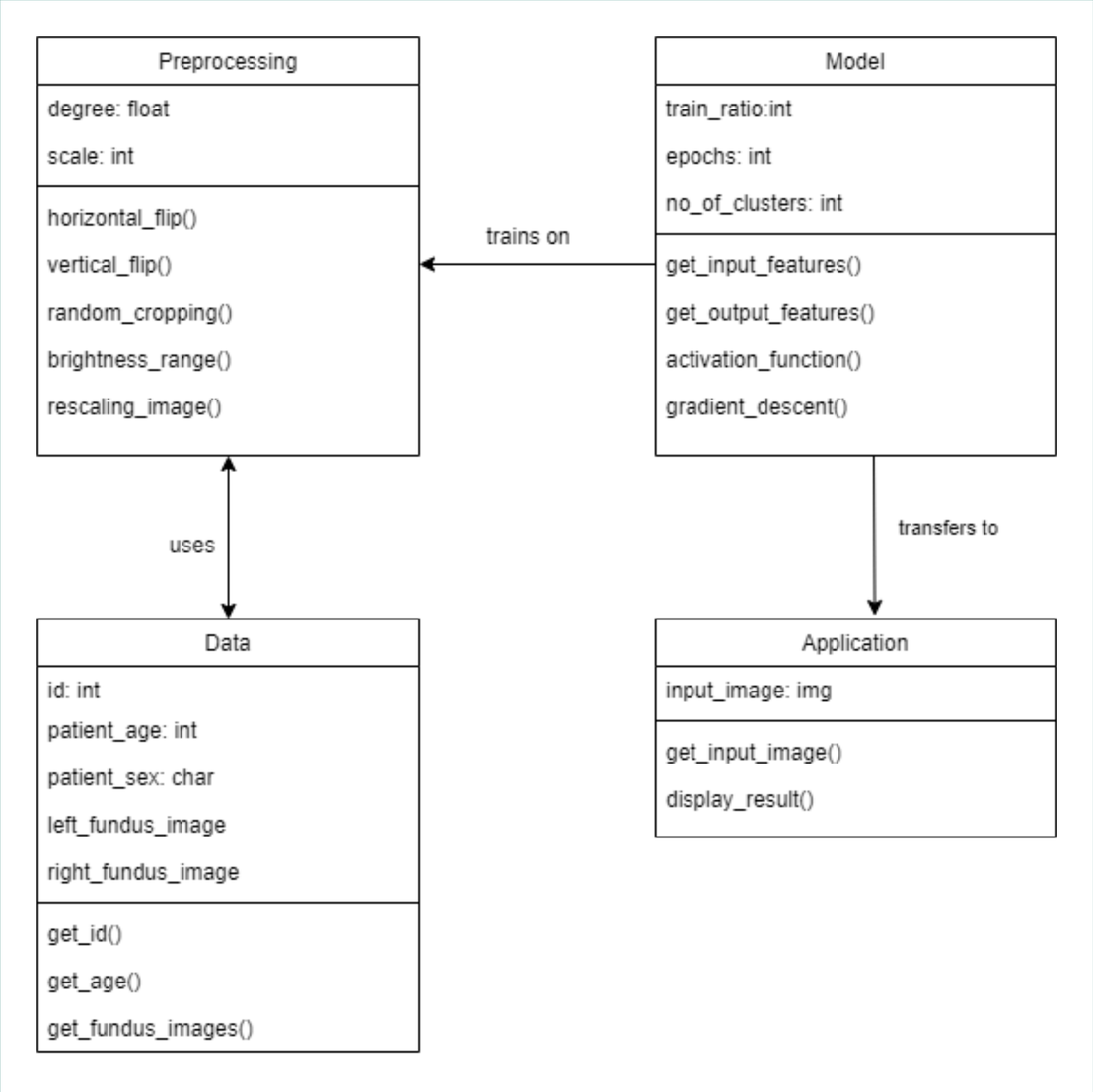
Use Case Diagram



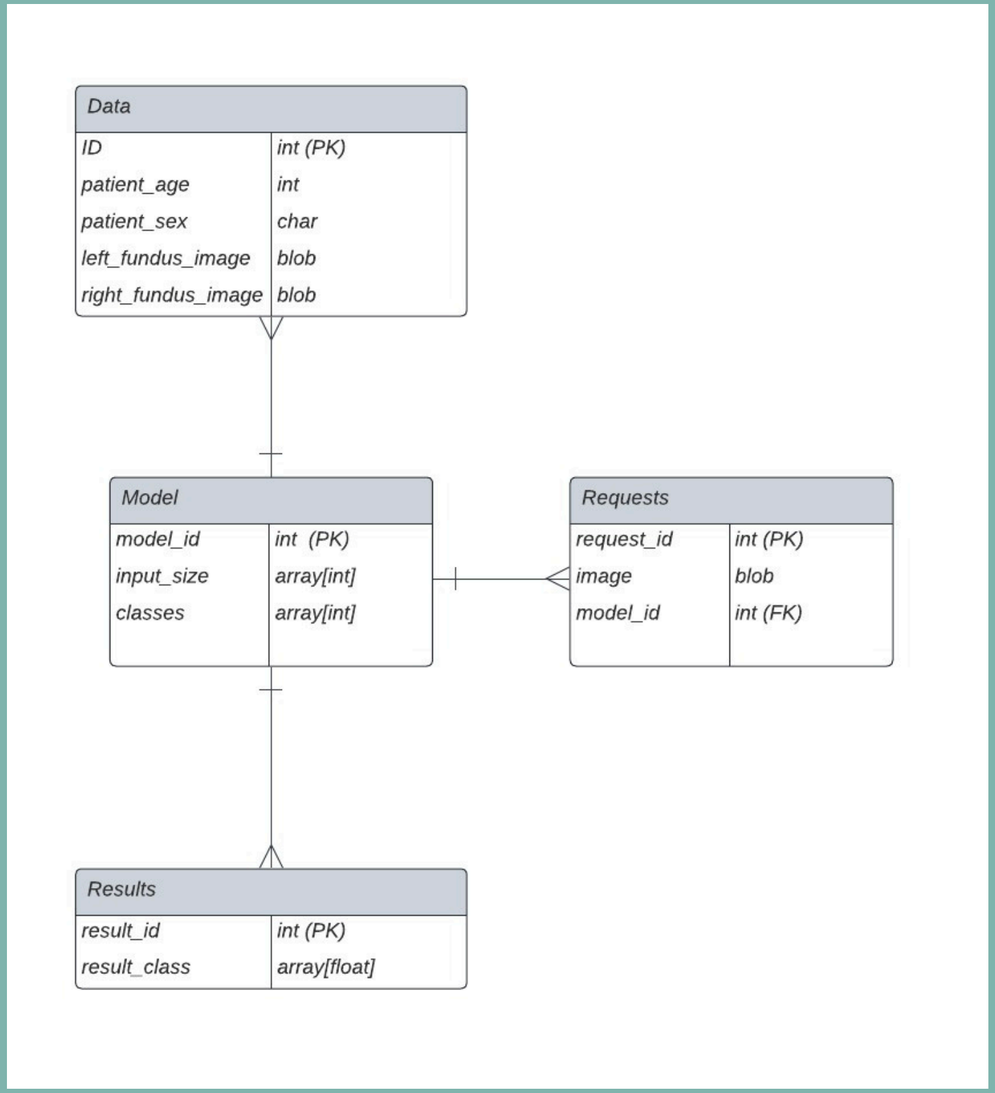
Data Flow Diagram



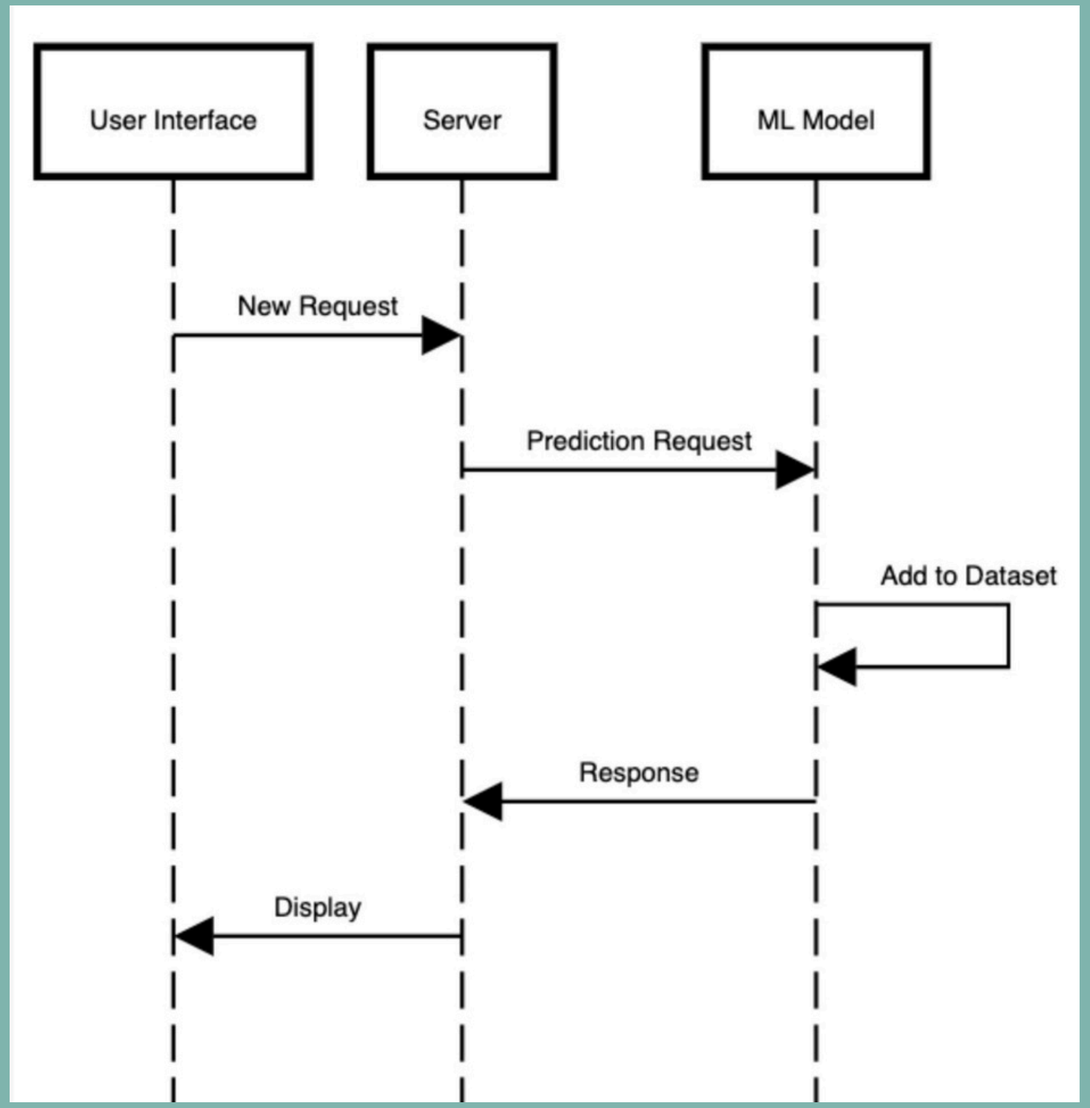
Class Diagram



Entity Relationship Diagram



Sequence Diagram



Algorithms

1. Convolutional Neural Networks:-
   - A Convolutional Neural Network (ConvNet/CNN) is a Deep Learning algorithm which can take in an input image, assign importance (learnable weights and biases) to various aspects/objects in the image and be able to differentiate one from the other.

2. VGG-16:-
   - VGG16 is object detection and classification algorithm which is able to classify 1000 different categories with 92.7% accuracy. It is one of the popular algorithms for image classification and is easy to use with transfer learning.

Algorithms

3. RESNET50:-

- ResNet short for Residual Networks is a classic neural network used as a backbone for many computer vision tasks. The important breakthrough with ResNet was that it allowed the training of extremely deep neural networks with 150+layers successfully. Prior to ResNet training very deep neural networks was difficult due to the problem of vanishing gradients.

Dataset Used

- Ocular Disease Intelligent Recognition (ODIR) is a structured ophthalmic database of 5,000 patients with color fundus photographs from left and right eyes, and diagnostic keywords from doctors.
- This dataset is meant to represent ‘‘real-life’’ set of patient information collected by Shanggong Medical Technology Co., Ltd. from different hospitals/medical centers in China.
- They classify patient into eight labels including:
- Normal (N), Diabetes (D), Glaucoma (G), Cataract (C), Other diseases/abnormalities (O), etc.

Implementation Details

- Dataset Preparation
- Preprocessing
- Model Architecture
- Transfer Learning

Implementation Details

- Training
- Validation
- Testing

Hardware and Software Requirements

- Hardware Requirements:-
  a. Intel processor i5
  b. 8GB RAM
  c. GPU Tesla T4

- Software Requirements:-
  - Latest version of browser like Google Chorme, Mozilla Firefox or Microsoft Edge etc.
  - Operating System: Windows, Mac OS, Linux etc.

Testing and Tools Used

- Confusion Matrix
- Accuracy
- Precision, Recall, and F1-score
- Receiver Operating Characteristic (ROC) Curve and AUC-ROC

Results and Graphs

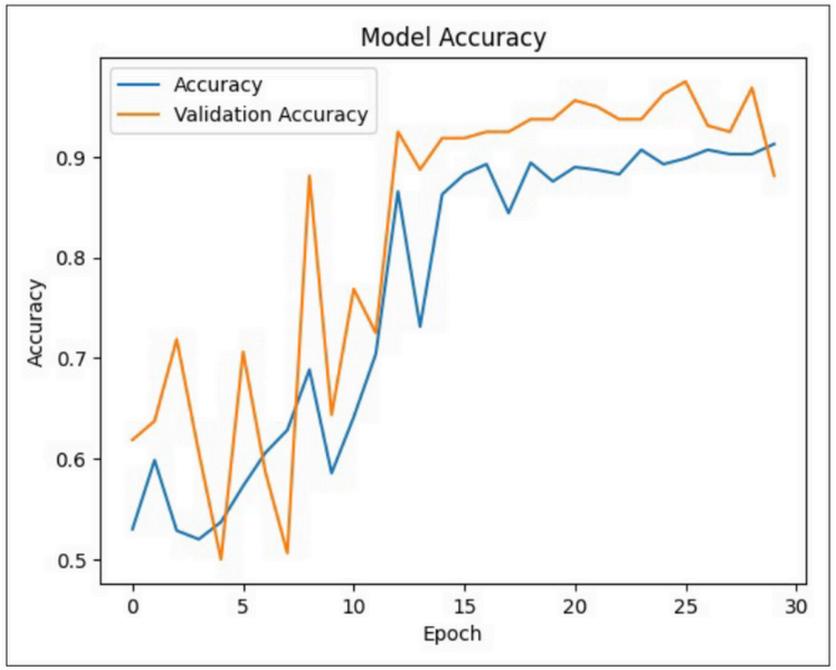


Figure 8.2: Model Accuracy

Results and Graphs

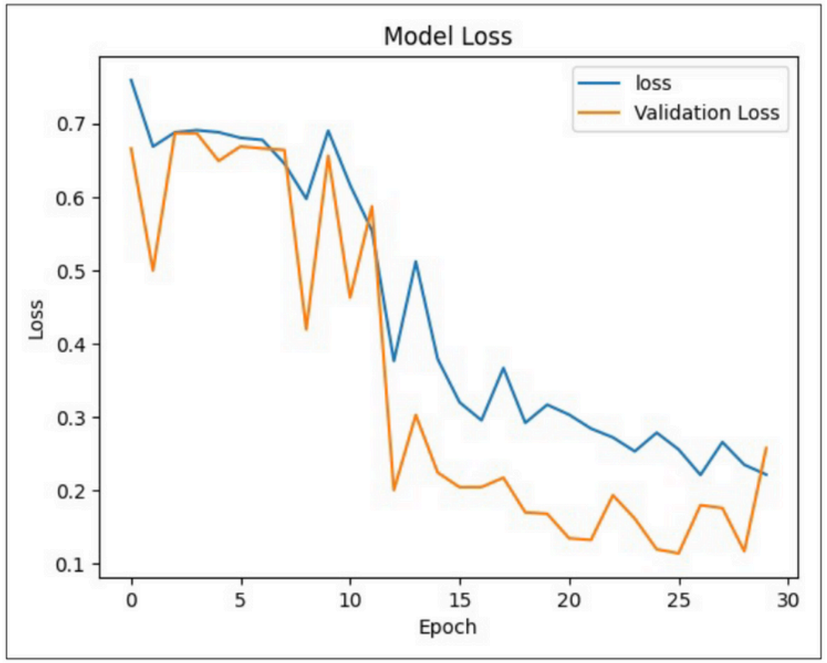
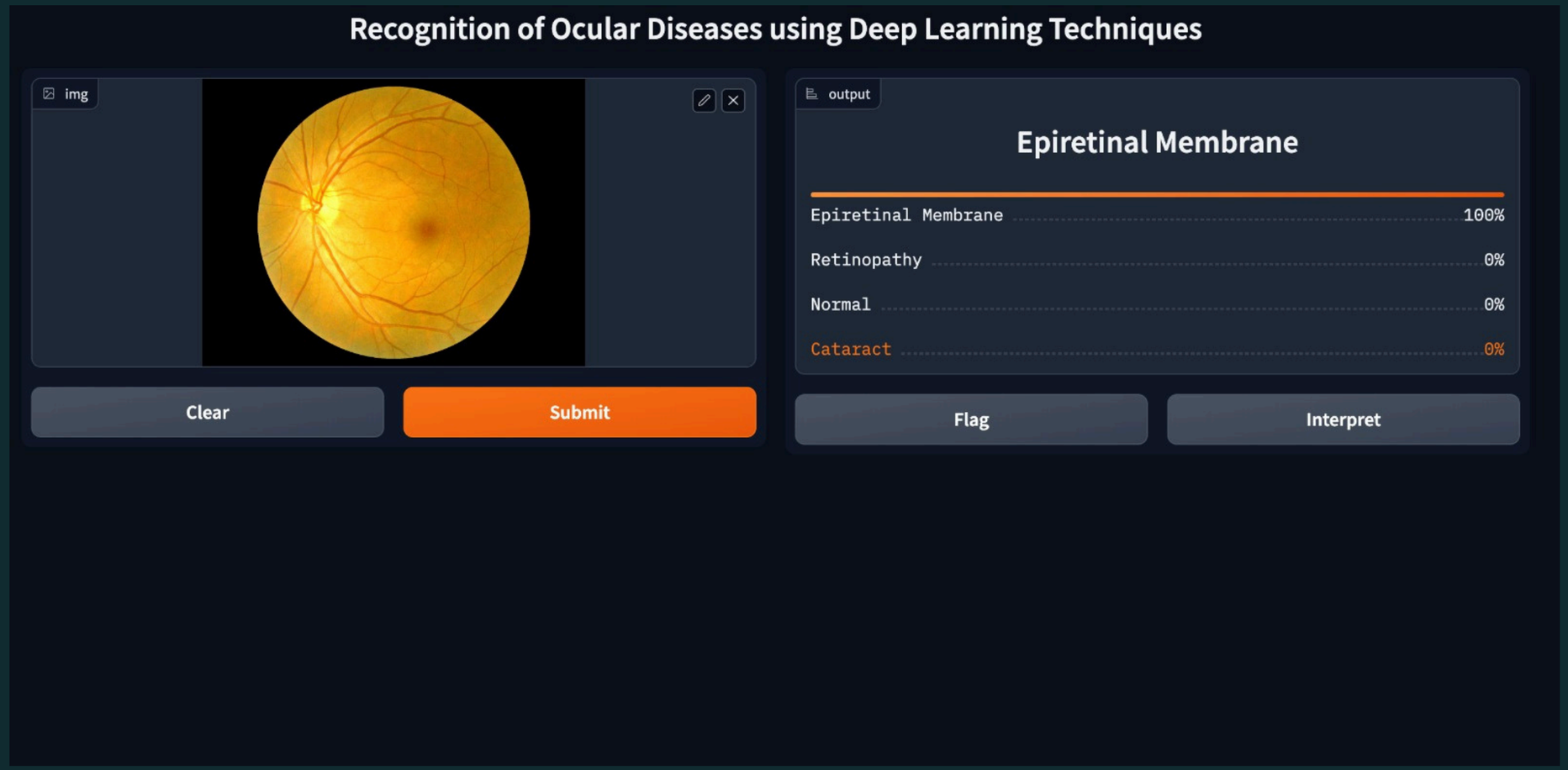
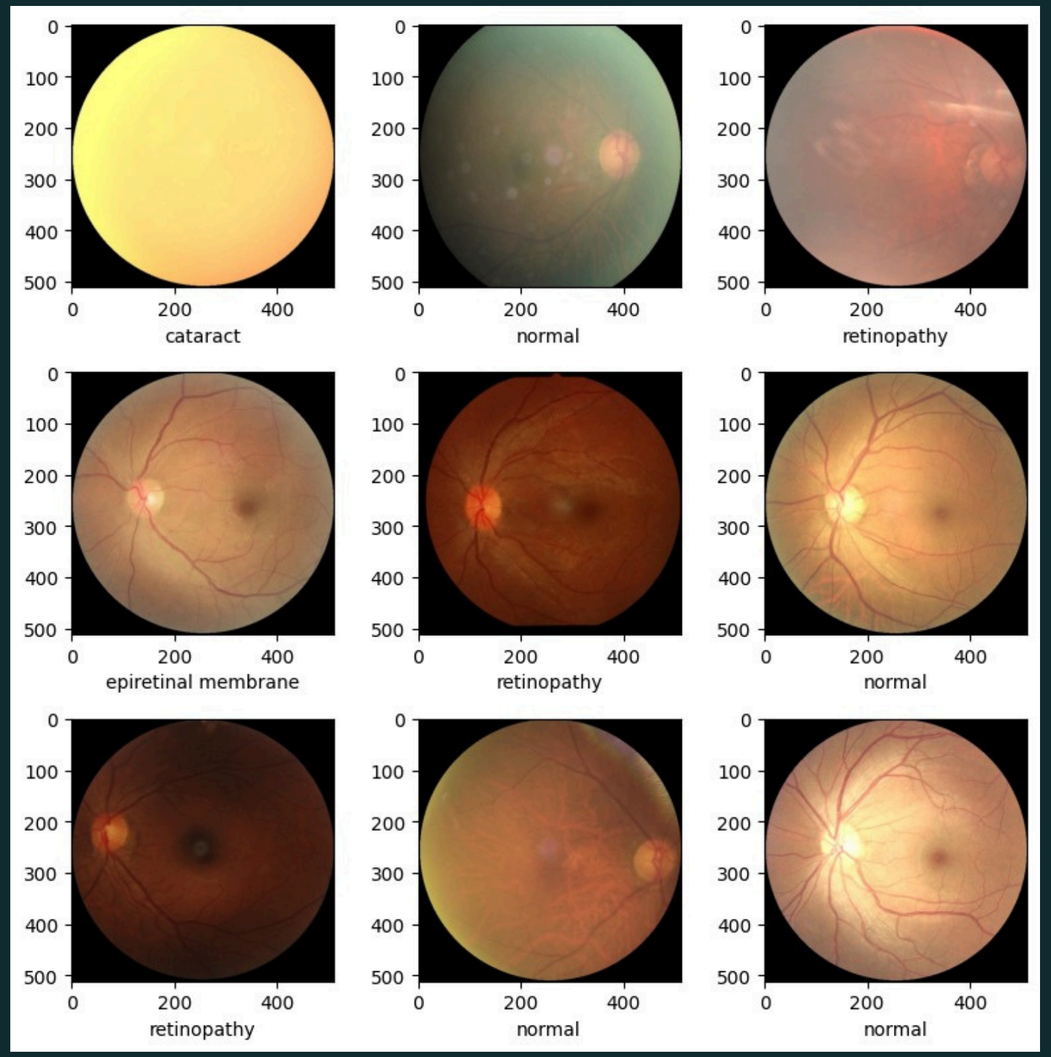


Figure 8.3: Model loss

Screenshots



Screenshots



Applications

- A user friendly, real time ocular disease classification system can be built.
- Efficient customer assistance due to less human interference.
- This will provide great help to direct users as well as medical professionals.
- Minimise the hassle of clinic appointments and take early action for higher chances of recovery.
- It can be extended to other diseases with similar categories.

Conclusion

- The convolutional neural network and VGG-16 helps to classify the input images and label them according to various diseases.
- The prediction made can be used for further investigation by the user.
- This early detection can significantly increase the chance of recovery.
- This method can be applied to other types of medical image-based disease classification.

Future Work

- Dataset inclusivity: Improvement in dataset inclusivity by making it more generalised and spread across geographical regions
- Enhanced Accuracy and Performance: Continued research and development can focus on improving the accuracy and performance of ocular disease detection algorithms and models.
- Integration with Emerging Technologies: Ocular disease detection projects can be integrated with emerging technologies to enhance their capabilities.

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