Project Report

1. INTRODUCTION

1.1 Project Overview

We have developed a web application focused on classifying various types of eye diseases attributed to factors such as age and diabetes. The classification encompasses Normal, Cataract, Diabetic Retinopathy, and Glaucoma. Leveraging the power of artificial intelligence, we employed deep-learning methods, specifically Transfer Learning techniques utilizing well-established models like Inception V3, VGG19, and Xception V3, renowned for their effectiveness in image analysis. The application allows users to upload eye images and utilizes these pre-trained models to predict the type of eye disease affecting the patient. The user-friendly interface features an upload button for image submission and a predict button to obtain rapid and accurate predictions.

1.2 Purpose

The purpose of this project is to leverage the capabilities of artificial intelligence, specifically deep learning and transfer learning techniques, for the accurate and efficient classification of various eye diseases. By focusing on conditions such as Normal, Cataract, Diabetic Retinopathy, and Glaucoma, we aim to provide a valuable tool for early detection and diagnosis. The integration of well-established models like Inception V3, VGG19, and Xception V3 enhances the predictive accuracy of our system. The web application serves as a user-friendly platform, allowing individuals to upload eye images easily. The ultimate goal is to contribute to proactive healthcare by enabling timely identification of eye diseases through advanced image analysis, thereby facilitating prompt medical intervention and improving overall patient outcomes.

2. LITERATURE SURVEY

2.1 Existing problem

One existing problem related to the eye disease prediction problem statement is the lack of accessible and user-friendly tools for early detection and classification of eye diseases. Many individuals, especially in underserved communities, may not have easy access to specialized eye care services or may face barriers in obtaining timely diagnoses. Traditional methods of eye disease diagnosis often require in-person visits to healthcare professionals, causing delays in identifying and treating conditions.

2.2 References

https://healthtechmagazine.net/article/2022/11/innovations-eye-care-how-technology-transforming-ophthalmology-perfcon

https://www.nature.com/articles/s41586-023-06555-x

https://www.hindawi.com/journals/cin/2022/5007111/

https://www.researchgate.net/publication/351048594_Improved_Model_of_Eye_Disease_Recognition_Based_on_VGG_Model

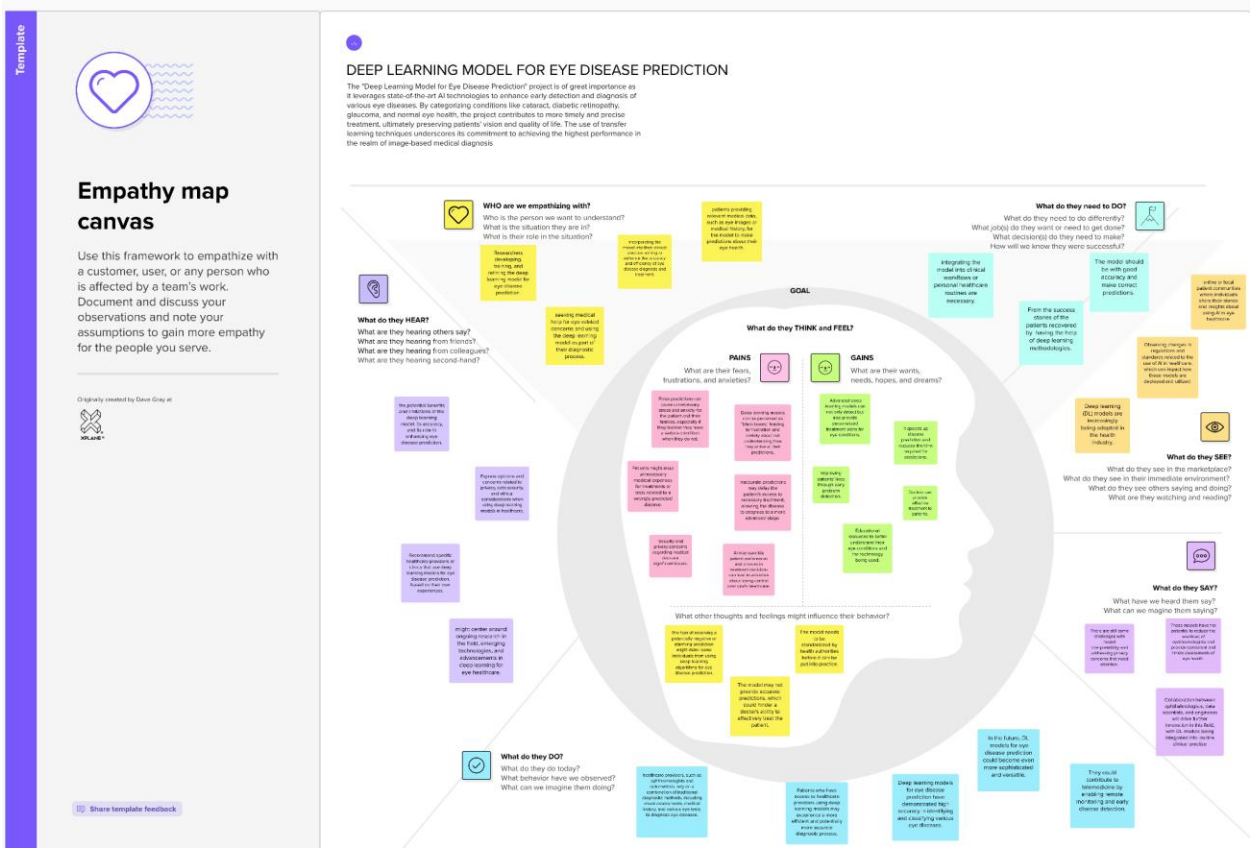
2.3 Problem Statement Definition

In this project we are classifying various types of Eye Diseases that people get due to various reasons like age, diabetes, etc. These diseases are majorly classified into 4 categories namely Normal, cataract, Diabetic Retinopathy & Glaucoma. Deep-learning (DL) methods in artificial intelligence (AI) play a dominant role as high-performance classifiers in the detection of the Eye Diseases using images.

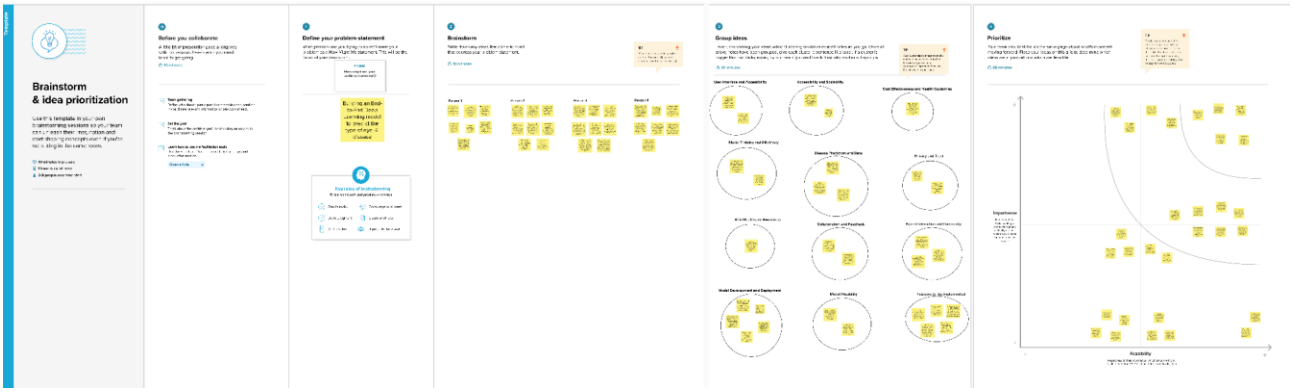
Transfer learning has become one of the most common techniques that has achieved better performance in many areas, especially in image analysis and classification. We used Transfer Learning techniques like Inception V3, VGG19, Xception V3 that are more widely used as a transfer learning method in image analysis and they are highly effective.

3.IDEATION & PROPOSED SOLUTION

3.1 Empathy Map Canvas



3.2 Ideation & Brainstorming



4. REQUIREMENT ANALYSIS

4.1 Functional requirement:

User Authentication and Security:

Implement a secure user authentication system to ensure that only authorized individuals can access the application and its functionalities. This is particularly important to protect sensitive medical information.

Compatibility and Responsiveness:

The web application should be compatible with various devices and browsers. It should be responsive, providing a consistent and user-friendly experience across different screen sizes.

Error Handling:

The system should have robust error-handling mechanisms to address issues such as incorrect file formats, upload failures, or any other unexpected errors during the prediction process.

Data Privacy:

Ensure compliance with data privacy regulations and implement measures to safeguard user-uploaded images and any associated personal information. This includes secure storage and transmission of data.

Real-time Prediction:

The application should provide real-time predictions, ensuring a quick turnaround for users to receive the results of the eye disease classification.

Result Display:

The predicted output, indicating the type of eye disease (Normal, Cataract, Diabetic Retinopathy, Glaucoma), should be clearly displayed to the user along with any relevant confidence scores or probabilities.

4.2 Non-Functional requirements

Response Time:
The system should provide predictions within a reasonable and acceptable response time, ensuring a smooth user experience.

Scalability:
The application should be able to handle an increasing number of users and image processing requests without a significant decrease in performance.

Data Encryption:
Implement encryption for data transmission and storage to protect sensitive user information.

Access Control:
Enforce strict access controls to ensure that only authorized individuals can access and interact with the system.Maintainability:

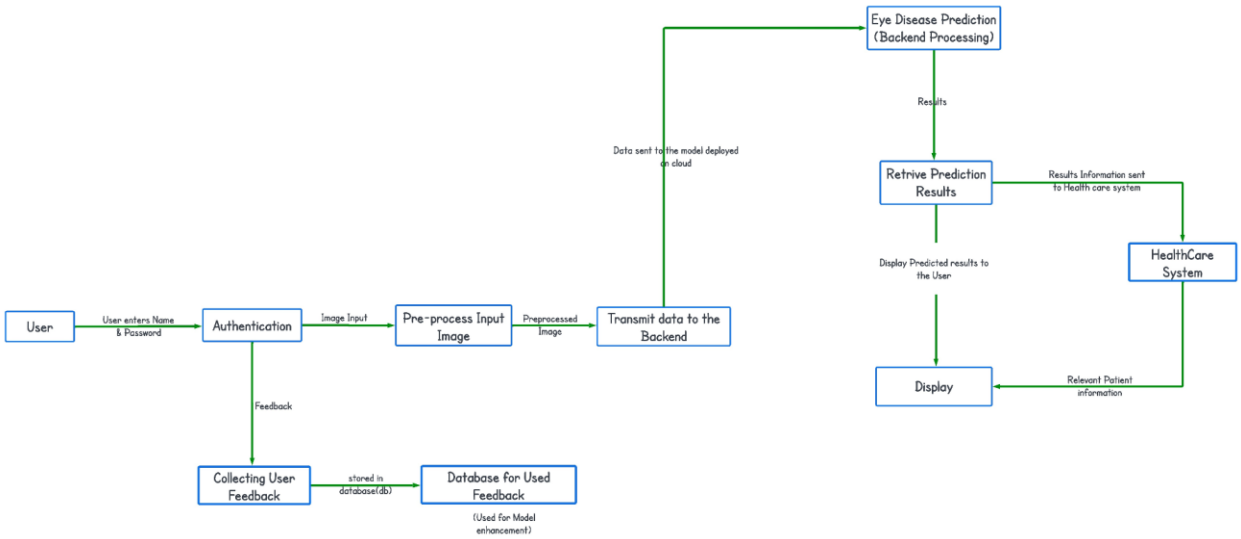
Code Maintainability:
Write clean and well-documented code to facilitate future updates, modifications, and maintenance.

System Updates:
Implement a mechanism for easy updates and patches to keep the system current and secure.

Logging:
Implement robust logging mechanisms to track system activities and errors for troubleshooting and auditing purposes.

5. PROJECT DESIGN

5.1 Data Flow Diagrams & User Stories

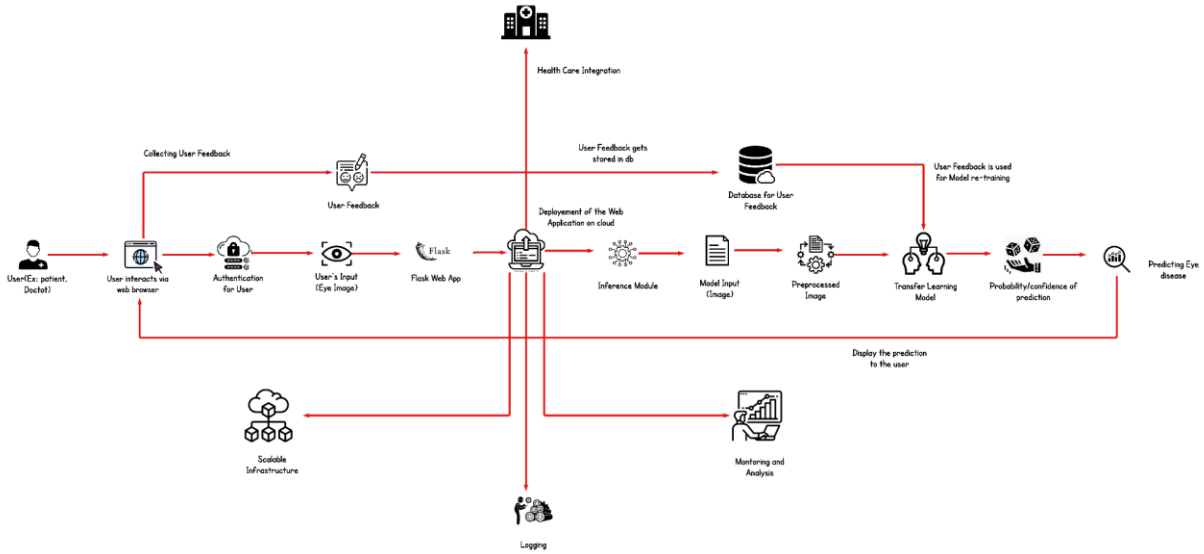


Data Flow:

1. User interacts via Web Browser
2. Request processed by Flask Web App (Frontend)
3. Frontend sends image to Inference module
4. Inference module loads and processes image
5. Processed image input to Transfer Learning Model
6. Model predicts disease probability and classification
7. Results sent back to Frontend for display
8. User can provide feedback through the User Interface
9. Feedback stored in User Feedback Database
10. Integration with Healthcare Systems for timely alerts.

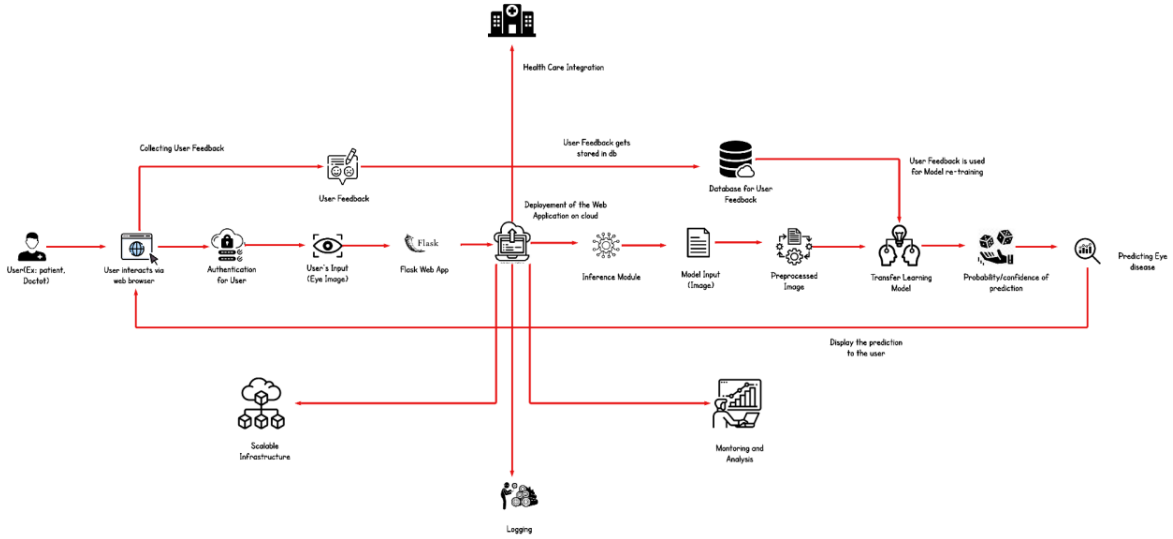
User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Patients	Login	USN-1	As a patient, I want to register an account to access the eye disease prediction system.	The patient should be able to successfully create an account using valid personal information.	High	Sprint-1
	Image Uploadation	USN-2	As a patient, I want to upload eye images for analysis.	The system should allow the patient to upload eye images in common formats (e.g., JPEG, PNG).	High	Sprint-2
	Eye Health Monitoring	USN-3	As a patient, I want to view the prediction results and understand the likelihood of having an eye disease.	the patient should be able to view a clear and understandable prediction report indicating the likelihood of having an eye disease, with relevant details and explanations provided for transparency.	Medium	Sprint-2
Ophthalmologists and Eye Care Professionals	Login	USN-1	As a doctor, I want to log in to the system to access patient data securely.	The system should authenticate the doctor's credentials securely, granting access only to authorized personnel	High	Sprint-1
	Treatment Planning	USN-2	As a doctor, I want to review patient history and eye images for diagnosis.	The system should present a well-organized patient history, including relevant medical information.	Medium	Sprint-2
AI/ML Developers	Model Development	USN-3	Improving Machine Learning Model for Eye Disease Prediction.	The ML developer should be able to access the model's source code, implement enhancements, and validate the changes through testing.	Medium	Sprint-3

5.2 Solution Architecture



6. PROJECT PLANNING & SCHEDULING

6.1 Technical Architecture



6.2 Sprint Planning & Estimation

Product Backlog, Sprint Schedule, and Estimation

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members

Sprint-1	Login	USN-1	As a user, I want to register an account to access the eye disease prediction system.	23	High	Rahul , Tejaswini
	Image Uploadation	USN-2	As a user, I want to upload eye images for analysis.	5	High	Rahul,Tejaswini
	Eye Health Monitoring	USN-3	As a user, I want to view the prediction results and understand the likelihood of having an eye disease.	7	Medium	Kesava kumar, Suchitha
Sprint-2	Login	USN-4	As a doctor, I want to log in to the system to access patient data securely.	25	High	Rahul ,Tejaswini
	Treatment Planning	USN-5	As a doctor, I want to review patient history and eye images for diagnosis.	10	Medium	Rahul,Tejaswini
Sprint-3	Model Development	USN-6	Improving a Machine Learning Model for Eye Disease Prediction.	30	Medium	Kesava Kumar,Suchitha

Project Tracker, Velocity & Burndown Chart: s

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	35	6 days	1-11-2023	6-11-2023	35	6-11-2023
Sprint-2	35	7 days	7-11-2023	13-11-2023	30	14-11-2023
Sprint-3	30	7 days	14-11-2023	20-11-2023	30	20-11-2023

Velocity:

velocity=(35)/5=7
velocity=(30)/5=6
velocity=(30)/5=6

AV=35+30+30\6+6+7
=5

Burndown Chart:

- Duration: 6 dys
- Sprint Backlog: 6 tasks
- Velocity: 12 available hours

Step 1 – Create Estimate Effort

Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
12	10	8	6	4	2	0

Step 2 – Track Daily Process

Task	Hours	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Total Hours
Task1	2	1	0	0	0	0	1	2
Task 2	2	0	1	0	0	1	0	2
Task 3	1	1	0	0	0	0	0	1
Task 4	2	0	0	2	0	0	0	2
Task 5	3	0	0	0	3	0	0	3
Task 6	2	0	2	0	0	0	0	3

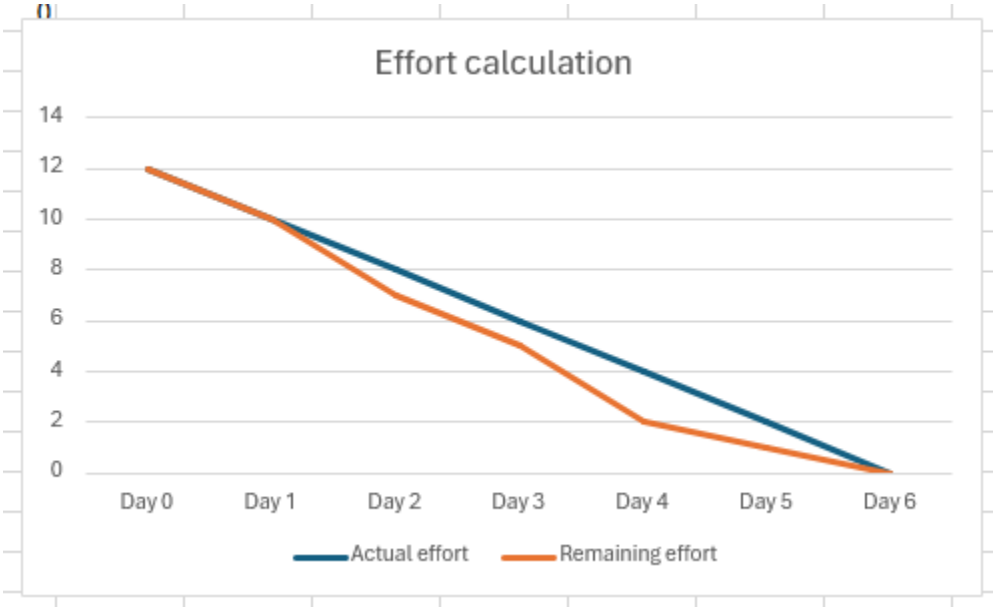
Step 3 – Compute the Actual Effort

	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Actual effort	12	10	8	6	4	2	0
Remaining effort	12	10	7	5	2	1	0

Step 4 – Obtain the Final Dataset

	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Actual effort	12	10	8	6	4	2	0
Remaining effort	12	10	7	5	2	1	0

Step 5 – Plot the Burndown using the Dataset



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	35	6 days	1-11-2023	6-11-2023	35	6-11-2023
Sprint-2	35	7 days	7-11-2023	13-11-2023	30	14-11-2023
Sprint-3	30	7 days	14-11-2023	20-11-2023	30	20-11-2023

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

7.1 Feature 1

User authentication

User authentication to control access to certain parts of the application. Users need to log in with a valid username and password.

```
app.secret_key = os.urandom(24)

# Dummy users for demonstration purposes (replace with your user data)
users = {'username': 'password', 'user2': 'password2'}

@app.route('/', methods=['GET', 'POST'])
def index():
    if 'username' in session:
        return redirect(url_for('protected'))

    if request.method == 'POST':
        username = request.form['username']
        password = request.form['password']

        if username in users and users[username] == password:
            session['username'] = username
            return redirect(url_for('protected'))

    return render_template('login.html')
```

User authentication is a crucial aspect of web applications to control access to certain functionalities. In this feature, you've implemented a basic user authentication system. The code maintains a dictionary (users) with predefined username-password pairs for demonstration purposes.

```
users = {'username': 'password', 'user2': 'password2'}
```

- The '/' route serves both GET and POST requests.
- Checks if a user is already logged in; if yes, redirects to the protected page.
- If the request method is POST, it validates the entered username and password against the predefined dictionary.
- If the credentials are valid, the user is redirected to the protected page.

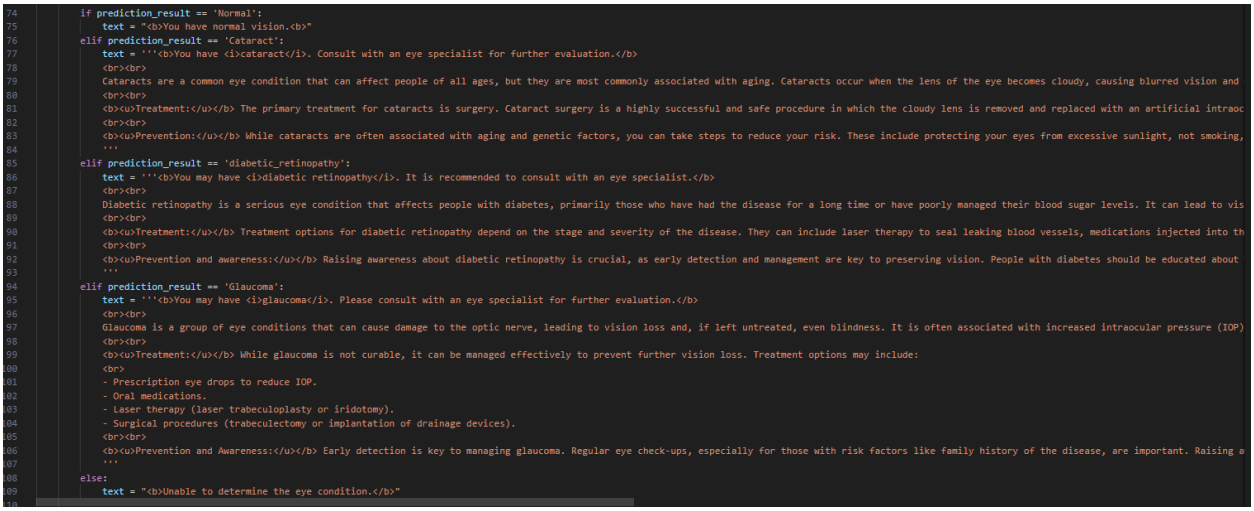
```
@app.route('/', methods=['GET', 'POST'])
def index():
    if 'username' in session:
        return redirect(url_for('protected'))

    if request.method == 'POST':
        username = request.form['username']
        password = request.form['password']

        if username in users and users[username] == password:
            session['username'] = username
            return redirect(url_for('protected'))

    return render_template('login.html')
```

7.2 Feature 2

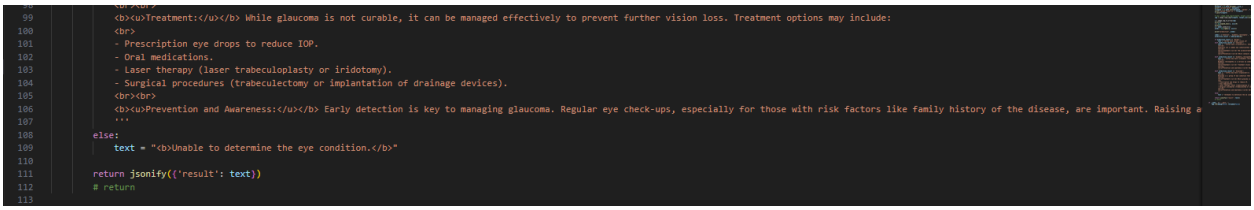
Image Upload and Processing

Users can upload eye images for disease prediction. The uploaded image is processed using a pre-trained deep learning model to predict the eye condition.

```
@app.route('/predict', methods=['POST'])
def upload():
    if request.method == 'POST':
        f = request.files['image']
        print("current path")
        basepath = os.path.dirname(__file__)
        print("current path", basepath)
        filepath = os.path.join(basepath, 'uploads', f.filename)
        print("upload folder is ", filepath)
        f.save(filepath)

        # img = image.load_img(filepath, target_size=(64, 64))
        img = image.load_img(filepath, target_size=(224, 224))

        x = image.img_to_array(img)
        print(x)
        x = np.expand_dims(x, axis=0)
        print(x)
        y = model.predict(x)
        preds = np.argmax(y, axis=1)

        print("prediction", preds)

        index = ['Cataract', 'diabetic_retinopathy', 'Glaucoma','Normal']
        prediction_result = index[preds[0]]

        if prediction_result == 'Normal':
            text = "<b>You have normal vision.<b>"
        elif prediction_result == 'Cataract':
            text = '''<b>You have <i>cataract</i>. Consult with an eye specialist for further evaluation.</b>
            <br><br>
            Cataracts are a common eye condition that can affect people of all ages, but they are most commonly associated with aging. Cataracts occur when the lens of the eye becomes cloudy, causing blurred visi
            <br><br>
```



```
    if prediction_result == 'Normal':
        text = "<b>You have normal vision.<b>"
    elif prediction_result == 'Cataract':
        text = '''<b>You have <i>cataract</i>. Consult with an eye specialist for further evaluation.</b>
        <br><br>
        Cataracts are a common eye condition that can affect people of all ages, but they are most commonly associated with aging. Cataracts occur when the lens of the eye becomes cloudy, causing blurred vision and
        <br><br>
        <b><u>Treatment:</u></b> The primary treatment for cataracts is surgery. Cataract surgery is a highly successful and safe procedure in which the cloudy lens is removed and replaced with an artificial intraoc
        <br><br>
        <b><u>Prevention:</u></b> While cataracts are often associated with aging and genetic factors, you can take steps to reduce your risk. These include protecting your eyes from excessive sunlight, not smoking,
        '''
    elif prediction_result == 'diabetic_retinopathy':
        text = '''<b>You may have <i>diabetic retinopathy</i>. It is recommended to consult with an eye specialist.</b>
        <br><br>
        Diabetic retinopathy is a serious eye condition that affects people with diabetes, primarily those who have had the disease for a long time or have poorly managed their blood sugar levels. It can lead to vis
        <br><br>
        <b><u>Treatment:</u></b> Treatment options for diabetic retinopathy depend on the stage and severity of the disease. They can include laser therapy to seal leaking blood vessels, medications injected into th
        <br><br>
        <b><u>Prevention and awareness:</u></b> Raising awareness about diabetic retinopathy is crucial, as early detection and management are key to preserving vision. People with diabetes should be educated about
        '''
    elif prediction_result == 'Glaucoma':
        text = '''<b>You may have <i>glaucoma</i>. Please consult with an eye specialist for further evaluation.</b>
        <br><br>
        Glaucoma is a group of eye conditions that can cause damage to the optic nerve, leading to vision loss and, if left untreated, even blindness. It is often associated with increased intraocular pressure (IOP)
        <br><br>
        <b><u>Treatment:</u></b> While glaucoma is not curable, it can be managed effectively to prevent further vision loss. Treatment options may include:
        <br>
        - Prescription eye drops to reduce IOP.
        - Oral medications.
        - Laser therapy (laser trabeculoplasty or iridotomy).
        - Surgical procedures (trabeculectomy or implantation of drainage devices).
        <br><br>
        <b><u>Prevention and Awareness:</u></b> Early detection is key to managing glaucoma. Regular eye check-ups, especially for those with risk factors like family history of the disease, are important. Raising a
        '''
    else:
        text = "<b>Unable to determine the eye condition.</b>"
```



```
        <b><u>Treatment:</u></b> While glaucoma is not curable, it can be managed effectively to prevent further vision loss. Treatment options may include:
        <br>
        - Prescription eye drops to reduce IOP.
        - Oral medications.
        - Laser therapy (laser trabeculoplasty or iridotomy).
        - Surgical procedures (trabeculectomy or implantation of drainage devices).
        <br><br>
        <b><u>Prevention and Awareness:</u></b> Early detection is key to managing glaucoma. Regular eye check-ups, especially for those with risk factors like family history of the disease, are important. Raising a
        '''
    else:
        text = "<b>Unable to determine the eye condition.</b>"

    return jsonify({'result': text})
    # return
```

- The '/predict' route handles POST requests for image uploads.
- Retrieves the uploaded image, saves it to a specified folder, and loads it for processing.
- Uses a pre-trained deep learning model (VGG19) to predict the eye condition based on the image.
- The prediction result is sent back as a JSON response.

8. PERFORMANCE TESTING

8.1 Performance Metrics

Classification report on testing data:

```
Classification Report:
----------------------
                      precision    recall  f1-score   support

            cataract       0.90      0.96      0.92        45
diabetic_retinopathy       1.00      1.00      1.00        54
            glaucoma       0.98      0.84      0.91        57
              normal       0.88      0.96      0.92        55

            accuracy                           0.94       211
           macro avg       0.94      0.94      0.94       211
        weighted avg       0.94      0.94      0.94       211
```

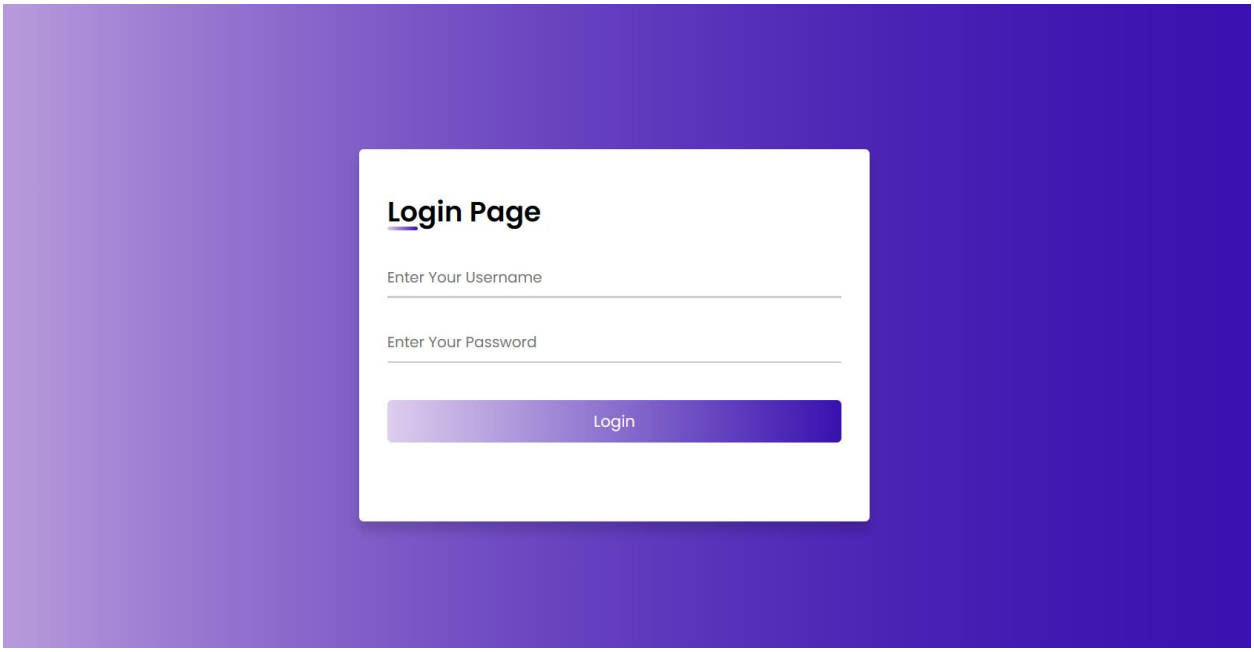
Confusion Matrix :

9. RESULTS

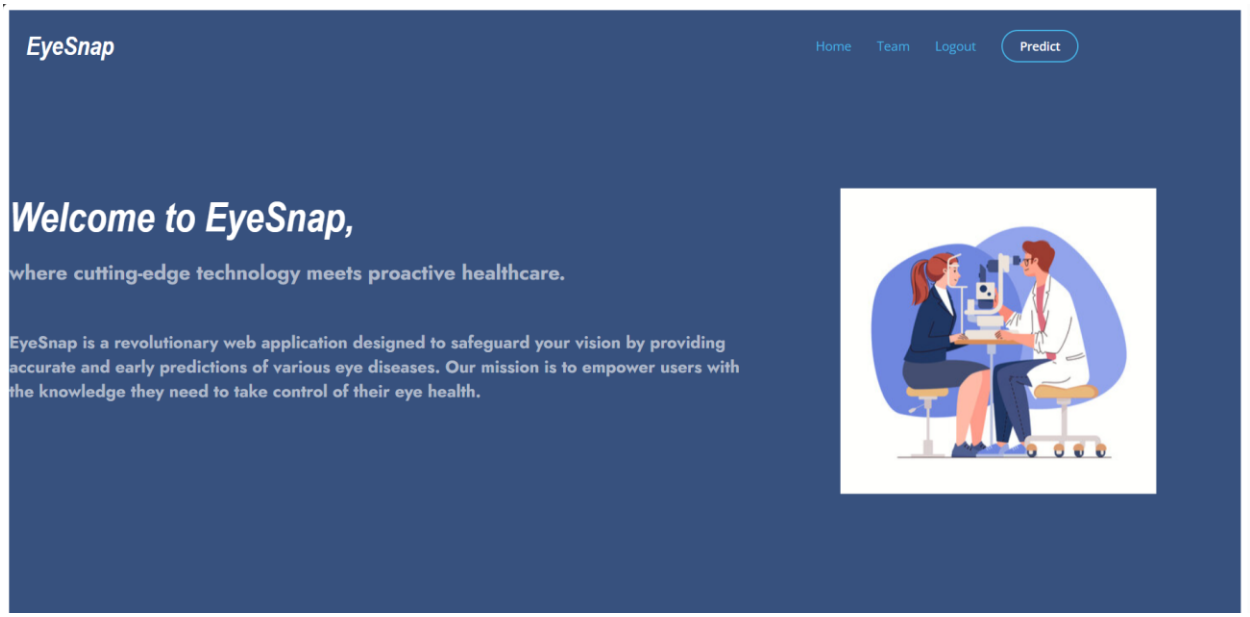
9.1 Output Screenshots

WEBSITE:

Login Page



Home Page



Team Page

TEAM

RAHUL CHEREDDY

Vellore Institute of Technology

KESAVA KUMAR MATTUPALLI

Vellore Institute of Technology

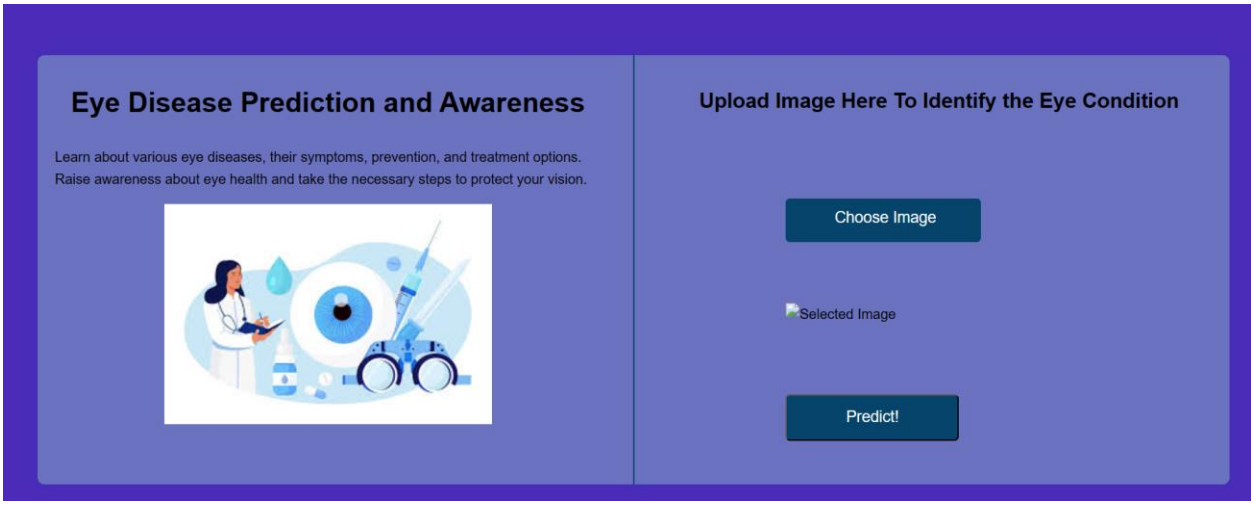
TEJASWINI RAYA

Vellore Institute of Technology

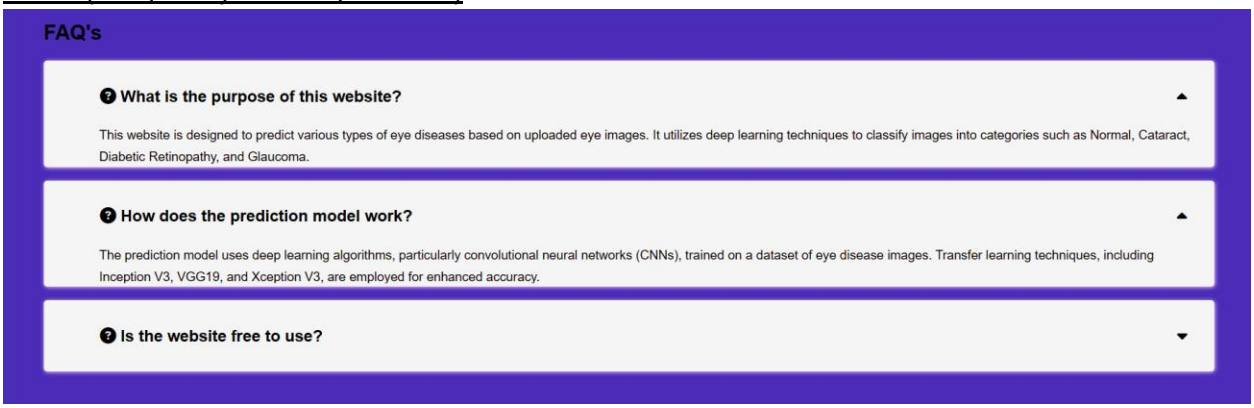
SREERAM VENKATA SAI SUCHITHA

Vellore Institute of Technology

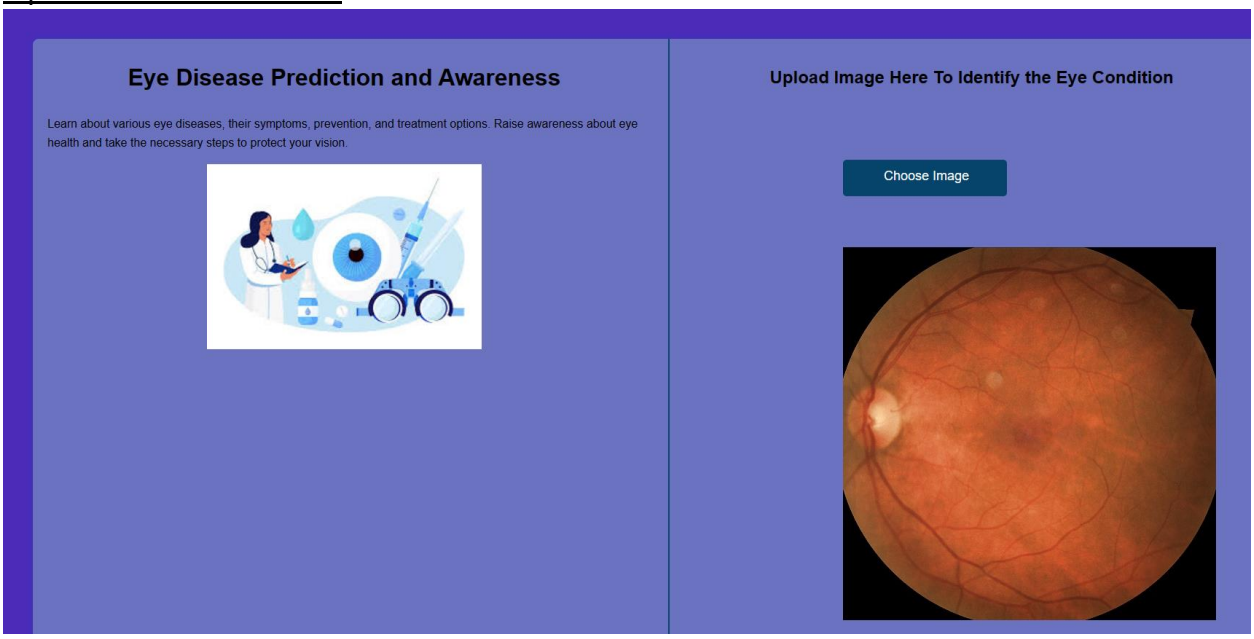
Prediction Page



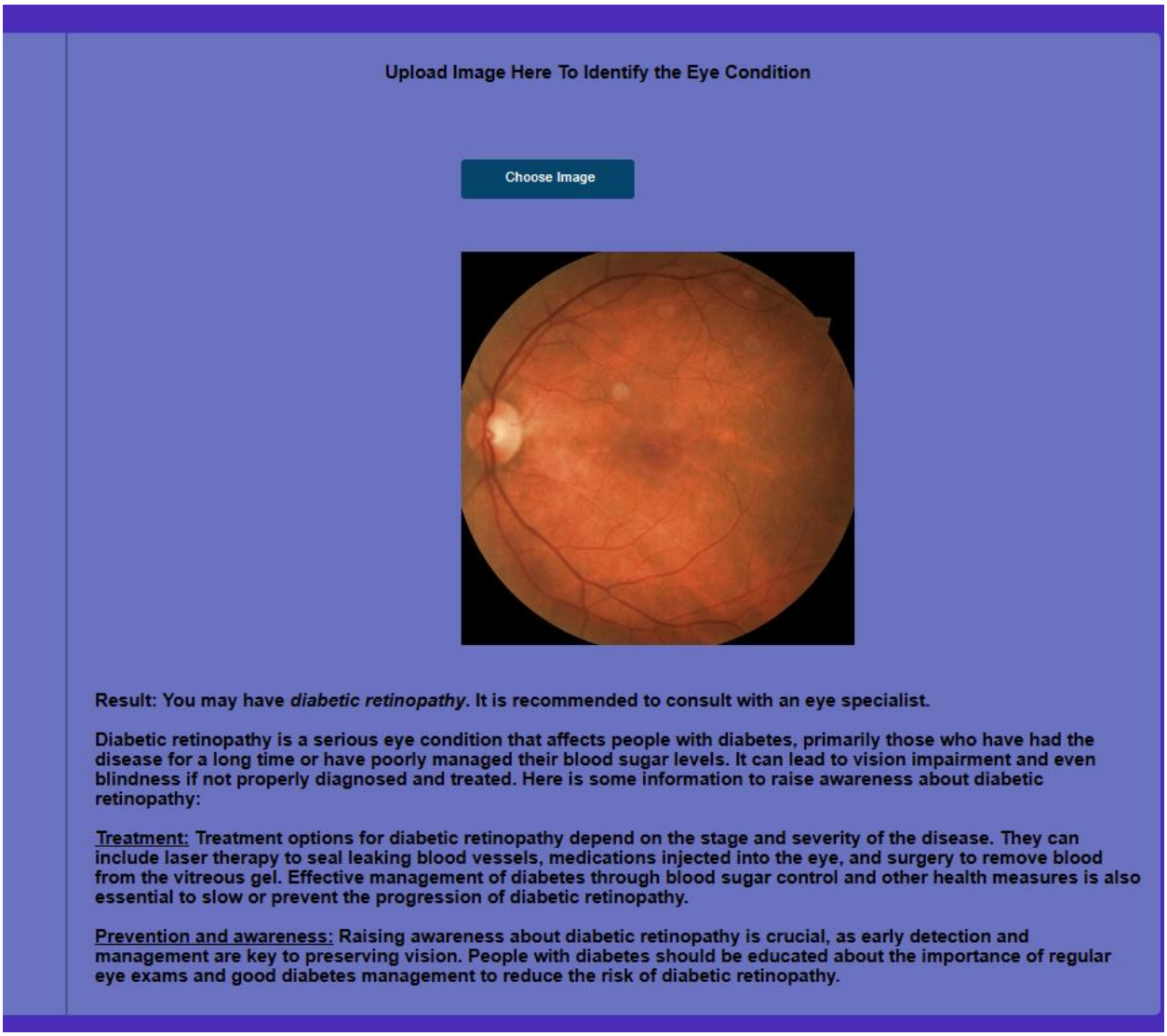
FAQ's(Frequently asked questions)



Input Given for Prediction:



Output:



10. ADVANTAGES & DISADVANTAGES

Advantages:

1.Early Detection and Intervention:

The web application facilitates early detection of eye diseases, enabling timely intervention and treatment. This is crucial for preventing the progression of conditions and improving patient outcomes.

2. Accessibility:

- The system increases accessibility to eye disease diagnosis, especially for individuals in remote or underserved areas who may have limited access to specialized eye care services. Users can upload images from the comfort of their homes.

3. Efficiency and Speed:

Leveraging deep learning models allows for quick and efficient analysis of eye images, providing rapid predictions. This speed is essential for timely decision-making in healthcare.

4. User-Friendly Interface:

The user-friendly interface simplifies the process of uploading images and receiving predictions, making it accessible to individuals with varying levels of technical expertise.

5.Cost-Effective Screening:

- Automated image analysis can serve as a cost-effective screening tool, potentially reducing the need for extensive manual examinations and enabling efficient allocation of healthcare resources.

Disadvantages:

1. Dependency on Image Quality:

The accuracy of predictions is highly dependent on the quality of the uploaded images. Poor-quality images may result in inaccurate or unreliable predictions.

2. Over Reliance on Pre-Trained Models:

- While pre-trained models like Inception V3, VGG19, and Xception V3 are effective, they might not cover all demographic groups or specific types of eye diseases. Over Reliance on these models may lead to biases or limitations in the system's performance.

3. Data Privacy Concerns:

- Handling sensitive medical images raises concerns about data privacy and security. Ensuring compliance with data protection regulations is critical to maintaining user trust and legal adherence.

4. Need for Regular Model Updates:

The field of deep learning evolves, and models may become outdated. Regular updates to the deep learning models are necessary to ensure the system's continued effectiveness in detecting new patterns and variations of eye diseases.

5.Limited Human Interaction:

The automated nature of the system may result in a lack of direct interaction with healthcare professionals. While it serves as a screening tool, it cannot replace the expertise and nuanced understanding provided by human practitioners.

6. Potential for False Positives/Negatives:

Like any diagnostic tool, the system may produce false positives or false negatives. It is essential for users and healthcare providers to interpret the results within the context of a broader clinical assessment.

11. CONCLUSION

In conclusion, the development of a web application for predicting eye diseases using deep learning models represents a significant step toward enhancing the accessibility and efficiency of eye care diagnostics. The advantages, such as early detection, increased accessibility, and cost-effective screening, demonstrate the potential impact on public health. However, it is essential to acknowledge and address the challenges, including the dependency on image quality, potential biases in pre-trained models, data privacy concerns, and the need for regular updates. Striking a balance between the automated nature of the system and the crucial role of human healthcare professionals is vital.

As advancements continue in the field of deep learning, ongoing monitoring and refinement of the system are necessary to ensure accuracy, reliability, and adherence to ethical and privacy standards. This web application holds promise in contributing to proactive healthcare by providing a valuable tool for the early identification of eye diseases, ultimately improving patient outcomes and contributing to a more accessible and efficient healthcare landscape.

12. FUTURE SCOPE

The future scope of the eye disease prediction web application is promising and encompasses several areas for further enhancement and impact. Firstly, ongoing research and development efforts can focus on refining and expanding the deep learning models to address a broader spectrum of eye diseases, ensuring the system's effectiveness across diverse demographic groups and clinical scenarios. Integration with emerging technologies, such as augmented reality or virtual reality, could enhance the user experience and provide more immersive insights for healthcare professionals.

Additionally, collaborating with healthcare institutions for real-time data exchange and incorporating electronic health records could further streamline the diagnostic process. As the field of artificial intelligence progresses, continual updates to the web application's models and algorithms will be imperative to stay abreast of advancements and improve overall accuracy. Exploring opportunities for mobile applications or telemedicine integrations could extend the reach of the tool, especially in remote or rural areas.

Finally, fostering partnerships with eye care organizations and regulatory bodies can ensure compliance with evolving healthcare standards and facilitate the integration of the application into broader healthcare systems. The future holds exciting possibilities for this technology, making strides towards more accessible, efficient, and comprehensive eye care diagnostics.

13. APPENDIX

GitHub Source Code
https://github.com/rahulch-1/EyeSnap

Project Demo Link
https://drive.google.com/file/d/1r466rd2nLh6LaUyGQ_PevCV_skpHeozK/view?usp=sharing