Project Documentation

Deep Learning Model For Eye Disease Prediction

Team Id: 592350

Members:

Anish Joshi 21BCE1649(Leader)

Achintya Kant Rastogi 21BCE1493

1. INTRODUCTION

1.1 Project Overview

Eye diseases are a major global health concern, affecting millions of people worldwide. These diseases can lead to vision loss and blindness, which can have a devastating impact on a person's quality of life. Early detection and treatment of eye diseases is crucial for preventing vision loss, but current diagnostic methods are often time-consuming and expensive.

This project aims to develop an accurate and efficient deep learning-based system for classifying various types of eye diseases using medical imaging data. The system will be able to classify eye diseases into four main categories: Normal, Cataract, Diabetic Retinopathy, and Glaucoma.

Objectives

The primary objectives of this project are:

1. To develop a robust and accurate deep learning model for classifying various types of eye diseases.
2. To utilize transfer learning techniques to improve the performance of the deep learning model.
3. To create a user-friendly interface for easy interaction with the prediction model.
4. To evaluate the performance of system using performance metrics.

Methodology

The project will follow a three-step methodology:

1. **Data Collection and Preprocessing:** A large dataset of eye images will be collected from various sources. The images will be pre-processed to ensure that they are of high quality and consistent format.
2. **Model Development and Training:** A deep learning model will be developed using a Convolutional neural network (CNN) architecture. The model will be trained on the pre-processed dataset of eye images.
3. **Evaluation and Deployment:** The performance of the trained model will be evaluated on a separate dataset of eye images. The model will then be deployed on a cloud platform for real-time predictions.

1.2 Purpose

The purpose of this project is to develop a deep learning-based system for classifying various types of eye diseases using medical imaging data. The system will be able to classify eye diseases into four main categories: Normal, Cataract, Diabetic Retinopathy, and Glaucoma.

The project has several objectives:

- To develop a robust and accurate deep learning model for classifying various types of eye diseases.
- To utilize transfer learning techniques to improve the performance of the deep learning model.
- To create a user-friendly interface for easy interaction with the prediction model.
- To evaluate the performance of the system using performance metrics

The project is expected to have several outcomes:

- An accurate and efficient deep learning-based system for classifying various types of eye diseases.
- Improved early detection and treatment of eye diseases, leading to better patient outcomes.
- Reduced costs associated with eye disease diagnosis and treatment.
- Increased access to eye care services, particularly in underserved communities.

By developing an accurate and efficient deep learning-based system for classifying eye diseases, this project has the potential to make a significant contribution to the field of ophthalmology and improve the lives of millions of people around the world.

2. LITERATURE SURVEY

2.1 Existing problem

In the context of creating an Eye Disease Prediction Model, several existing problems persist within the healthcare and ophthalmology industry. These challenges highlight the need for innovative solutions, such as predictive models, to address gaps and improve the current state of eye disease diagnosis and management:

1. **Late-stage Diagnosis:**
    - One of the significant challenges in eye care is the late-stage diagnosis of diseases. Many patients seek medical attention only when symptoms become severe, leading to delayed interventions and reduced treatment effectiveness.
2. **Limited Access to Specialized Care:**
    - Access to specialized eye care is often limited, particularly in rural or underserved areas. Patients may face challenges in reaching ophthalmologists, leading to delayed diagnoses and treatments.
3. **Workforce Shortages:**
    - Shortages of ophthalmologists and eye care professionals in certain regions contribute to delays in appointments and potential backlogs in eye examinations. This shortage can impact the timely delivery of eye care services.
4. **High Healthcare Costs:**
    - Eye examinations and diagnostic procedures can be expensive, leading to financial barriers for some individuals. High healthcare costs may deter people from seeking regular eye check-ups, resulting in undetected eye conditions.

2.2 References

1.https://ieeexplore.ieee.org/abstract/document/9587740/
2. https://www.mdpi.com/2076-3417/9/14/2789
3.https://link.springer.com/chapter/10.1007/978-981-16-6289-8_59
4. https://ieeexplore.ieee.org/abstract/document/9096838
5. https://www.mdpi.com/2076-3417/10/18/6185
6. https://ieeexplore.ieee.org/abstract/document/8929666

2.3 Problem Statement Definition

Accurate diagnosis of eye diseases is crucial for preventing vision loss and blindness, but current diagnostic methods often face challenges in accuracy, efficiency, and accessibility.

Challenges in Current Diagnostic Methods

1. **Subjectivity and Human Error:** Manual examination by ophthalmologists, while valuable, can be subjective and prone to human error, leading to misdiagnoses or missed diagnoses.
2. **Time-Consuming and Costly:** Traditional diagnostic methods often involve multiple visits, extensive testing, and expert interpretation, making the process time-consuming and costly.
3. **Limited Accessibility:** Access to ophthalmologists and specialized eye care facilities is often limited in underserved areas, leading to delayed diagnoses and reduced treatment options.

Potential Solutions with Deep Learning

Deep learning models have emerged as a promising approach to address the challenges of eye disease diagnosis, offering several advantages over traditional methods:

1. **High Accuracy and Efficiency:** Deep learning models can analyze vast amounts of medical imaging data with high accuracy and efficiency, reducing the risk of human error and improving diagnostic speed.
2. **Early Detection Capabilities:** Deep learning models can identify subtle patterns in eye images that may indicate early signs of disease, enabling early intervention and treatment before vision loss occurs.
3. **Scalability and Accessibility:** Deep learning models can be easily scaled to handle large datasets and can be deployed in various settings, including remote and underserved areas, improving accessibility to eye care services.
4. **Automated Grading and Severity Assessment:** Deep learning models can not only classify eye diseases but also grade their severity, providing valuable information for treatment planning and patient monitoring.
5. **Multi-modal Analysis:** Deep learning models can integrate information from multiple modalities, such as fundus images, optical coherence tomography (OCT) scans, and electronic health records (EHRs), providing a more comprehensive assessment of eye health.
6. **Personalized Medicine:** Deep learning models can be tailored to individual patients, considering their unique genetic and environmental factors, leading to personalized treatment recommendations.
7. **Real-Time Prediction:** Deep learning models can perform real-time predictions

on eye images, enabling immediate diagnostic feedback and facilitating point-of-care screening.

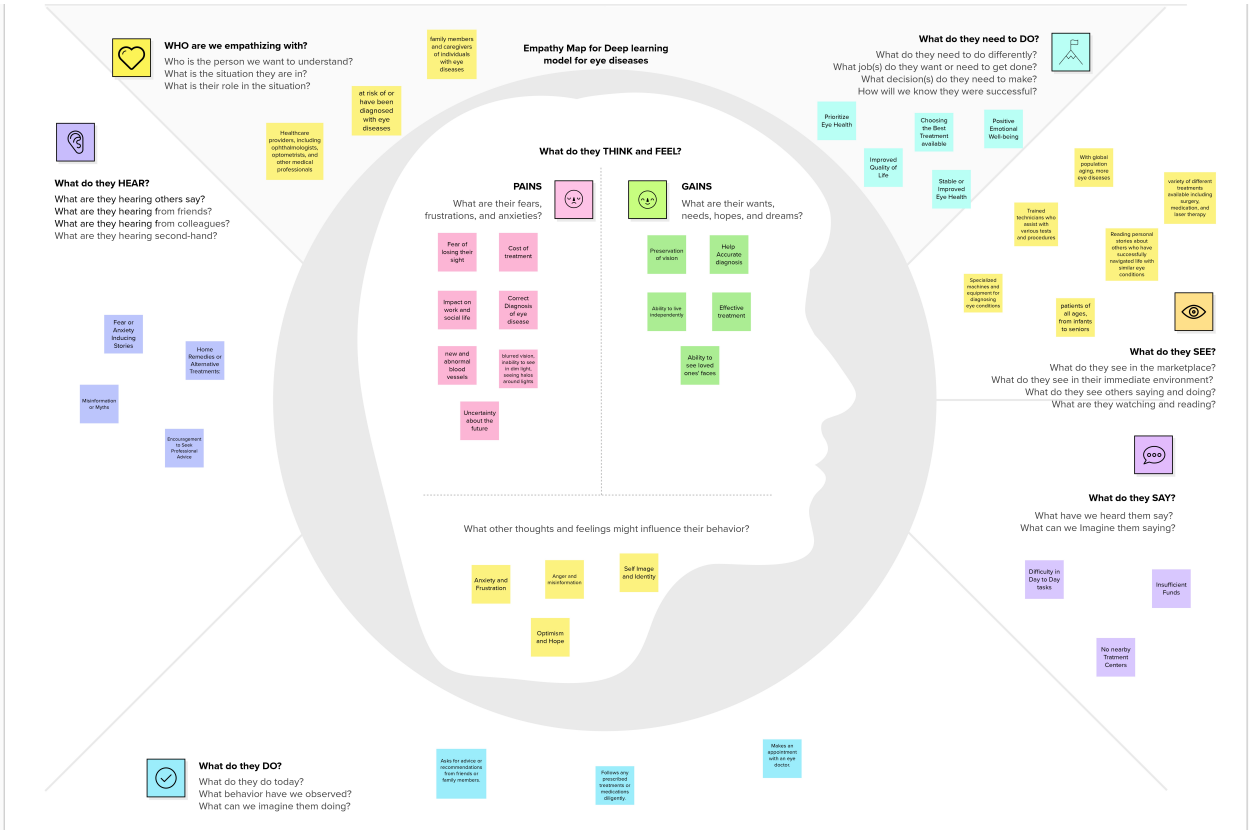
Impact of Deep Learning on Eye Disease Diagnosis

By addressing the challenges of current diagnostic methods, deep learning has the potential to revolutionize eye disease diagnosis, leading to:

1. **Improved Diagnostic Accuracy:** Deep learning models can provide more accurate and consistent diagnoses, reducing the risk of misdiagnoses and missed diagnoses.
2. **Early Intervention and Treatment:** Early detection through deep learning can enable timely intervention and treatment, preventing vision loss and preserving patient quality of life.
3. **Increased Accessibility to Eye Care:** Deep learning-based diagnostic tools can be deployed in underserved areas, expanding access to eye care services and improving patient outcomes.
4. **Personalized Treatment Plans:** Deep learning models can provide personalized treatment recommendations, tailoring care to individual patient needs and improving treatment effectiveness.

3. IDEATION & PROPOSED SOLUTION

3.1 Empathy Map Canvas



3.2 Ideation & Brainstorming

2

Brainstorm

Write down any ideas that come to mind that address your problem statement.

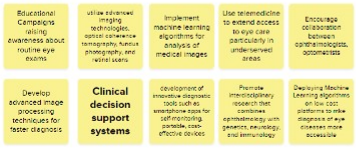
⏱ 10 minutes

TIP

You can select a sticky note and hit the pencil [switch to sketch] icon to start drawing!

Person 1

Person 2



3

Group ideas

Take turns sharing your ideas while clustering similar or related notes as you go. Once all sticky notes have been grouped, give each cluster a sentence-like label. If a cluster is bigger than six sticky notes, try and see if you and break it up into smaller sub-groups.

⏱ 20 minutes

TIP

Add customizable tags to sticky notes to make it easier to find, browse, organize, and categorize important ideas as themes within your mural.

4

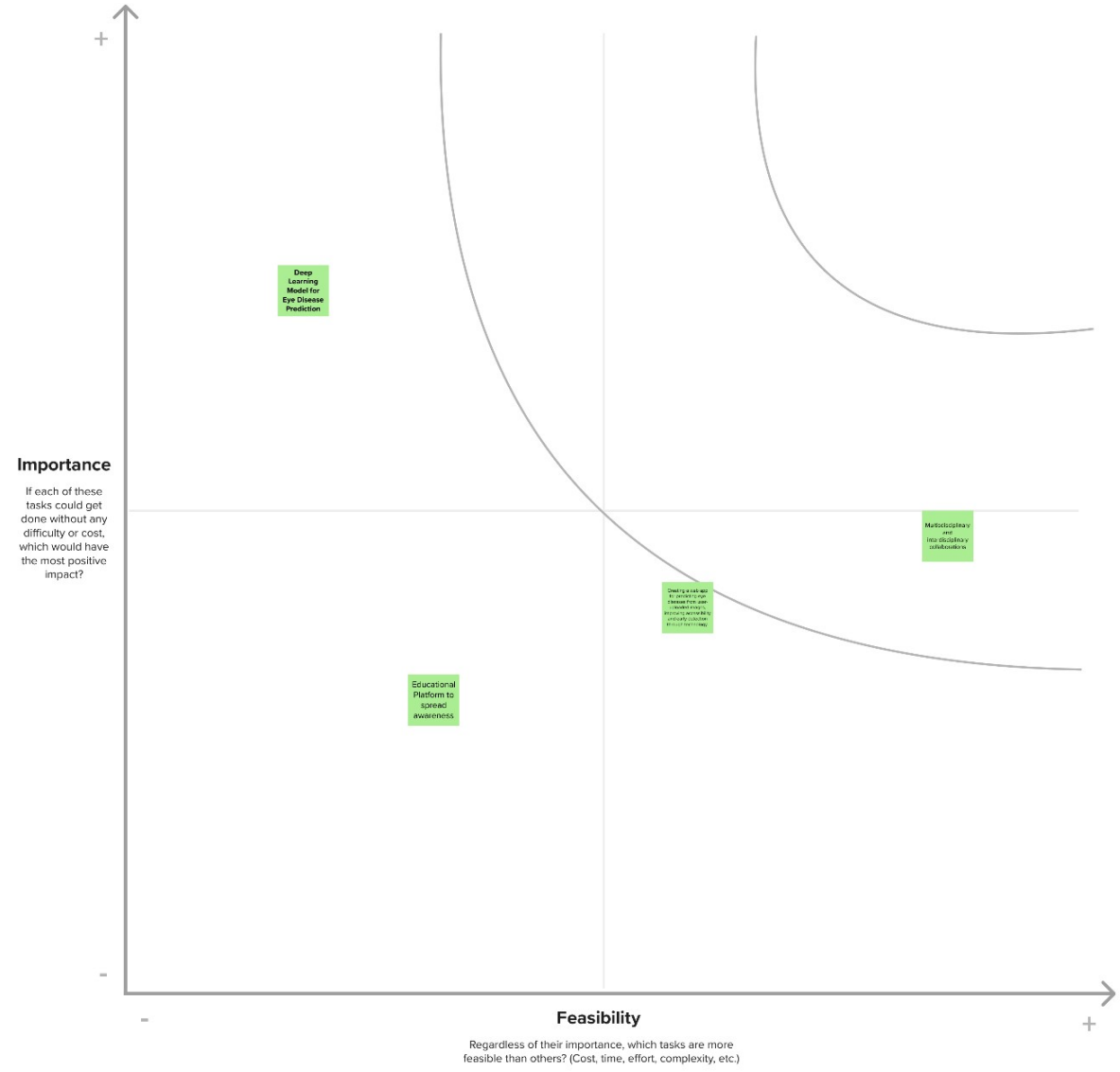
Prioritize

Your team should all be on the same page about what's important moving forward. Place your ideas on this grid to determine which ideas are important and which are feasible.

20 minutes

TIP

Participants can use their cursors to point at where sticky notes should go on the grid. The facilitator can confirm the spot by using the laser pointer holding the **H key** on the keyboard.



Importance

If each of these tasks could get done without any difficulty or cost, which would have the most positive impact?

Feasibility

Regardless of their importance, which tasks are more feasible than others? (Cost, time, effort, complexity, etc.)

4. REQUIREMENT ANALYSIS

4.1 Functional requirement

1. **Data Input and Preprocessing:**
    a. The model should be able to take input data in the form of fundus images obtained from OCT Scans.
    b. Input data should be pre-processed to ensure uniformity and compatibility with the model architecture.
    c. Create a function for preprocessing input eye images, including resizing them to the required input size for the pre-trained model.
    d. Implement data augmentation techniques to enhance model generalization during training.
2. **Model Architecture:**
    a. Load a pre-trained Convolutional neural network (CNN) model for transfer learning.
    b. Allow flexibility to choose from popular pre-trained models such as VGG16, ResNet, Inception or Exception.
    c. Modify the loaded pre-trained model by removing its fully connected layers and adding a custom prediction head.
    d. Allow customization of the number of fully connected layers, units, and activation functions in the custom prediction head.
3. **Training:**
    a. Develop a training pipeline that includes data splitting into training and validation sets.
    b. Implement a mechanism for data augmentation to increase model generalization.
    c. Define a loss function appropriate for the classification task.
    d. Set up an optimization algorithm (e.g., stochastic gradient descent) to train the model.
    e. Monitor and log training metrics (accuracy, loss) during the training process.
4. **Validation:**
    a. Implement a validation mechanism to assess the model's performance on unseen data.
    b. Evaluate metrics such as accuracy, precision, recall, and F1 score to gauge model performance.

    c. Implement early stopping to prevent overfitting and ensure optimal model generalization.
5. **Hyper-parameter Tuning:**
    a. Provide the ability to tune hyper-parameters such as learning rate, batch size, and others to optimize model performance.
6. **Prediction:**
    a. Develop a function for making predictions on new eye images or diagnostic data.
    b. Output the predicted class probabilities or labels.
7. **Model Deployment:**
    a. Create a deployment-ready version of the model, considering the integration into different environments (e.g., web applications, mobile apps).
    b. Choose an appropriate deployment platform (e.g., React JS).
8. **User Interface:**
    a. Design a user interface for users to interact with the model.
    b. Allow users to upload eye images or input relevant diagnostic data.
9. **Logging and Monitoring:**
    a. Implement logging mechanisms to record model predictions, inputs, and outputs.
    b. Set up monitoring for model performance over time.
10. **Security and Privacy:**
    a. Implement security measures to protect the model and user data.
    b. Ensure compliance with privacy regulations and guidelines.

4.2 Non-Functional requirements

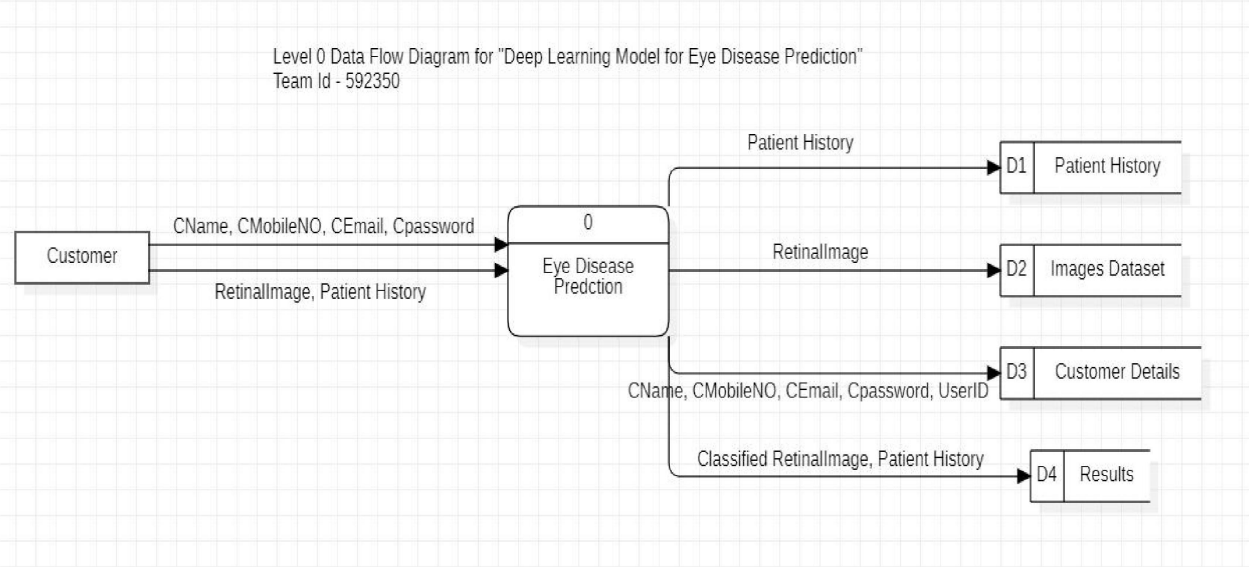
1. **Performance:**
    a. The model should achieve high accuracy (minimum 85%) and be able to generalize well to new, unseen eye images.
2. **Scalability:**
    a. Design the model to handle an increasing volume of data and requests efficiently.
3. **Robustness:**
    a. Ensure the model's robustness to variations in input data and potential noise.
4. **Interpretable:**

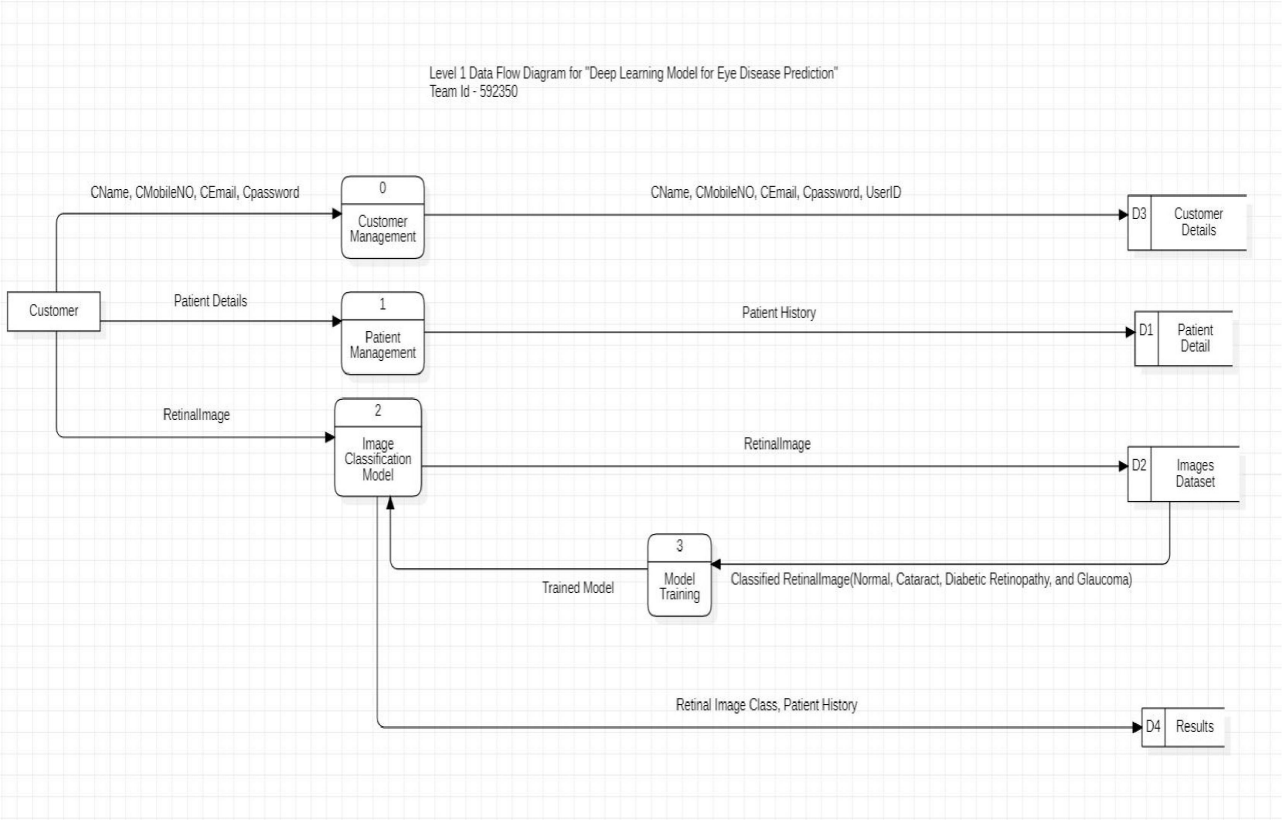
a. Provide options or functions for interpreting and explaining model predictions, especially in healthcare applications.

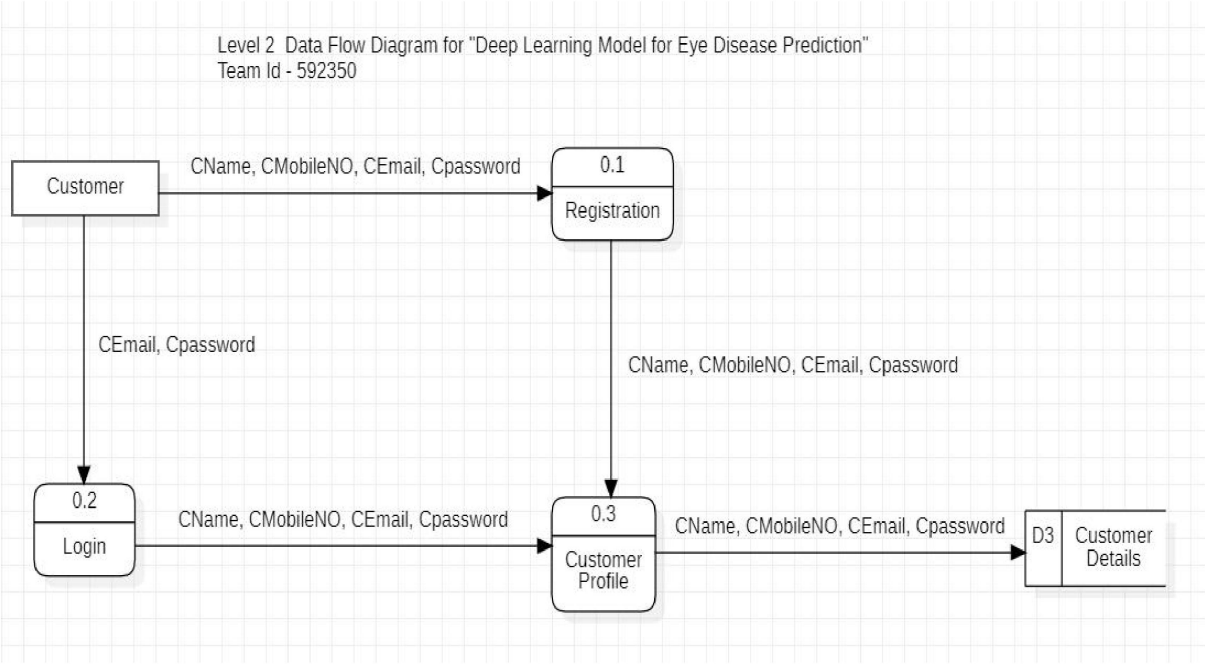
5. **Documentation:**
    a. Document the functions and their parameters comprehensively for users to understand and use the model effectively.
6. **Security and Privacy:**
    a. Implement security measures to protect the model and user data, adhering to privacy regulations and guidelines.

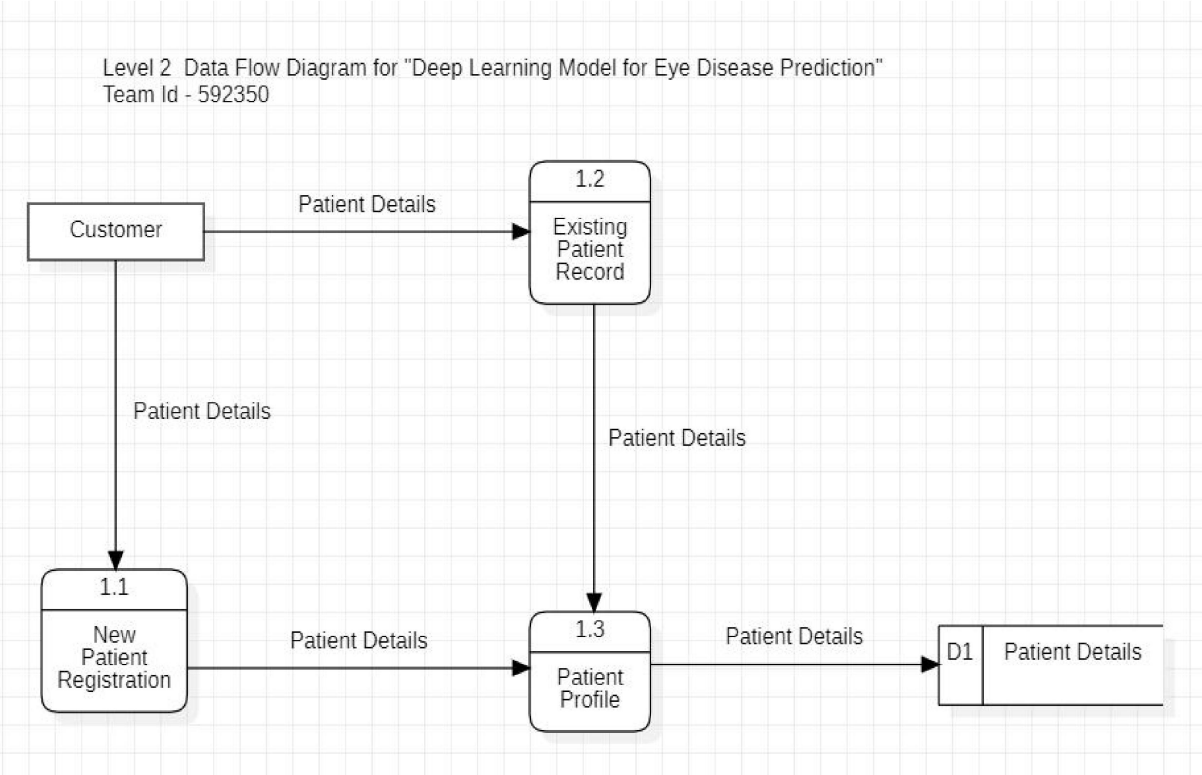
5. PROJECT DESIGN

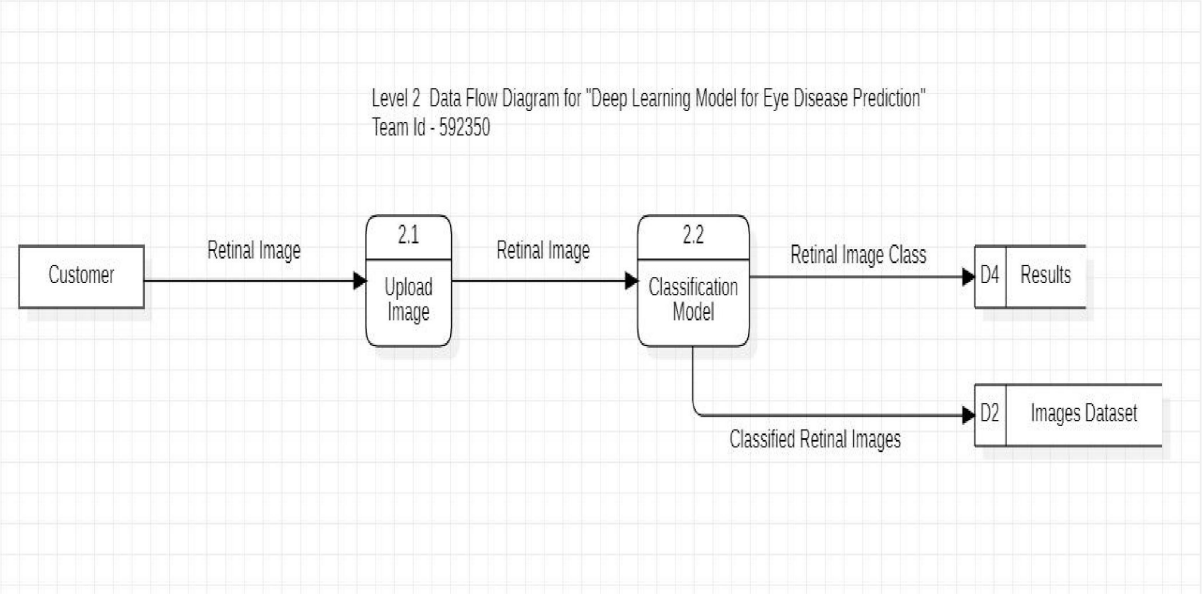
5.1 Data Flow Diagrams & User Stories

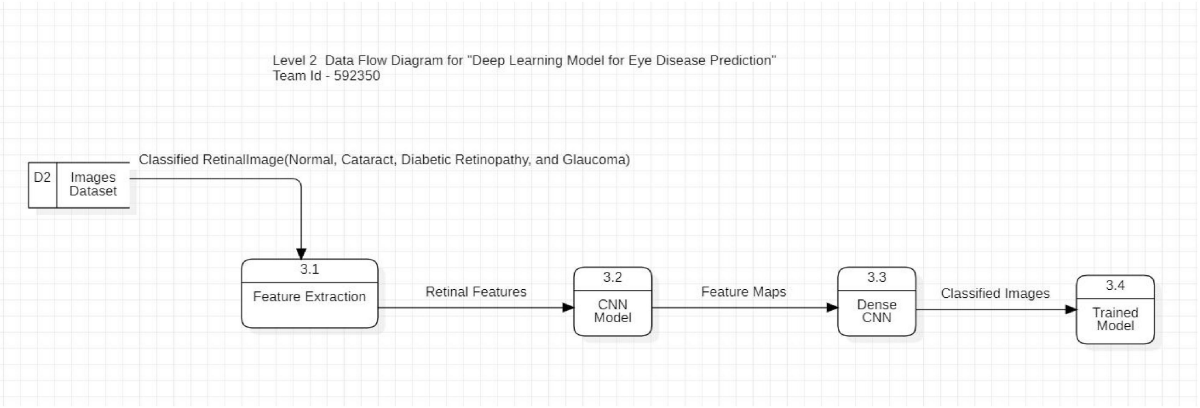



Level 1 Data Flow Diagram for "Deep Learning Model for Eye Disease Prediction"
Team Id - 592350
CName, CMobileNO, CEmail, Cpassword
0
Customer Management
CName, CMobileNO, CEmail, Cpassword, UserID
D3
Customer Details
Customer
Patient Details
1
Patient Management
Patient History
D1
Patient Detail
RetinalImage
2
Image Classification Model
RetinalImage
D2
Images Dataset
3
Model Training
Trained Model
Classified RetinalImage(Normal, Cataract, Diabetic Retinopathy, and Glaucoma)
Retinal Image Class, Patient History
D4
Results


Level 2 Data Flow Diagram for "Deep Learning Model for Eye Disease Prediction"
Team Id - 592350
Customer
CName, CMobileNO, CEmail, Cpassword
0.1
Registration
CEmail, Cpassword
CName, CMobileNO, CEmail, Cpassword
0.2
Login
CName, CMobileNO, CEmail, Cpassword
0.3
Customer Profile
CName, CMobileNO, CEmail, Cpassword
D3
Customer Details

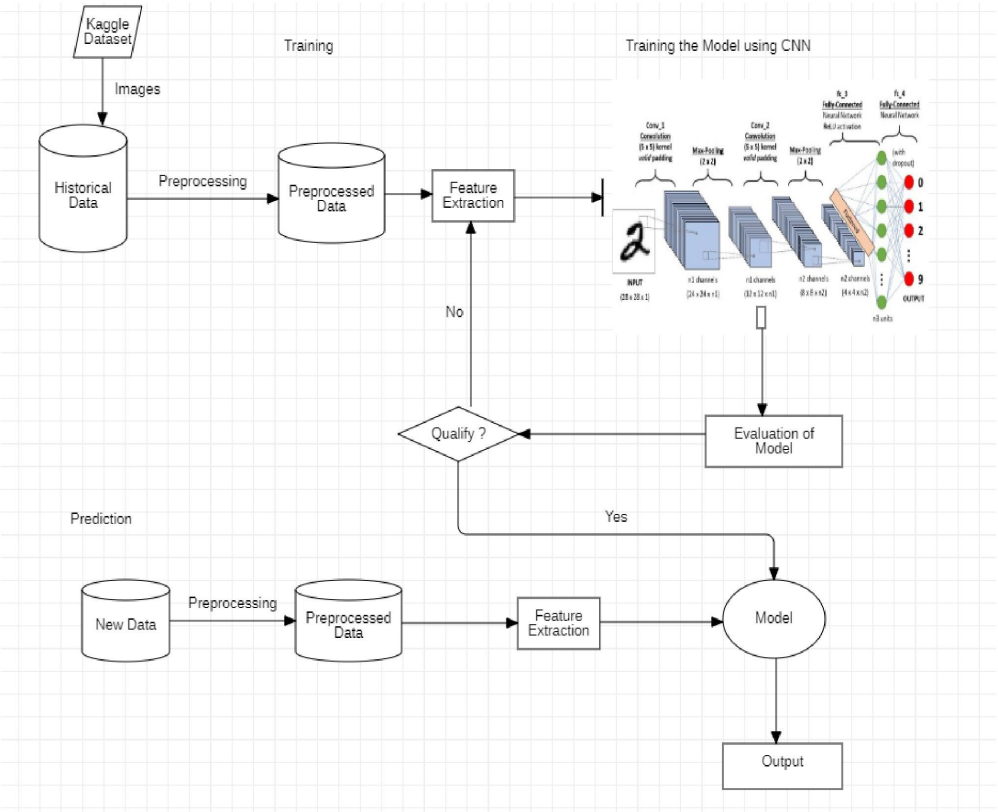

Level 2 Data Flow Diagram for "Deep Learning Model for Eye Disease Prediction"
Team Id - 592350
Customer
Patient Details
1.2
Existing Patient Record
Patient Details
Patient Details
1.1
New Patient Registration
Patient Details
1.3
Patient Profile
Patient Details
D1
Patient Details


Level 2 Data Flow Diagram for "Deep Learning Model for Eye Disease Prediction"
Team Id - 592350
Customer
Retinal Image
2.1
Upload Image
Retinal Image
2.2
Classification Model
Retinal Image Class
D4
Results
D2
Images Dataset
Classified Retinal Images



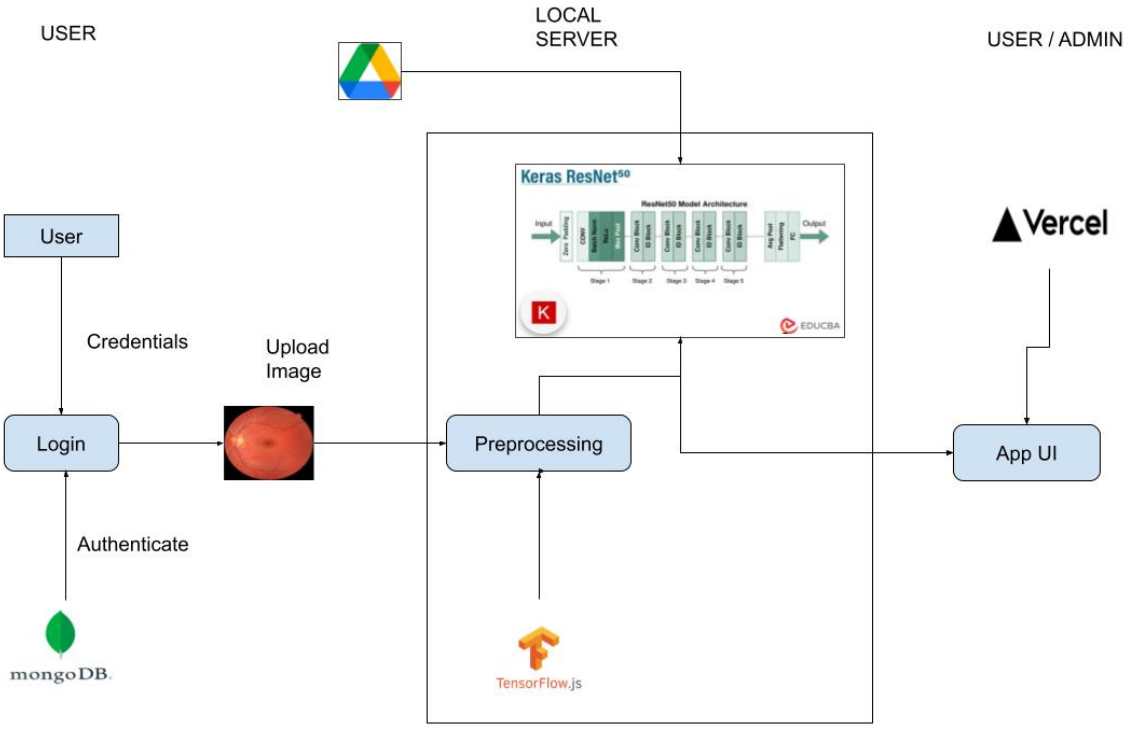
5.2 Solution Architecture

SOLUTION ARCHITECTURE



6. PROJECT PLANNING & SCHEDULING

6.1 Technical Architecture



6.2 Sprint Planning & Estimation

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer / Healthcare Professionals	Registration	USN-1	As a user, I can register for the application by entering my name, email, Mobile number, password, and confirming my password.	I can access my account / Home page	High	Sprint-1

		USN-2	As a user,I will receive confirmation email once I have registered for the application	I can receive confirmation email & click confirm	Low	Sprint-3
	Login	USN-3	I want a secure login process to the dashboard using my credentials, enabling me to accessclassification results and patient data.	I can access my account / Home page	High	Sprint-1
	Home Page	USN-4	I prefer a user-friendly dashboard interface with clear instructions and tooltips, facilitating easy navigation and utilization of features without any confusion.	I can access my home page	Medium	Sprint-3
		USN-5	As a user, I want to be able to add new patient records to the system so that I can keep track of their medical history and provide them with better care.	I can add new patients	High	Sprint-1
		USN-6	I need the ability to search for specific patients using unique identifiers like patient ID or name, allowing for swift retrieval of their classification history.	I can view patient's records	High	Sprint-2

	Classification	USN-7	As a user, I want to be able to upload fundus images of my patients to the system so that I can get a better understanding of their eye health and diagnose eye diseases more accurately.	I can upload Fundus images of my Patients	High	Sprint-2
		USN-8	I require access to detailed classification reports for each patient, containing images, date of classification, and identified eye condition, aiding in my diagnosis process.	I can view the details of classificati on	High	Sprint-2
Administrator	Administration	USN-9	As an administrator, I require the capability to reset user passwords and provide support for users who may have forgotten their login credentials.	I can reset user passwords	Low	Sprint-4
		USN-10	I need the dashboard to feature an intuitive user interface for managing user accounts, simplifying tasks like account creation, modification, and deletion.	I can Create/Modif y/Delete accounts	Low	Sprint-4

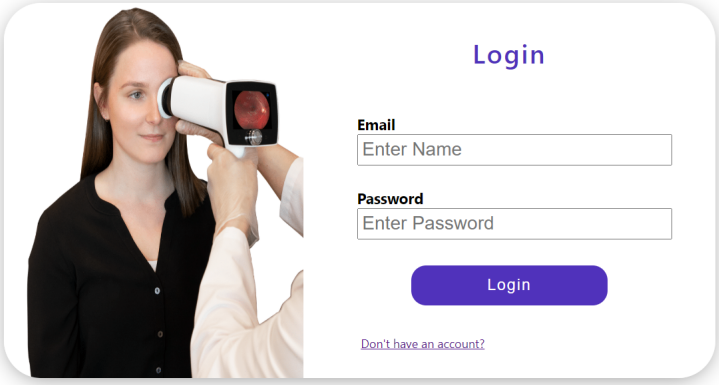
6.3 Sprint Delivery Schedule

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-1	4	6 Days	24 Oct 2022	29 Oct 2022	4	29 Oct 2022
Sprint-2	5	6 Days	30 Oct 2022	04 Nov 2022	9	4 Nov 2022
Sprint-3	2	6 Days	05 Nov 2022	7 Nov 2022	11	7 Nov 2022
Sprint-4	2	6 Days	7 Nov 2022	8 Nov 2022	13	8 Nov 2022

7. CODING & SOLUTIONING (Explain the features added in the project along with code)

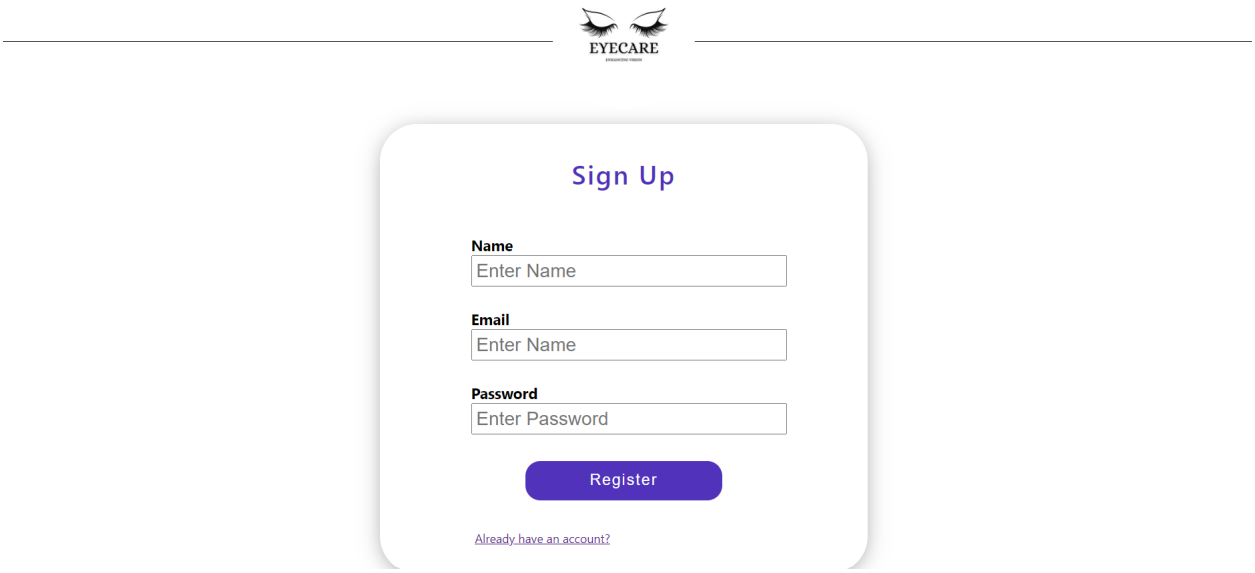
7.1 LOGIN:

the user will be able to login with his credentials.



7.2 Registration:

The user will be able to create an account with his details.

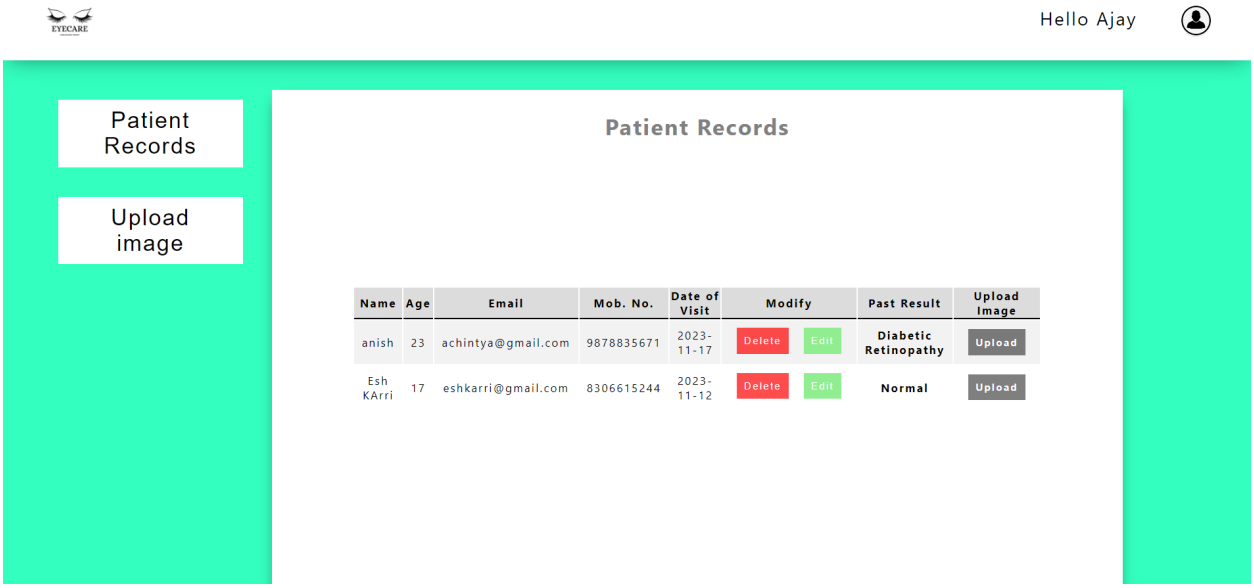


7.3 Create A New Patient

The user will be able to create a new patient and add it to the database.

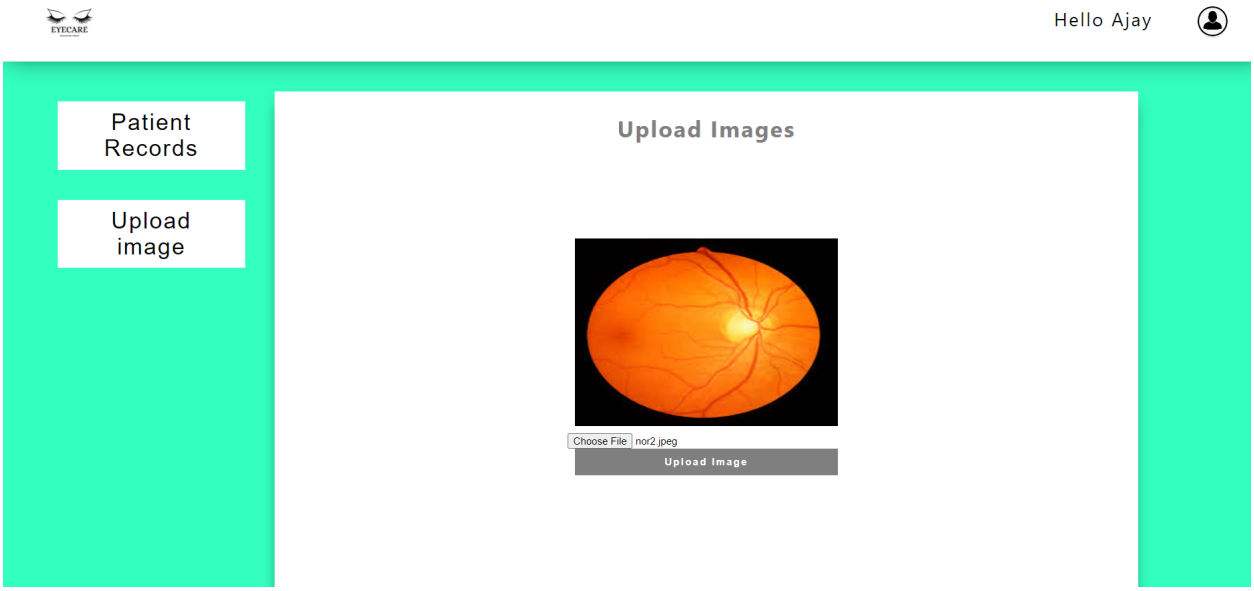
7.4 View Patient Records:

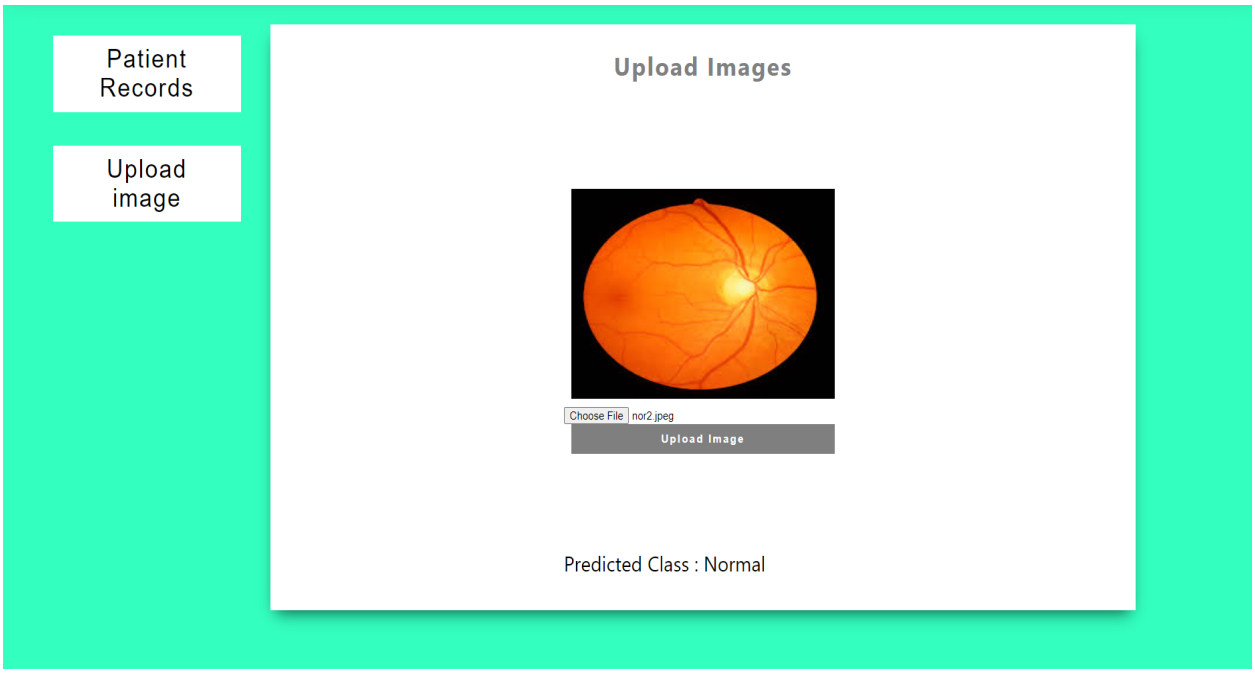
The logged in user can view all the records of the patients



7.5 Prediction

The user can upload an image of a patient and then get it classified using the upload image button.





7.6 Database Schema:

Employee (Login):

```
const mongoose = require('mongoose')

const EmployeeSchema = new mongoose.Schema({
    name:String,
    email:String,
    password:String

},
{
    collection: "login"
})

const EmployeeModel = mongoose.model("employees",EmployeeSchema)
module.exports = EmployeeModel
```

Patient:

```
const mongoose = require("mongoose")

const PatientSchema = new mongoose.Schema({
    name:String,
    age:String,
    email:String,
    MobNo:String,
    Date:String,
    docEmail:String,
    result:String

},
{
    collection:"Patients"
})

const PatientModel = mongoose.model("patients",PatientSchema)
module.exports = PatientModel;
```

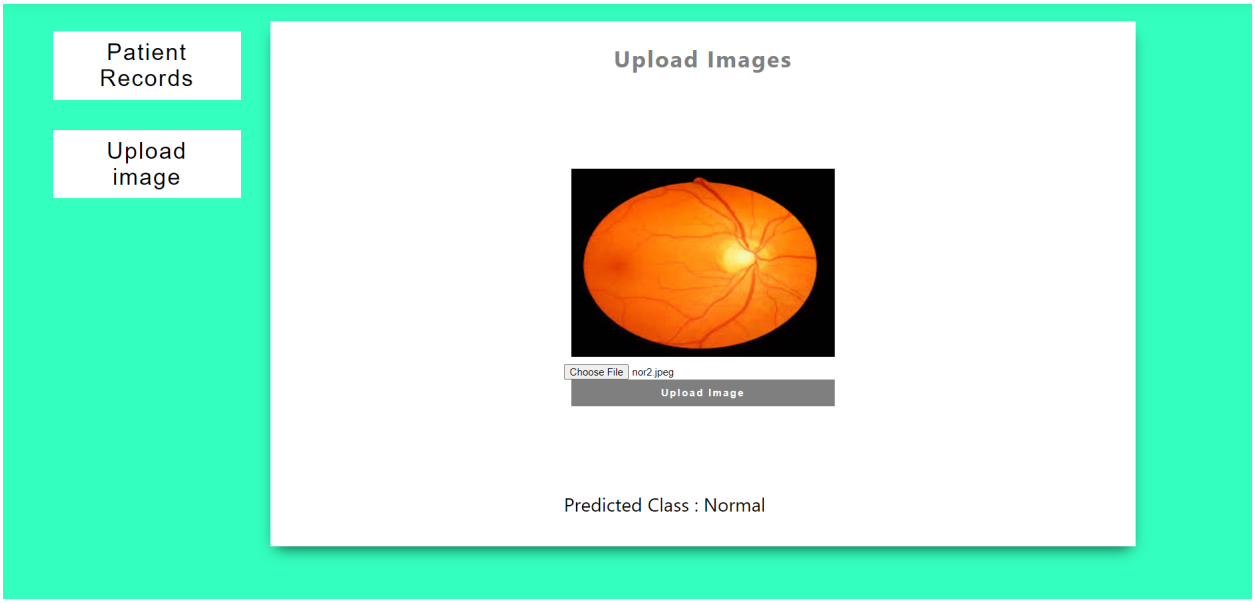
8. PERFORMANCE TESTING

8.1 Performance Metrics

```
Confusion Matrix:
[[177   3   3  24]
 [  0 216   3   0]
 [  3   5 156  37]
 [  2   4  21 187]]

Classification Report:
                     precision    recall  f1-score   support

           cataract       0.97      0.86      0.91       207
diabetic_retinopathy       0.95      0.99      0.97       219
           glaucoma       0.85      0.78      0.81       201
             normal       0.75      0.87      0.81       214

           accuracy                           0.88       841
          macro avg       0.88      0.87      0.87       841
       weighted avg       0.88      0.88      0.88       841


Accuracy Score: 0.8751486325802615
```

9. RESULTS

9.1 Output Screenshots



10. ADVANTAGES & DISADVANTAGES

Advantages:

1. **Early Detection:**
    - The primary advantage is the potential for early detection of eye diseases, allowing for prompt medical intervention and improved treatment outcomes.
2. **Time Efficiency:**
    - The automated nature of the model can significantly reduce the time required for analysis compared to manual examination by healthcare professionals.
3. **Scalability:**
    - The use of cloud-based deployment allows for scalability, making it easier to handle a large volume of data and accommodate growing user demands.
4. **Objective Analysis:**
    - The model provides an objective and standardized analysis of eye images, reducing the risk of human errors and subjective interpretations.
5. **Accessibility:**

    - The system can be accessible remotely, enabling healthcare professionals to analyze eye images from various locations, which is particularly beneficial for telemedicine.
6. **Educational Tool:**
    - The model can serve as an educational tool, helping healthcare professionals learn more about different eye diseases and their visual representations.

Disadvantages:

1. **Dependency on Data Quality:**
    - The accuracy of the model is highly dependent on the quality and diversity of the training data. Biases in the data could lead to biased predictions.
2. **Interpretable:**
    - Deep learning models, especially complex ones like CNNs, can lack interpretable, making it challenging to understand the reasoning behind specific predictions.
3. **Ethical Concerns:**
    - There may be ethical concerns related to the use of AI in healthcare, especially if decisions made by the model impact patient care without sufficient human oversight.
4. **Integration Challenges:**
    - Integrating the model into existing healthcare systems may pose challenges, requiring collaboration with IT departments and adherence to healthcare standards.
5. **Security Risks:**
    - Storing and processing medical images may raise security concerns, and measures must be in place to protect patient privacy and comply with data protection regulations.
6. **False Positives/Negatives:**
    - Like any diagnostic tool, the model may produce false positives or false negatives, leading to unnecessary treatments or overlooking actual health issues.
7. **Limited to Imaging Data:**
    - The model is limited to the information present in the provided images and may not consider other relevant patient data that could contribute to a more comprehensive diagnosis.

8. **Cost of Implementation:**
    - Implementing and maintaining the infrastructure for cloud-based deployment may involve significant upfront and ongoing costs.

11. CONCLUSION

The Eye Disease Prediction Model project represents a significant step forward in the application of artificial intelligence to medical diagnostics. By combining advanced technologies and medical expertise, this project seeks to contribute to the improvement of eye disease detection, ultimately leading to better healthcare outcomes for patients.

12. FUTURE SCOPE

!The future scope of your Eye Disease Prediction Model project is vast, and there are several potential directions for expansion and improvement.

Enhanced Diagnostic Capabilities:

- Continuously improve the model's diagnostic accuracy by incorporating more diverse and comprehensive datasets. Consider collaborating with multiple healthcare institutions to access a broader range of patient data, allowing the model to recognize a wider array of eye diseases.

Continuous Model Learning:

- Implement mechanisms for continuous learning to keep the model up-to-date with evolving medical knowledge and emerging patterns in eye diseases. Regularly update the model to adapt to changes in disease prevalence and diagnostic criteria.

Educational Initiatives:

- Develop educational materials and initiatives to train healthcare professionals in the use of AI tools for eye disease prediction. Promote awareness and understanding of the model's capabilities and limitations.

Ethical Considerations and Regulatory Compliance:

- Stay abreast of evolving ethical guidelines and regulatory requirements in the healthcare and AI fields. Ensure that your project complies with data protection regulations, privacy standards, and any other relevant ethical considerations.

13. APPENDIX

Project GitRepo Link:

https://github.com/smartinternz02/SI-GuidedProject-600102-1697612404/tree/main

Website Frontend Repository Link

https://github.com/AnishJ3/Eye-Disease-Prediction-Frontend

Website Backend Repository Link

https://github.com/AnishJ3/Eye-Disease-Prediction-Backend

Deployment Link:

https://eye-disease-prediction-frontend-c2ei.vercel.app/

Project Demo Link:

https://drive.google.com/file/d/11EXhjRrd2U6LCcMSh-qIO0ZbZ0qFR6iJ/view?usp=sharing