EYE DISEASE DETECTION USING DEEP LEARNING

TEAM MEMBERS:

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INTRODUCTION

1.1 **Project Overview**

Eye diseases are a growing concern worldwide, affecting millions of individuals due to factors such as aging, diabetes, and genetic predisposition. Early detection and accurate classification of eye diseases are crucial for effective treatment and prevention of severe vision impairment.

This project focuses on classifying various types of eye diseases using deep learning techniques. The classification is performed across four primary categories: Normal, Cataract, Diabetic Retinopathy, and Glaucoma. Traditional methods of eye disease detection rely on manual examination by ophthalmologists, which can be time-consuming and prone to human error. However, advancements in artificial intelligence (AI) and deep learning (DL) have significantly improved the accuracy and efficiency of disease detection using medical imaging.

Deep learning-based models, particularly Convolutional Neural Networks (CNNs), have shown exceptional performance in image analysis tasks. Transfer learning, a widely used approach in deep learning, enhances the capability of pre-trained models to recognize patterns in medical images with minimal computational resources. In this project, we leverage state-of-the-art transfer learning architectures such as Inception V3, VGG19, and Xception V3 to classify eye diseases effectively. These models, trained on large-scale image datasets, enable high-performance classification, reducing the dependency on manually labeled medical data.

1.2 **Purpose**

The primary objective of this project is to develop a robust and accurate deep learning model capable of detecting and classifying eye diseases based on retinal images. The key purposes of this project include:

- **Early Detection:** Providing an AI-driven solution that assists in the early diagnosis of eye diseases, helping patients receive timely treatment.
- **Automated Classification:** Implementing deep learning techniques to classify eye conditions efficiently, reducing the workload of ophthalmologists and increasing diagnostic accuracy.
- **Enhanced Accuracy:** Utilizing transfer learning methodologies to achieve high precision in image classification, ensuring reliable results.
- **Scalability and Accessibility:** Developing a model that can be integrated into telemedicine platforms, making eye disease detection more accessible in remote areas with limited healthcare facilities.

By integrating deep learning techniques with medical imaging, this project aims to bridge the gap between AI and ophthalmology, enhancing the diagnostic process and improving overall patient care.

IDEATION PHASE

2.1 **Problem Statement**

Date	28/02/2025
Team ID	
Project Name	Eye Disease Detection Using Deep Learning
Maximum Marks	2 Marks

Customer Problem Statement Template:

Millions of people worldwide suffer from eye diseases that, if left undiagnosed or untreated, can lead to severe vision impairment or blindness. Traditional diagnostic methods depend on manual examination by ophthalmologists, which can be time-consuming, inconsistent, and inaccessible to many individuals, particularly in remote or underserved areas. The lack of early detection and misdiagnosis can result in irreversible vision loss, significantly impacting the quality of life of affected individuals.

There is a critical need for an automated, accurate, and scalable solution that can aid in the early detection and classification of eye diseases. Patients require a reliable and accessible system that can quickly diagnose conditions such as Cataract, Diabetic Retinopathy, and Glaucoma based on retinal images. Ophthalmologists and healthcare providers also need a tool that can enhance diagnostic accuracy, reduce workload, and optimize patient care.

This project addresses these challenges by leveraging deep learning and transfer learning techniques to develop an AI-powered system capable of efficiently identifying and categorizing eye diseases. By providing a fast, precise, and cost-effective diagnostic solution, this project aims to improve early detection rates, facilitate timely medical intervention, and enhance overall eye health outcomes.

Problem Statement (PS)	**I am (Customer)**	**I'm trying to**	**But**	**Because**	**Which makes me feel**
PS-1	Doctor	Improve the efficiency of diagnosing eye diseases using AI – driven solution	Manually it is time consuming and prone to error	Shortage of doctors	Overwhelmed by the work
PS-2	Optometrist	Want the solution to detect eye disease using an AI driven solution	But I can't do that as not a specialist to read images	Only specialist can perform such thing	Concerned about missing critical diagnoses, pressured to provide accurate results quickly which made me feel underwhelmed as an eye specialist can do only.

2.2 **Empathy Map Canvas**

What does he SAY?

- “I want to detect eye diseases early before they worsen.”
- “Access to eye specialists is difficult in remote areas.”
- “Traditional eye tests take too long and can be expensive.”
- “I need a reliable, fast, and affordable way to check my eye health.”

What does he THINK?

- “What if I lose my vision due to late diagnosis?”
- “Is there a way to detect my condition accurately without visiting a doctor frequently?”
- “I’m not sure if I can trust AI-based diagnosis methods.”

What he DO?

- Visits an ophthalmologist when symptoms appear, but often delays due to cost and accessibility.
- Searches for online information about eye diseases and self-diagnoses symptoms.
- Uses smartphone apps or devices for preliminary eye health checks when available.

What does he FEELS?

- Worried about potential blindness or deteriorating vision.
- Frustrated with the time and cost involved in getting a diagnosis.
- Hopeful that AI-powered solutions can provide a faster, more accurate diagnosis.

Requirement Analysis

3.1 **Solution Requirements (Functional & Non-functional)**

Date	01 February 2025
Team ID	
Project Name	Eye Disease Detection Using Deep Learning
Maximum Marks	4 Marks

Functional Requirements:

Following are the functional requirements of the proposed solution:

FR No.	**Functional Requirement (Epic)**	**Sub Requirement (Story / Sub-Task)**
FR-1	User Registration	Registration through Form
		Registration through Gmail
		Registration through LinkedIn
FR-2	User Confirmation	Confirmation via Email
		Confirmation via OTP
FR-3	Image Upload & Preprocessing	Users can upload retinal images
		Image is pre-processed (resizing, normalization) before passing to the model
FR-4	Disease Detection & Prediction	Image is analysed using VGG19-based model
		The system predicts the disease category (Cataract, Glaucoma, etc.)
FR-5	Report Generation & Download	A detailed report of the prediction is generated

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
		Users can download or share the report
FR-6	User Dashboard & History	Users can view their past predictions and reports
		History is stored for future reference
FR-7	Admin Panel	Admin can manage users and review reports
		Admin can monitor model performance

Non-functional Requirements

Following are the non-functional requirements of the proposed solution:

NFR No.	Non-Functional Requirement	Description
NFR-1	Usability	The application should have a user-friendly UI, especially for doctors with minimal technical knowledge.
NFR-2	Security	User data, including uploaded images and reports, must be encrypted and securely stored.
NFR-3	Reliability	The system should provide accurate and consistent results without frequent crashes or downtime.
NFR-4	Performance	Predictions should be generated within a few seconds to ensure a smooth user experience.
NFR-5	Availability	The application should be available 24/7 with minimal downtime for maintenance.
NFR-6	Scalability	The system should be capable of handling an increasing number of users and uploaded images efficiently.

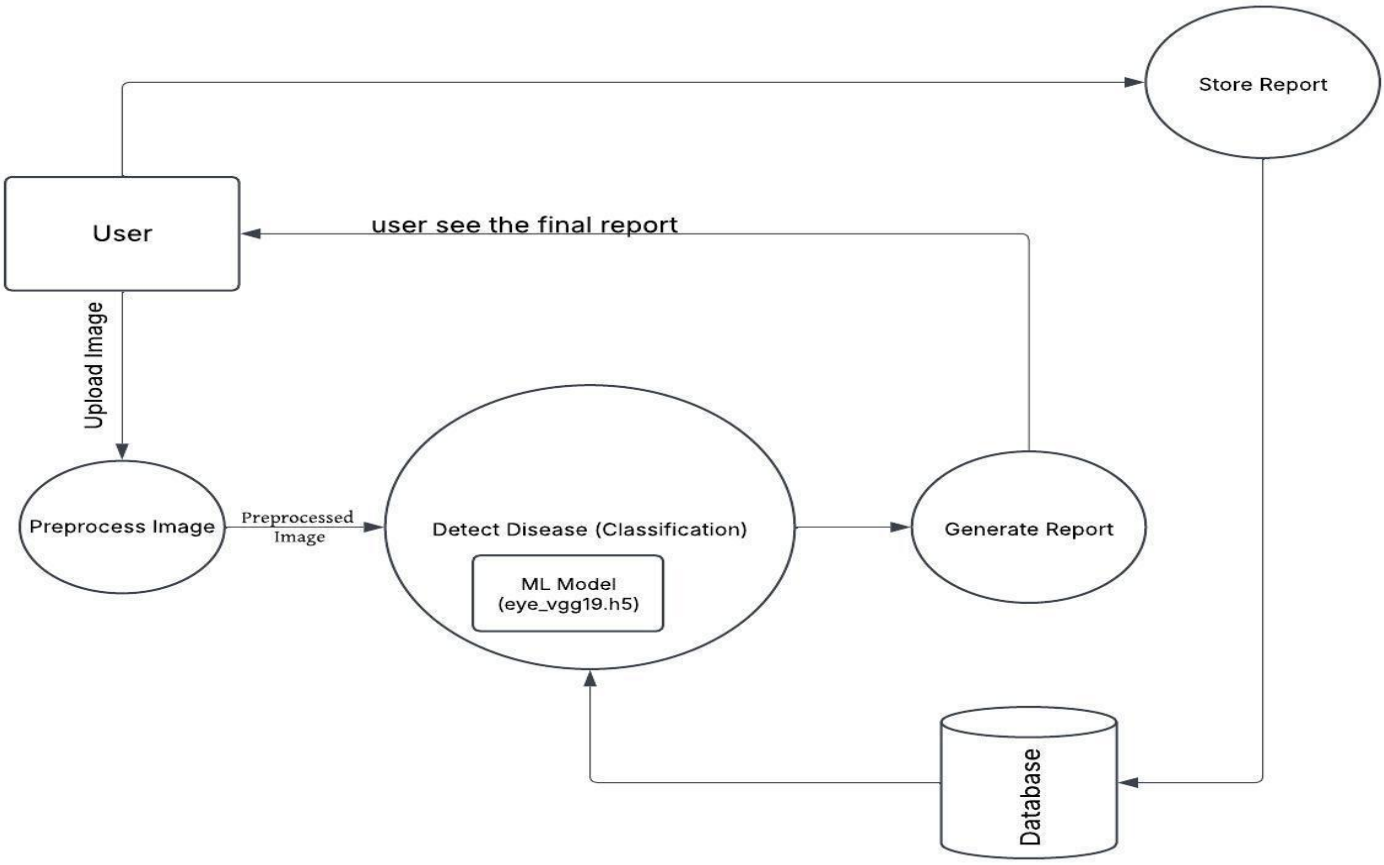
3.2 **Data Flow Diagram & User Stories**

Date	01 February 2025
Team ID	
Project Name	Eye Disease Detection Using Deep Learning
Maximum Marks	4 Marks

Data Flow Diagrams:

A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the right amount of the system requirement graphically. It shows how data enters and leaves the system, what changes the information, and where data is stored.

Level 1 DFD:



3.3 **User Stories**

User Stories Table

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance Criteria	Priority	Release
Customer (Mobile user)	**Registration**	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	I can access my account/dashboard.	High	Sprint-1
		USN-2	As a user, I will receive a confirmation email once I have registered for the application.	I can receive a confirmation email & click confirm.	High	Sprint-1
		USN-3	As a user, I can register for the application through Facebook.	I can register & access the dashboard with Facebook Login.	Low	Sprint-2
		USN-4	As a user, I can register for the application through Gmail.	I can register & access the dashboard with Gmail Login.	Medium	Sprint-1

Login	**Authentication**	USN-5	As a user, I can log into the application by entering my email & password.	I can successfully log in to my account.	High	Sprint-1
		USN-6	As a user, I can reset my password if I forget it.	I can receive a reset link and change my password.	High	Sprint-2
Dashboard	**View Reports**	USN-7	As a user, I can view my past eye disease reports.	I can see a list of past predictions and their details.	High	Sprint-1
	Upload Image	USN-8	As a user, I can upload an eye image for disease detection.	I can upload an image & see the results.	High	Sprint-1
	Receive Prediction	USN-9	As a user, I can receive a disease prediction based on the uploaded image.	I can see the detected disease & confidence score.	High	Sprint-1
	Download Report	USN-10	As a user, I can download my diagnosis report as a PDF.	I can successfully download a formatted report.	Medium	Sprint-2

Customer (Web user)	**Profile Management**	USN-11	As a user, I can edit my profile details like name, email, and password.	I can update my details successfully.	Medium	Sprint-2
	View History	USN-12	As a user, I can check my past uploads and their results.	I can see a history of my disease detections.	High	Sprint-1
Customer Care Executive	**Support Requests**	USN-13	As a support executive, I can view user queries and complaints.	I can access a dashboard of user requests.	Medium	Sprint-3
	Respond to Queries	USN-14	As a support executive, I can respond to user questions via chat or email.	Users receive timely responses to their queries.	Medium	Sprint-3
Administrator	**Manage Users**	USN-15	As an admin, I can block or unblock user accounts if needed.	I can manage user access and restrictions.	High	Sprint-2
	Monitor System Performance	USN-16	As an admin, I can track system performance and server load.	I can see analytics & performance metrics.	Medium	Sprint-3

3.3 **Technology Stack (Architecture & Stack)**

Date	02 February 2025
Team ID	
Project Name	Eye Disease Detection Using Deep Learning
Maximum Marks	4 Marks

Technical Architecture:

The Deliverable shall include the architectural diagram as below and the information as per the table1 & table 2

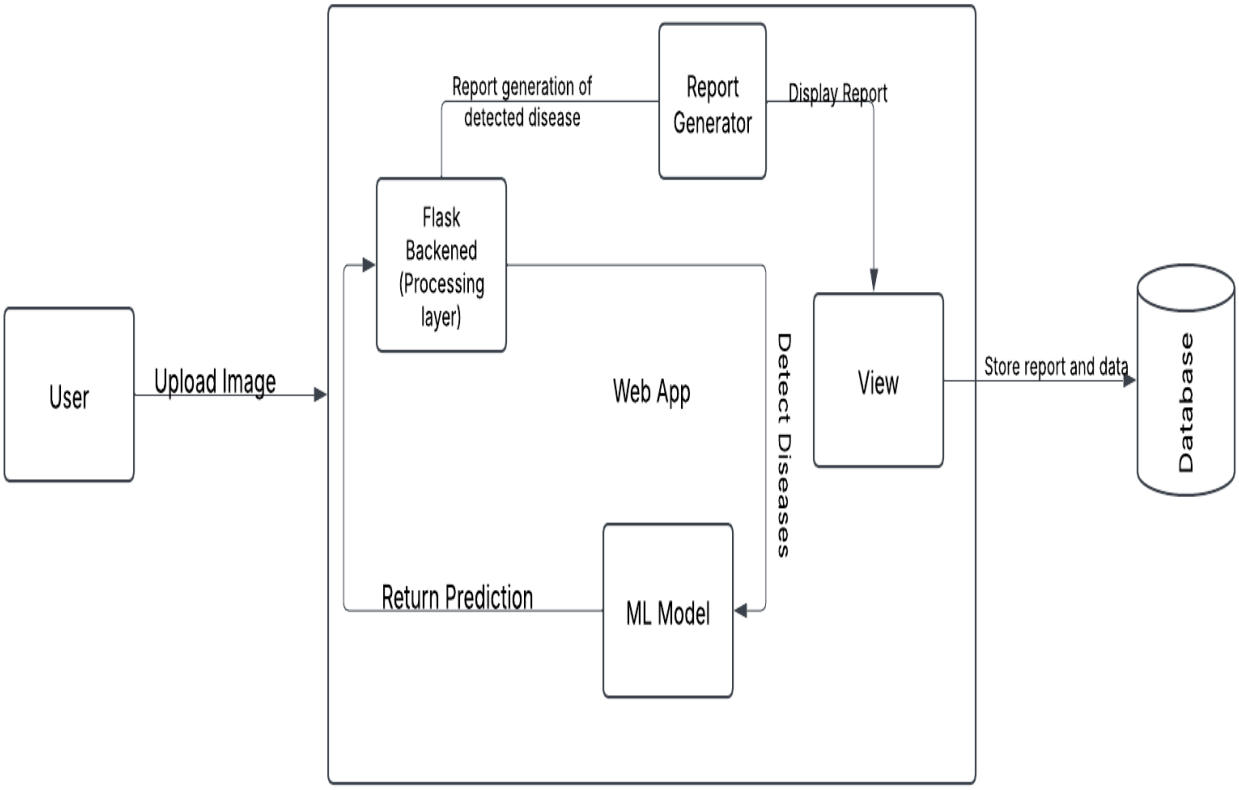


Table 1: Components & Technologies

S.No	Component	Description	Technology
1	User Interface	Web UI where doctors can upload images, view results, and download reports.	HTML, CSS, JavaScript, React.js, Flask
2	Application Logic-1	Backend logic that handles image upload, preprocessing, and database interactions.	Python, Flask
3	Application Logic-2	Image preprocessing pipeline (resizing, normalization).	OpenCV, NumPy, TensorFlow/Keras
4	Application Logic-3	Model inference logic – passing the image to a trained CNN model.	TensorFlow, Keras
5	Database	Stores user details, image metadata, and prediction results.	PostgreSQL / MongoDB
6	Cloud Database	Cloud-based database for scalability.	Firebase, AWS RDS, MongoDB Atlas
7	File Storage	Stores uploaded images and generated reports.	AWS S3 / Google Cloud Storage / Local Filesystem
8	External API-1	API for user authentication (optional).	Google OAuth / Firebase Auth
9	External API-2	API for report sharing via email (optional).	SendGrid / Twilio
10	Machine Learning Model	Deep learning model for eye disease detection.	VGG19-based model, TensorFlow/Keras
11	Infrastructure (Server/Cloud)	Hosting and deployment of the application.	AWS EC2 / GCP App Engine / Azure

Table 2: Application Characteristics

S.No	Characteristics	Description	Technology
1	Open-Source Frameworks	Frameworks used for model development and backend.	Flask, TensorFlow, OpenCV, React.js
2	Security Implementations	Encryption of user data, secure authentication, protection against injection attacks.	SHA-256, SSL/TLS, Firebase Auth, Role-based Access Control (RBAC)
3	Scalable Architecture	The system follows a modular and scalable design, supporting cloud scaling.	Microservices architecture, Kubernetes, Docker
4	Availability	Ensuring minimal downtime by distributing workload using cloud services.	Load Balancing, Auto-scaling (AWS/GCP), Multiple Database Replicas
5	Performance	Optimized model inference and caching for faster predictions.	Redis Cache, CloudFront (CDN), Model Quantization

PROJECT DESIGN

4.1 Proposed Solution

Date	04 March 2025
Team ID	
Project Name	Eye Disease Detection Using Deep Learning
Maximum Marks	2 Marks

S.No.	Parameter	Description
1	Problem Statement (Problem to be solved)	Early detection of eye diseases like diabetic retinopathy, glaucoma, and cataracts is crucial to prevent vision loss. Many healthcare professionals lack quick and accurate diagnostic tools, leading to delayed treatment.
2	Idea / Solution Description	A machine learning-based web application that analyzes retinal images to detect potential eye diseases. The system provides risk assessment reports and recommendations, helping professionals with early diagnosis.
3	Novelty / Uniqueness	The solution integrates AI-based prediction with a user-friendly web interface, allowing seamless report generation and patient tracking. It also includes referral links to specialists and research institutions for further consultation.
4	Social Impact / Customer Satisfaction	It enhances diagnostic accuracy, reduces patient wait times, and provides better accessibility for remote healthcare centers. Medical professionals benefit from faster and more reliable insights.
5	Business Model (Revenue Model)	Subscription-based model for hospitals and clinics, pay-per-use API access for telemedicine platforms, and partnerships with research institutions for dataset sharing and model improvements.

S.No.	Parameter	Description
6	Scalability of the Solution	The system can expand to support more eye diseases, integrate with hospital management systems (HMS), and be deployed in multiple languages for global accessibility.

4.2 **Solution Architecture**

Date	15 February 2025
Team ID	
Project Name	Eye Disease Detection Using Deep Learning
Maximum Marks	4 Marks

Solution Architecture:

Solution architecture is a critical process that defines the structure, behaviour, and characteristics of the proposed AI-based eye disease prediction system. It ensures a seamless bridge between business needs and technical implementation.

Objectives of the Solution Architecture:

- Identify the best technology stack to provide accurate and efficient disease prediction.
- Define system components, workflows, and data processing steps.
- Ensure scalability, security, and interoperability with existing healthcare systems.
- Provide a structured approach for implementation and deployment.

Example - Solution Architecture Diagram:

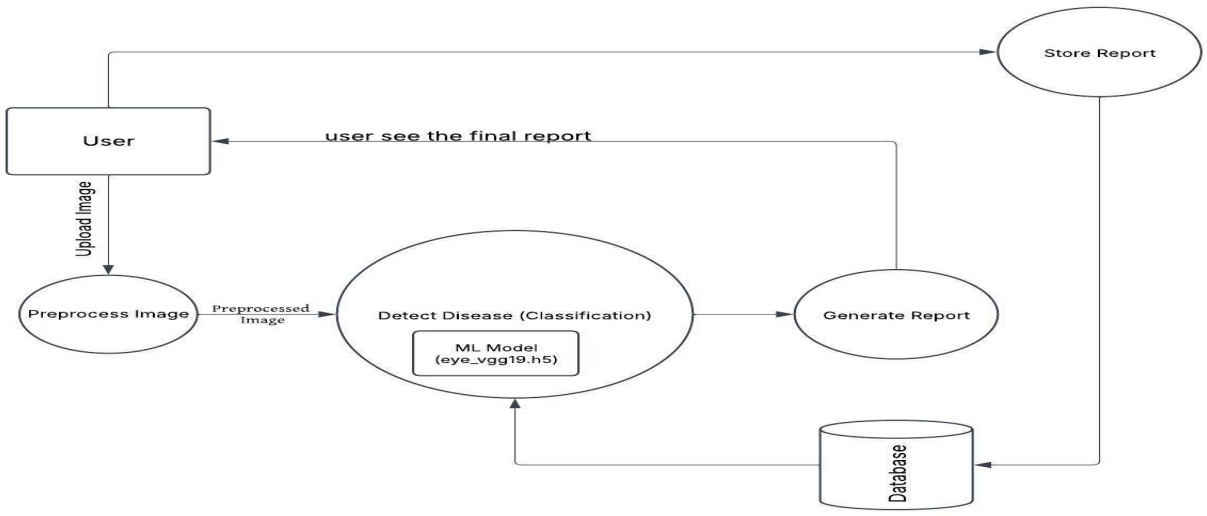


Figure 1: Architecture and data flow of the eye disease & diagnosis sample application.

Project Planning Phase

Project Planning Template (Product Backlog, Sprint Planning, Stories, Story points)

Date	11 March 2025
Team ID	
Project Name	Eye Disease Detection Using Deep Learning
Maximum Marks	5 Marks

Product Backlog, Sprint Schedule, and Estimation

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority
Sprint-1	Disease Prediction Backend	USN-1	As a user, I can input my eye scan/image into the system for disease prediction.	3	High
Sprint-1	Disease Prediction Backend	USN-2	As a system, I can analyse the input data and return a prediction result.	5	High
Sprint-1	Referral System	USN-3	As a user, I can access referral links to seek further consultation or treatment.	2	Medium
Sprint-2	UI for Report Display	USN-4	As a user, I can view my prediction report through a web interface.	3	High
Sprint-2	UI for Report Display	USN-5	As a user, I can download the report for offline use.	2	Medium

Project Tracker, Velocity & Burndown Chart

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	10	6 Days	28 Feb 2025	05 Mar 2025	10	05 Mar 2025
Sprint-2	5	6 Days	06 Mar 2025	11 Mar 2025	3	06 Mar 2025

Velocity Calculation

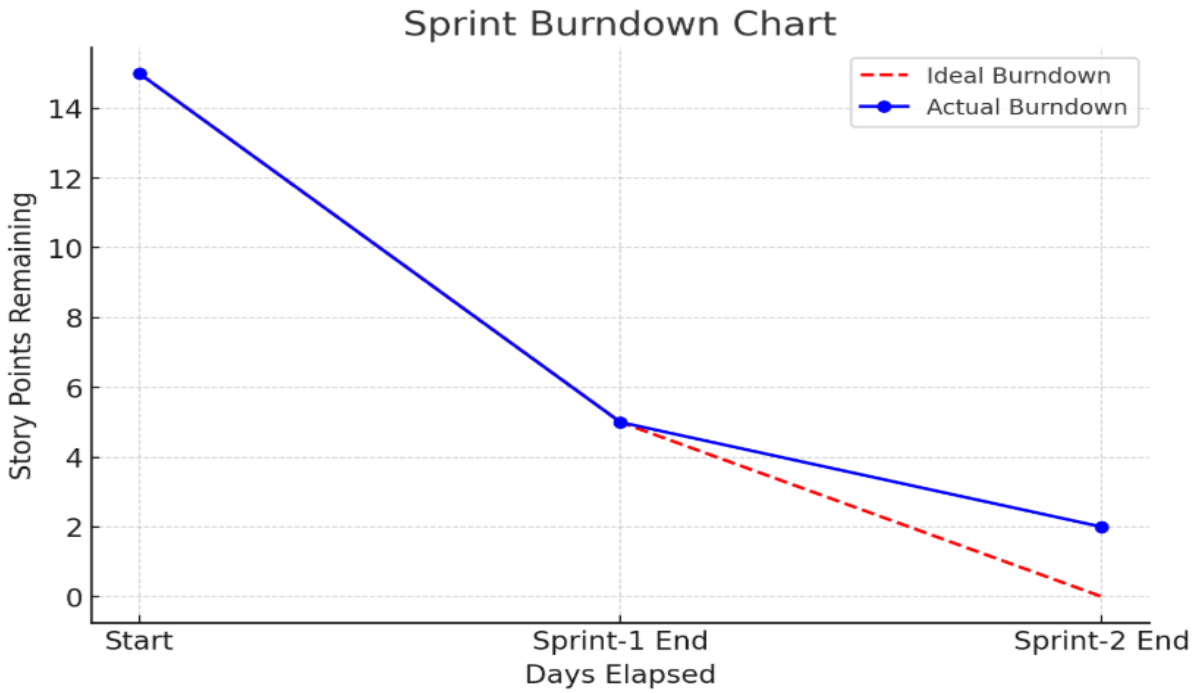
Given a sprint duration of 6 days and 10 story points completed in Sprint-1:

- Velocity = Total Story Points Completed / Sprint Duration
- Velocity = 10 / 6 ≈ 1.67 story points per day

Burndown Chart Explanation

A burndown chart represents the remaining work (in story points) versus time.

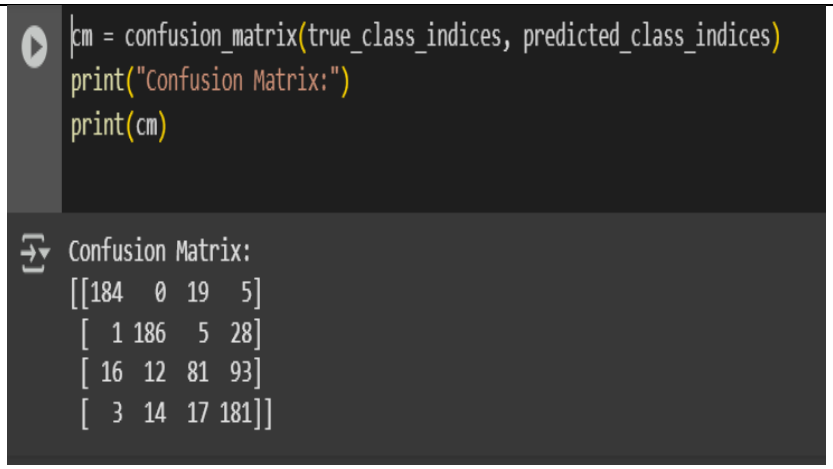
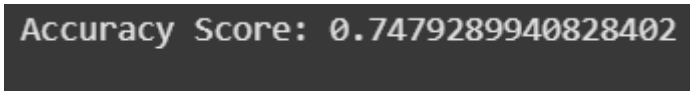
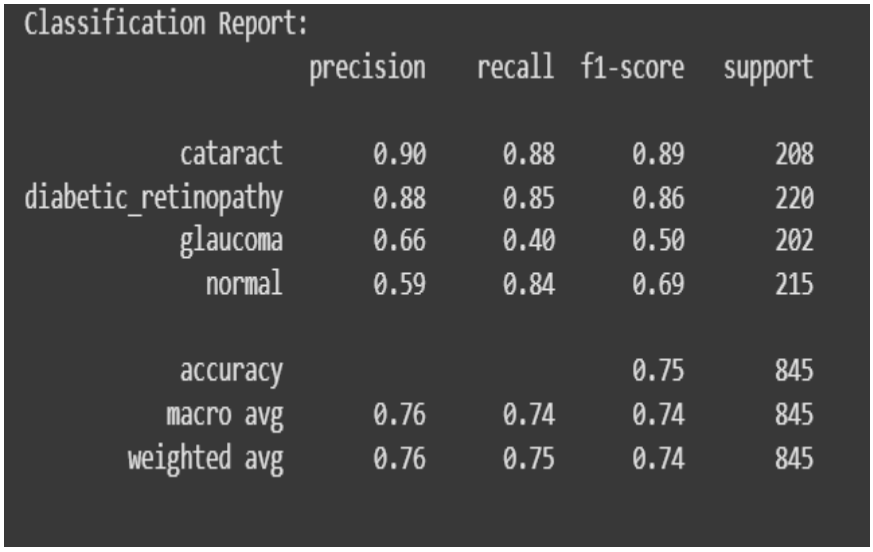
- Sprint-1 started with 10 points and completed all.
- Sprint-2 started with 5 points & completed 3 point.



FUNCTIONAL AND PERFOMANCE TESTING

Model Performance Test

Model Performance Testing:

S.No.	Parameter	Values	Screenshot
1.	Metrics	**Classification Model:** a. Confusion Matrix -	
		b. Accuracy Score-	
		c. Classification Report -	

RESULTS

Outputs Screenshot

Saved Model:

```
[ ]  model.save('eye_vgg19.h5')

     WARNING:absl:You are saving your model as an HDF5 file via `model.save()` or `keras.saving.save_model(model)`. This file format is conside
```

Performing prediction by taking an image:

```
[ ]  image_path = "/content/train_data/glaucoma/1209_left.jpg"
     predicted_class, confidence = eye_diseaes(image_path)
     print("predicted sisease:", predicted_class)
     print("Confidence:", confidence)

     1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 46ms/step
     predicted sisease: glaucoma
     Confidence: 0.747985
```

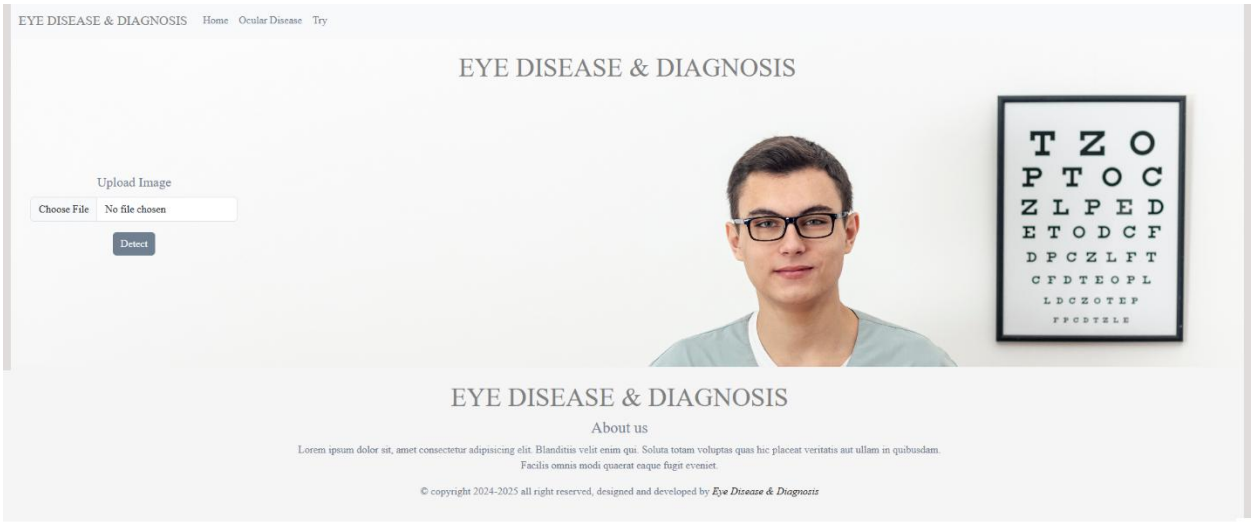
```
image_path = "/content/train_data/normal/1034_right.jpg"
predicted_class, confidence = eye_diseaes(image_path)
print("predict sisease:", predicted_class)
print("Confidence:", confidence)

1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 47ms/step
predict sisease: normal
Confidence: 0.42947558
```

BASIC UI OF OUR WEB APPLICATION:

1. This is the page where the user will visit, and it gives an option to try our model

2. This is the page where the user will be detecting the EYE DISEASE :

Currently we can proceed with the 3 diseases(Cataract, Diabetic Retinopathy, Glaucoma) and a Normal.



3. In this we can see that the Cataract is detected with the surety of the 0.98 (lies between 0 and 1)

Alternatively, can say that 98% is confirmed

ADVANTAGES & DISADVANTAGES

Advantages of the Eye Disease Classification using Deep Learning

- **Quick Diagnosis** – Reduces the time needed for manual diagnosis by the healthcare professionals.
- **Decision Support** – Acts as a second opinion for **doctors** to confirm their findings.
- **Early Detection** – Helps in detecting diseases like cataracts and glaucoma in the early stages.
- **Standardized Analysis** – Ensures uniformity in diagnosis, reducing human errors.
- **Patient Management** – Doctors can prioritize critical cases based on the model's predictions.
- **Model -** It can be improved by taking the data on a large amount from doctors and accuracy can also be achieved more than 90% by having proper resources.

For Business & Scalability

- **Market Expansion** – Can be integrated into telemedicine platforms to provide remote diagnosis.
- **Cost-Effective** – Reduces the need for expensive diagnostic tools in initial screening.
- **Scalable Solution** – Can be deployed across multiple hospitals and clinics.
- **Competitive Edge** – A tech-driven solution makes the business stand out in the healthcare industry.
- **Potential for Monetization** – Can be offered as a **subscription-based service** or **per-use model** for hospitals.

Disadvantages of the Eye Disease Classification using Deep Learning

- **Accuracy -** The accuracy of the Model trained is 74.8% it has to be increased as it may lead to incorrect result.
- **Not a Replacement for Doctors** – Can assist but should not be solely relied upon for critical decisions.
- **Limited Dataset Bias** – Model performance depends on dataset diversity; may struggle with rare cases.
- **Internet Dependency** – Cloud-based deployment requires a stable connection, affecting remote areas.
- **Hardware Limitations** – Running deep learning models on low-end systems can be slow.
- **Regulatory & Legal Hurdles** – Needs medical certification before commercial deployment.

CONCLUSION

The **Eye Disease Classification Model** built using **VGG19**, a pre-trained Convolutional Neural Network (CNN), successfully demonstrates the potential of **deep learning** in the **early detection of eye diseases**. With an accuracy of **74.8%**, the model can effectively classify common eye conditions like **cataracts**, **diabetic retinopathy**, **glaucoma**, and **normal** eye conditions, providing **valuable support** to medical professionals.

Key Insights:

- **Quick and Reliable Diagnoses**: The model reduces the time spent on diagnosing eye diseases, assisting doctors in making faster decisions.
- **Improved Patient Outcomes**: By facilitating early diagnosis, the model can help reduce the progression of eye diseases, leading to better treatment outcomes for patients.
- **Business Viability**: The integration of this model into telemedicine or clinic systems has the potential to **reduce costs**, **expand access to healthcare**, and offer a **scalable business solution** for diagnostic services.

Challenges and Limitations:

- **Dataset Limitations**: The model's performance is tied to the quality and diversity of the dataset used for training. The model may not perform well in unseen or rare cases.
- **Dependence on High-Quality Data**: To improve the model's accuracy and generalization, a more diverse dataset and advanced data augmentation techniques would be beneficial.
- **Regulatory Compliance**: For real-world deployment, the model needs to meet medical regulations and get certified as a medical device or diagnostic tool.

Conclusion Statement:

In conclusion, while the **Eye Disease Classification Model** provides promising results and is a step forward in **automating the diagnostic process**, there is a significant opportunity for continuous improvement and real-world validation. This solution has the potential to **revolutionize eye care**, making it more accessible, cost-effective, and scalable for healthcare providers worldwide.

FUTURE SCOPE

1. **Enhanced Model Accuracy**
    - Improve model accuracy by training on a larger and more diverse dataset.
    - Can implement advanced deep learning architectures such as EfficientNet or Vision Transformers (ViTs) for better feature extraction.
2. **Real-Time Detection**
    - Optimize the model for real-time detection using mobile or web applications.
    - Deploy a lightweight version of the model for on-device diagnosis without an internet connection.
3. **Multi-Disease Detection**
    - Expand the model to detect other eye diseases such as oracular degeneration and retinopathy of pre maturity (ROP).
    - Implement multi-class classification with higher granularity for better disease categorization.
4. **Explainable AI (XAI) for Trustworthiness**
    - Integrate explain ability techniques like Grad-CAM to highlight the affected eye regions.
    - Provide a confidence score and reasons for the model's predictions to improve trust among doctors.
5. **Business Expansion Opportunities**
    - Offer the application as a subscription-based service for hospitals and clinics.
    - Partner with eye care centers for automated preliminary screening, reducing workload on ophthalmologists.
6. **Cross-Platform Availability**
    - Develop a mobile application (Android/iOS) for wider accessibility.
    - Integrate with cloud platforms for easy data storage and retrieval.
7. **Regulatory Approval & Clinical Trials**
    - Improve model reliability to meet medical regulatory standards (e.g., FDA, CE certification).
    - Conduct clinical trials to validate the model’s performance before widespread adoption.

APPENDIX

Source Code :

https://github.com/suhailchoudhary/AI-ML/blob/main/Project%20Executable%20Files/Model-files/untitled11.py

Dataset Link :
https://www.kaggle.com/datasets/gunavenkatdoddi/eye-diseases-classification/data

Demo:

https://youtu.be/62PCVXzjlxU

Github :

https://github.com/suhailchoudhary/AI-ML