GLAUCOMA DETECTION USING CNN

A project report submitted in partial fulfilment of the requirement for the award of the degree of

BACHELOR OF TECHNOLOGY

in

COMPUTER SCIENCE AND ENGINEERING

Submitted by

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

ENGINEERING AND TECHNOLOGY PROGRAM

GAYATRI VIDYA PARISHAD COLLEGE FOR DEGREE AND PG COURSES (A)

Rushikonda, Visakhapatnam - 45

(Approved by AICTE| Accredited by NBA| Accredited by NAAC| Affiliated to Andhra University)

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

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CERTIFICATE

This is to certify that the project report entitled "GLAUCOMA DETECTION USING CNN" being submitted by Guntreddi Sai Yugandhar (5201411037), Bongu Dorababu (5201411029), Petla Girish (5201411067), Bulusu Venkata Subbarao (5201411012) in the partial fulfillment for the award of the Degree of Bachelor of Technology in Computer Science and Engineering to the Gayatri Vidya Parishad College for Degree and PG Courses, Visakhapatnam is a record of bonafied work carried out under my guidance and supervision.

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Associate Professor	**Professor**
M. Tech,Ph.D	M. Tech, Ph.D

External Examiner

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PSO 3: System Testing and Deployment: Verify and Validate the Systems, Procedures and Processes using various testing and verification techniques and tools.

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DECLARATION

We hereby declare that the project entitled **"GLAUCOMA DETECTION USING CNN"** submitted in partial fulfilment of the requirements for the award of Bachelor of Technology in Computer Science and Engineering, to Engineering and Technology Program, Gayatri Vidya Parishad College for Degree & PG Courses (A). We assure that this project is not submitted in any other University or College.

Name & Signature of the Students

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ABSTRACT

Glaucoma, a leading cause of global blindness, necessitates early detection and treatment to prevent vision loss. Detecting glaucoma in its early stages can be challenging. Convolutional neural networks (CNNs) have shown promise in glaucoma detection, but their accuracy can be further enhanced with larger and more diverse datasets. Datasets including DRISTHI, Rim-One, and ACRIMA are meticulously explored, and their combination is augmented for diversity. The code implements a CNN with optimized architecture, utilizing data augmentation and a careful dataset split. The method utilizes a large-scale dataset of fundus images from glaucoma patients and healthy controls, enhanced with various augmentation techniques to enhance image diversity. The proposed approach offers several advantages, including the use of a large-scale dataset, and robust evaluation on a test set. Early stopping is employed for robust training, and the resulting model is evaluated for accuracy on a comprehensive testing set.. This method holds great potential in improving glaucoma detection accuracy and subsequently preventing blindness. Its application could lead to the development of a clinical tool for glaucoma detection and contribute to a deeper understanding of the disease, fostering the development of novel treatments.

Keywords: feature extraction, deep learning, CNN, Image Data Generator, Glaucomatous.

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1. INTRODUCTION

1.1 About Project Problem

Glaucoma is a group of eye diseases that result in damage to the optic nerve (or retina) and causes vision loss. Open-angle glaucoma develops slowly over time and there is no pain. Peripheral vision may begin to decrease, followed by central vision, resulting in blindness if not treated. Closed-angle glaucoma can present gradually or suddenly. The most common type is open-angle (wide angle, chronic simple) glaucoma, in which the drainage angle for fluid within the eye remains open, with less common types including closed-angle (narrow-angle, acute congestive) glaucoma and normal-tension glaucoma. The sudden sight may involve severe eye pain, blurred vision, mid-dilated pupils, redness of the eye, and nausea. Vision loss from glaucoma, once it has occurred, is permanent. Eyes affected by glaucoma are referred to as being glaucomatous.

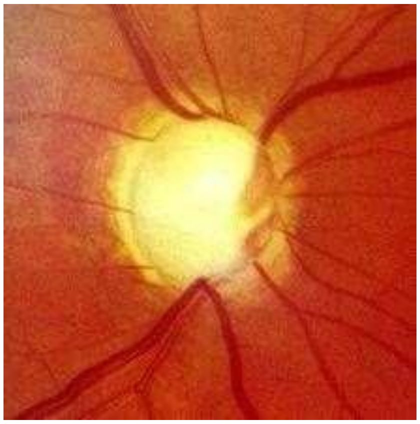


Figure 1.1: Optic nerve in advanced glaucoma disease

Risk factors for glaucoma include increasing age, high pressure in the eye, a family history of glaucoma, and use of steroid medication. For eye pressures, a value of 21 mmHg or 2.8 kPa above atmospheric pressure (760 mmHg) is often used, with higher pressures leading to greater risk. However, some may have high eye pressure for years and never develop damage. Conversely, optic nerve damage may occur with normal pressure, known as normal- tension glaucoma. The mechanism of open-angle glaucoma is believed to be the slow exit of humor through the trabecular meshwork, while in closed-angle glaucoma the iris blocks the trabecular meshwork. Diagnosis is achieved by performing a dilated eye examination. Often, the optic nerve shows an abnormal amount of cupping.

If treated early, it is possible to slow or stop the progression of the disease with medication, laser treatment, or surgery. The goal of these treatments is to decrease eye pressure. Several different classes of glaucoma medication are available. Laser treatments may be effective in both open-angle and closed-angle glaucoma. Several types of glaucoma surgeries may be used in people who do not respond sufficiently to other measures. Treatment of closed-angle glaucoma is a medical emergency.

About 70 million people have glaucoma globally, with about two million patients in the United States. It is the leading cause of blindness in African Americans. It occurs more commonly among older people, and closed-angle glaucoma is more common in women. Glaucoma has been called the "silent thief of sight" because the loss of vision usually occurs slowly over a long period. Worldwide, glaucoma is the second-leading cause of blindness after cataracts. Cataracts caused 51% of blindness in 2010, while glaucoma caused 8%. The word "glaucoma" is from the Ancient Greek glaucous, which means "shimmering." In English, the word was used as early as 1587 but did not become commonly used until after 1850, when the development of the ophthalmoscope allowed doctors to see optic nerve damage.

There are a large number of types of glaucoma which occurs in the human eyes both at the primary level, secondary level & at tertiary level, which is termed as the normal, moderate & the re level in context the of severity of the disease. Here, in this section, different types of glaucoma are discus as below. These are marked by an increase of intraocular pressure (IOP) or pressure inside the eye.

- Open-Angle Glaucoma

- Angle-Closure
- Normal Tension Glaucoma
- Congenital Glaucoma
- Primary Glaucoma
- Secondary Glaucoma
- Neo-vascular glaucoma
- Neo-vascular glaucoma
- Exfoliate Glaucoma
- Pigmentary Glaucoma
- Chronic Glaucoma
- Traumatic Glaucoma

The research work that we are going to take up further is going to deal with the primary glaucoma detection along with the hardware implementation of the same so that both at the simulation level & at implementation level, it would have been validated.

1.1.1 Signs and Symptoms

As open-angle glaucoma is usually painless with no symptoms early in the disease process, screening through regular eye exams is important. The only signs are gradually progressive visual field loss and optic nerve changes (increased cup-to-disc ratio on fundoscopic examination).

About 10% of people with closed angles present with acute angle closure characterized by sudden ocular pain, seeing halos around lights, red eye, very high intraocular pressure (>30 mmHg (4.0 kPa)), nausea and vomiting, sudden decreased vision, and a fixed, mid-dilated pupil. It is also associated with an oval pupil in some cases. Acute angle closure is an emergency. Opaque specks may occur in the lens in glaucoma, known as glaukomflecken.

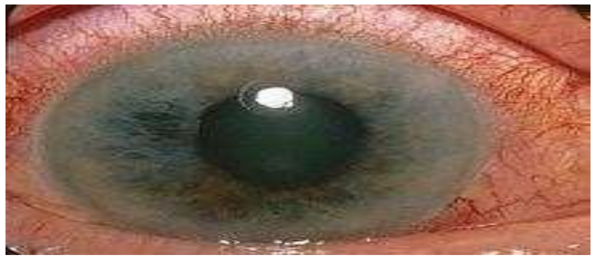


Figure 1.2: Photo showing conjunctival vessels dilated at the cornea edge and hazy cornea characteristics of acute closure glaucoma

1.1.2 Causes

Ocular hypertension (increased pressure within the eye) is the most important risk factor for glaucoma, but only about 50% of people with primary open-angle glaucoma have elevated ocular pressure. Ocular hypertension—an intraocular pressure above the traditional threshold of 21 mmHg (2.8 kPa) or even above 24 mmHg (3.2 kPa)—is not necessarily a pathological condition, but it increases the risk of developing glaucoma. One study found a conversion rate of 18% within five years, meaning fewer than one in five people with elevated intraocular pressure will develop glaucomatous visual field loss over that period. It is a matter of debate whether every person with elevated intraocular pressure should receive glaucoma therapy; currently, most ophthalmologists favor the treatment of those with additional risk factors.

Open-angle glaucoma accounts for 90% of glaucoma cases in the United States. Closed- angle glaucoma accounts for fewer than 10% of glaucoma cases in the United States, but as many as half of glaucoma cases in other nations (particularly East Asian countries).

1.1.3 Other

Other factors can cause glaucoma, known as "secondary glaucoma", including prolonged use of steroids (steroid-induced glaucoma); conditions that severely restrict blood flow to the eye, such as severe diabetic retinopathy and central retinal vein occlusion (neovascular glaucoma); ocular trauma (angle-recession glaucoma); and inflammation of the middle layer of the pigmented vascular eye structure (uveitis), known as uveitis glaucoma.

1.1.4 Diagnosis

Screening for glaucoma is usually performed as part of a standard eye examination performed by optometrists and ophthalmologists. Testing for glaucoma includes measurements of the intraocular pressure using tonometry, anterior chamber angle examination, or gonioscopy as well as an examination of the optic nerve to discern visible damage, changes in the cup-to-disc ratio, rim appearance, and vascular change. In figure 1.3, we can observe the cross-sectional view of an eye. A formal visual field test is performed. The retinal nerve fibre layer can be assessed with imaging techniques such as optical coherence tomography, scanning laser polarimetry, or scanning laser ophthalmoscopy (Heidelberg retinal tomogram). Visual field loss is the most specific sign of the condition, though it occurs later in the course of the disease.

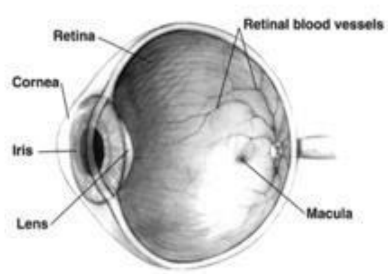


Figure 1.3: Human eye cross-sectional view

As all methods of tonometry are sensitive to corneal thickness, methods such as Goldmann tonometry may be augmented with pachymetry to measure the central corneal thickness (CCT). A thicker cornea can result in a pressure reading higher than the true pressure but a thinner cornea can produce a pressure reading lower than the true pressure.

Because pressure-measurement error can be caused by more than just CCT (such as by corneal hydration or elastic properties), it is impossible to adjust pressure measurements based only on CCT measurements. The frequency-doubling illusion can also be used to detect glaucoma with the use of a frequency-doubling technology perimeter.

1.1.5 Data Pre-processing

Data pre-processing is a process of preparing the raw data and making it suitable for a machine learning model. It is the first and crucial step while creating a machine-learning model. Image pre-processing is the term for operations on images at the lowest level of abstraction. These operations do not increase image information content but they decrease it if entropy is an information measure. The aim of pre-processing is an improvement of the image data that suppresses undesired distortions or enhances some image features relevant for further processing and analysis tasks.

Geometric transforms permit the elimination of geometric distortion that occurs when an image is captured. When creating a machine learning project, it is not always the case that we come across clean and formatted data. And while doing any operation with data, it is mandatory to clean it and put it in a formatted way. So, for this, we use a data pre-processing task.

1.1.6 Data Augmentation

Data augmentation is a technique of artificially increasing the training set by creating modified copies of a dataset using existing data. It includes making minor changes to the dataset or using deep learning to generate new data points.

Image Augmentation

Geometric transformations: randomly flip, crop, rotate, stretch, and zoom images. You need to be careful about applying multiple transformations on the same images, as this can reduce model performance.

Color space transformations: randomly change RGB color channels, contrast, and brightness.

Kernel filters: randomly change the sharpness or blurring of the image.

Random erasing: delete some part of the initial image.

Mixing images: blending and mixing multiple images.

Image Data Generator

ImageDataGenerator is used to determine the source of the data, after which it randomly alters the data and produces an output result that only contains the freshly altered data. No new information is provided. To increase the generality of the model as a whole, data augmentation is also carried out using the Keras picture data generator class. Data augmentation conducts random operations such as translations, scale changes, shearing, rotations, and horizontal flips using an image data generator. Image data generators are employed to produce batches of data from tensor images in the field of actual data augmentation. We can cycle through the input in batches while using Keras' picture data generator. The picture data generator class has a number of methods and arguments that aid in defining the data generation's behaviour. Only the newly changed data is returned by the ImageDataGenerator after accepting the original data and randomly transforming it.

Operations in data generator

a. Randomly Zoomed

The image is zoomed using the zoom augmentation technique. With this technique, the image is randomly zoomed in or enlarged by adding pixels all around it. The zoom range argument from the ImageDataGenerator class is used in this method.

The same boundary values apply to zoom as they do in the case of the brightness parameter. The figure is zoomed in when the magnification value is lesser than l1.0 and out when it is larger than 1.0. The supplied image's actual class designation will remain unchanged once these changes are applied.

b. Random Brightness

The image's brightness fluctuates erratically. Additionally, it is a really helpful augmentation strategy as our item won't always be under ideal illumination. It is crucial to develop our model on photographs taken in various lighting scenarios. Accordingly, depending on the argument we supply to the ImageDataGenerator class function Object() { [native code] }, this method may make the images a little bit brighter, darker, or both. This is possible thanks to the brightness range setting. The maximum and minimum values are sent as floats, which treat them as percentages to be applied to the image. One boundary value, 1.0, determines how bright things are and how dark things are. In contrast to [0.5,1.0], where a number greater than 1.0 brightens the image, a value less than 1.0 will cause it to become darker.

c. Random Flips

The pixels will be turned around, either row-wise or column-wise, depending on whether the flip is vertical or horizontal. The vertical flip and horizontal flip arguments will be used to call this method within the ImageDataGenerator class. A horizontal flip effectively rotates both columns and rows simultaneously. A vertical flip, in essence, turns both columns and rows vertically. The mirror image of the sector in the vertical line across the centre of the image can then be used to define the updated coordinates of each corner. For the mathematically interested, the vertical bisector of the line connecting the old corner and the new, changed corner would be the vertical line going through the centre.

d. Random Shifts

When a picture is shifted, all of its pixels are moved in a single direction—such as horizontally or vertically—while maintaining its original dimensions. This implies that some pixels will be removed from the image and that new number of pixels will need to be given for a portion of the image. The pixels of the image move horizontally when a horizontal shift amplification is used, but the image's dimensions remain unchanged. New pixels would be added to a region that already contains pixels in order to keep the same image dimension.

e. Random Rotations

Picture rotation, which makes the image autonomous of the object's orientation, is one of the often-used methods of augmentation. You can rotate images arbitrarily over any angle from 0 to 360 degrees using the ImageDataGenerator course by providing an integer value in the rotation limit argument. Certain pixels will rotate outside the image, producing a void that needs to be filled up. The augmentation object also selects a value between zero and the highest (which we defined). Once these modifications are made, the actual class classification of the supplied image will not change. The training model will, however, treat each changed image as if it were a brand-new image, thus in this manner, we are performing a different kind of regularisation procedure. Additionally, you can apply this technique to a future deep-learning project.

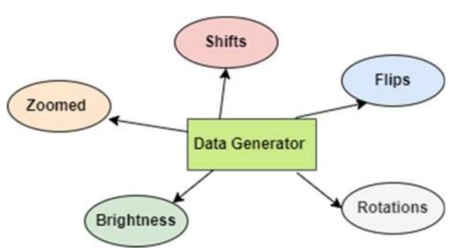


Figure 1.4: Operations in data generator

1.1.7 Classification

Classification predictive modeling involves assigning a class label to input examples. Classification is the process of finding or discovering a model or function which helps in separating the data into multiple categorical classes i.e. discrete values. In classification, data is categorized under different labels according to some parameters given in input and then the labels are predicted for the data.

The derived mapping function could be demonstrated in the form of "IF-THEN" rules. The classification process deal with the problems where the data can be divided into binary or multiple discrete labels. Convolutional neural networks receive images as input and use them to train a classifier. The network employs a special mathematical operation called a "convolution" instead of matrix multiplication. The architecture of a convolutional network typically consists of four types of layers: convolution, pooling, activation, and fully connected.

1.2 Scope

Using Convolutional Neural Networks will achieve good results, as CNN is used for learning complex features efficiently as the model has many layers and CNN performs intensive computational tasks simultaneously. We are using individual datasets to make a large dataset. So, we included CNN doesn't need any manual power i.e. human supervision. We can determine the stage of glaucoma of an individual using the amount of ocular pressure, optic disc, and optic cup. Data augmentation can be applied for small datasets. Another advantage of Data Augmentation is it multiples the images so that detection is performed more productively.

1.3 Purpose

From the literature surveyed in section 2, it is found that most of the researchers have worked with a relatively small number of images, fundus images from private datasets and datasets that lack real time variations in image quality. This hampers the robustness of the system. There is a need to develop a model which works for images acquired under different environmental conditions. Also, there is scope in enhancing the classification accuracy as much as possible. Although there have been a significant number of techniques proposed in the literature, it is required to develop an efficient algorithm using a maximum number of subjects.

1.4 Motivation

Being the second largest cause of blindness worldwide, it can lead the person towards complete blindness if an early diagnosis does not take place. Concerning this underlying issue, there is an immense need of developing a system that can effectively work in the absence of excessive equipment, skilled medical practitioners and also is less time consuming. As a result, clinicians in rural areas can also be able to efficiently use this application for their diagnosis. As glaucoma diagnosis is a time-consuming procedure and requires skilled professionals, no special skills are required to work with developed applications

1.5 Problem Statement

The eyes are important sensory organs that provides sight. Glaucoma is a neuro-degenerative eye disease developed due to an increase in the Intraocular Pressure inside the retina. When the cup-to-disc ratio is greater than the normal range, the patient's eye is suspected as glaucomatous eye. Doctors need to perform many tests such as: Ophthalmic Test, Tonometry, Ophthalmoscopy, Perimetry, Pachymetry, Gonioscopy. After getting results from different test, doctor have to decide whether it is a glaucomatous eye or not. Careful evolution is important to detect glaucoma and there is a high chance of not getting accurate result due to lack of skill. Being the second largest cause of blindness worldwide, it can lead the person towards complete blindness if an early diagnosis does not take place. With respect to this underlying issue, there is an immense need of developing a system that can effectively work in the absence of excessive equipment, skilled medical practitioners and also is less time consuming.

2. LITERATURE SURVEY

Amer Sallam, Abdulguddoos S. A. Gaid, Wedad Q.A Saif, published a research paper named after "**Early Detection of Glaucoma using Transfer Learning from Pre-trained CNN Models**" which describes its abstract as "Glaucoma is one of the common diseases that might cause visual field loss, and typically affects elderly people. It is caused by fluid imbalance within the eye that leads to increase in intraocular pressure (IOP), and therefore a damage to the optic nerve head (ONH) which is responsible in transmitting visual neurological signals to the brain. Traditional methods for detecting Glaucoma disease either tedious and slow or too expensive. Hence, early detection of Glaucoma is essential to avoid permanent blindness which might be caused by the ONH failure. In this paper, an automated detection method on the basis of pre-trained Convolutional Neural Network (CNN) models is proposed to detect Glaucoma from fundus images. The proposed method not only contributes to early detection of Glaucoma disease, but also helps optometry doctors in making fast decision with inexpensive tools. Pre-trained AlexNet, VGG11, VGG16, VGG19, GoogleNet (Inception V1), ResNET-18, ResNET 50, ResNET-101 and ResNet-152 models were leveraged to develop the proposed Glaucoma detection method. The proposed method was evaluated by Large-scale Attention based Glaucoma (LAG) dataset. Satisfying results of 81.4%, 80%, 82.2%, 80.9%, 82.9%, 86.7%, 85.6%, 86.2%, and 86.9% were observed on LAG dataset using AlexNet, VGG11, VGG16, VGG19, GoogleNet (Inception V1), ResNET-18, ResNET-50, ResNET-101 and ResNet-152 models respectively. Out of these results, the ResNet-152 model found to be the best that achieved a high accuracy with precision 86.9% and recall 86.9%."

Liu Li, Mai Xu, Hanruo Liu, Yang Li, Xiaofei Wang, Lai Jiang, Zulin Wang, Xiang Fan, and Ningli Wang,published a research paper named after "**A Large-scale Database and a CNN Model for Attention-based Glaucoma Detection**" which describes its abstract as "Glaucoma is one of the leading causes of irreversible vision loss. Many approaches have recently been proposed for automatic glaucoma detection based on fundus images. However, none of the existing approaches can efficiently remove high redundancy in fundus images for glaucoma detection, which may reduce the reliability and accuracy of glaucoma detection. To avoid this disadvantage, this paper proposes an attention-based convolu tional neural network (CNN) for glaucoma detection, called AG CNN. Specifically, we first establish a large-scale attention-based glaucoma (LAG) database, which includes 11,760 fundus images labeled as either positive glaucoma (4,878) or negative glaucoma (6,882). Among the 11,760 fundus images, the attention maps of 5,824 images are further obtained from ophthalmologists through a simulated eye-tracking experiment. Then, a new structure of AG-CNN is designed, including an attention prediction subnet, a pathological area localization subnet and a glaucoma classification subnet. The attention maps are predicted in the attention prediction subnet to highlight the salient regions for glaucoma detection, under a weakly supervised training manner. In contrast to other attention-based CNN methods, the features are also visualized as the localized pathological area, which are further added in our AG CNN structure to enhance the glaucoma detection performance. Finally, the experiment results from testing over our LAG database and another public glaucoma database show that the proposed AG-CNN approach significantly advances the state-of-the-art in glaucoma detection."

Ms Arkaja Saxena, Ms Abhilasha Vyas, Mr Lokesh Parashar, Mr Upendra Singh published a research paper named after "**A Glaucoma Detection using Convolutional Neural Network**" which describes its abstract as "Glaucoma is a disease that relates to the vision of the human eye. This disease is considered as the irreversible disease that results in the vision deterioration. Much deep learning (DL) models have been developed for the proper detection of glaucoma so far. So this paper presents architecture for the proper glaucoma detection based on the deep learning by making use of the convolutional neural network (CNN). The differentiation between the patterns formed for glaucoma and non-glaucoma can find out with the use of the CNN. The CNN provides a hierarchical structure of the images for differentiation. Proposed work can be evaluated with a total of six layers. Here the dropout mechanism is also used for achieving the adequate performance in the glaucoma detection. The datasets used for the experiments are the SCES and ORIGA. The analysis is performed for both the dataset and the obtained values are .822 and .882 for the ORIGA and SCES dataset respectively."

3. REQUIREMENTS AND ANALYSIS

3.1 Existing system

Several studies have delved into the realm of glaucoma detection utilizing convolutional neural network (CNN) architectures. Despite their innovative approaches, these models typically exhibit average accuracies ranging between 83% to 95.75%. For instance, ResNet-50, a renowned deep CNN architecture, has achieved a commendable accuracy of 94.5%. Similarly, other architectures like the Efficient-net CNNs model (88%), CNN model (94%), Inception V3 (90.4%), googleNet (83%), and DENet (91.83%) have also been explored. While these models display reasonable performance, they often grapple with limitations associated with relatively small datasets. The restricted data size and quality hinder their ability to attain optimal accuracy, thereby compromising their effectiveness in real-world applications. Despite their advancements, these existing systems underscore the ongoing challenge in glaucoma detection, urging for further refinement to enhance diagnostic accuracy and reliability.

3.2 Proposed system

In stark contrast, our proposed system marks a significant leap forward in glaucoma detection efficacy. By capitalizing on a larger and more diverse dataset, our model achieves a strikingly improved accuracy of 97-98%. This substantial enhancement is a result of meticulous integration of various components, including well-suited CNN architectures, sophisticated loss functions, data augmentation techniques, and early stopping mechanisms. Moreover, our approach ensures the creation of a balanced dataset, with equal representation of glaucoma and normal images. This strategic dataset curation empowers the model to generalize better, ensuring robust performance in real-world scenarios. Additionally, our system exhibits remarkable resilience in processing low-quality images, which is pivotal for its practical applicability in clinical settings where image quality may vary. In essence, our proposed system represents a pioneering advancement in glaucoma detection, offering unprecedented accuracy and reliability, thus holding immense promise for improving patient outcomes and clinical decision-making.

3.2.1 Project scope

1. Utilization of CNNs for glaucoma detection using meticulously curated and augmented datasets including DRISTHI, Rim-One, and ACRIMA.

2. Implementation of an optimized CNN architecture with data augmentation techniques for enhanced diversity and accuracy.

3. Evaluation of the proposed approach on a large-scale dataset, incorporating early stopping for robust training and comprehensive testing for accurate assessment.

3.2.2 Project objectives

1. Develop a robust CNN model for early glaucoma detection by leveraging diverse and large-scale datasets.
2. Optimize the CNN architecture and incorporate data augmentation techniques to enhance model performance and diversity.
3. Evaluate the trained model on a comprehensive testing set, utilizing early stopping for robust training and ensuring accurate assessment of glaucoma detection accuracy.

3.3 Functional Requirements

The functional requirements describe the inputs and outputs of the application. The functional requirements of this project are as follows:

- Fundus Image
- User Interface giving result

3.3.1 Actors

Actors represent external entities that interact with the system. An actor can be human or an external system. During this activity, developers identify the actors involved in this system. In this project, user is:

User: Any person

3.3.2 Use cases

Use cases are used during requirement elicitation and analysis to represent the functionality of the system. Use cases focus on the behaviour of the system from an external point of view. A use case describes a function provided by the system that yields a visible result for an actor. An actor describes any entity that interacts with the system.

The identification of actors and use cases results in the definition of the boundary of the system, which is, in differentiating the tasks accomplished by the system and the tasks accomplished by its environment. The actors are outside the boundary of the system, whereas the use cases are inside the boundary of the system.

Actors are external entities that interact with the system. Use cases describe the behaviour of the system as seen from an actor's point of view. Actors initiate a use case to access the system functionality. The use case then initiates other use cases and gathers more information from the actors. When actors and use cases exchange information, they are said to be communicate.

To describe a use case we use a template composed of six fields:

Use Case Name	:	The name of the use case
Participating Actors	:	The actors participating in the particular use case
Flow of events	:	Sequence of steps describing the function of use case

Exit Condition	:	Condition for terminating the use case
Quality Requirements	:	Requirements that do not belong to the use case but constraint the functionality of the system.

3.4. Non-Functional Requirements:

1. Security

   The system must be able to restrict user access and sessions. Data must also be stored in a secure manner and location. It necessitates a safe path for data transmission.

2. Concurrency and Capacity

   Multiple calculations should be able to run on the system. Concurrently and maybe in interaction with one another.

3. Performance

   Most people associate performance with a timeline. These are some of the most significant factors, particularly when the project is in the architecture phase.

4. Reliability

   It is necessary to ensure and notify about the system transactions and processing as simple as keeping a system log will increase the time and effort to get it done from the very beginning. Data should be transferred reliably and using trustful protocols.

5. Maintainability

   A well-designed system is intended to be operational for a long time. Consequently, it will Preventive and corrective maintenance are frequently required. Maintenance could mean the system's potential to expand and upgrade its features and functionalities.

6. Usability

One of the main pillars that supports a product is end-user approval and pleasure in project achievement. The user experience needs should be taken into account from the project's inception onward. This will significantly save time when the project is released. The user won't request adjustments or, in the worst-case scenario, clarifications.

7. Documentation

    All projects require a minimum of documentation at different levels. In many cases the users might even need training on it, so keeping good documentation practices and standards will do this task spread along the project development; but as well this must be established since the project planning to include this task in the list.

3.4.1 Hardware Specifications

The minimal hardware specifications of the proposed system are,

- Processor : Intel I5
- RAM : 8 GB
- Hard Disk : 64 GB

3.4.2 Software Specifications

The minimal software specifications of the proposed system are,

- Operating System : Windows XP
- Technology : Python3,HTML,CSS
- Framework : Flask
- Tools / Libraries : Tensor flow, Keras
- Dataset : Image data

Windows OS

The Windows Operating System, crafted by Microsoft, stands as a cornerstone in the realm of personal computing, captivating users with its intuitive interface, extensive hardware and software compatibility, and steadfast commitment to security. It has emerged as the go-to choice for millions worldwide, offering a seamless experience that balances functionality with ease of use. Continuously evolving to meet the ever-changing demands of technology, Windows remains at the forefront of innovation, introducing new features and enhancements with each iteration. Its robustness and adaptability make it a trusted companion for individuals, businesses, and institutions alike. As computing landscapes evolve, Windows continues to redefine possibilities, empowering users to achieve more and explore new horizons. With its enduring legacy and unwavering dedication to excellence, Windows remains an indispensable part of modern computing, shaping the digital experiences of generations to come.

Python

Python is an interpreted, high-level, general purpose programming language. Python has a design philosophy that emphasizes code readability, notably using significant whitespace. It provides constructs that enable clear programming on both small and large scales. Python features a dynamic type system and automatic memory management. It supports multiple programming paradigms, including object-oriented, imperative, functional and procedural. It also has a comprehensive standard library.

Python interpreters are available for many operating systems. CPython, the reference implementation of Python, is open source software and has a community-based development model, as do nearly all of Python’s other implementations. Python uses dynamic typing, and a combination of reference counting and a cycle-detecting garbage collector for memory management. It also features dynamic name resolution (late binding), which binds method and variable names during program execution.

Fig. 3.4.1.9 Python Language logo

HTML

HTML (Hypertext Markup Language) serves as the backbone of the World Wide Web, providing a standardized markup language for creating web pages and web applications. Developed by Tim Berners-Lee in the early 1990s, HTML facilitates the structuring of content on webpages through a system of tags and attributes. These tags define various elements such as headings, paragraphs, links, images, and forms, enabling the creation of rich and interactive web experiences. HTML documents are inherently hierarchical, organized in a tree-like structure known as the Document Object Model (DOM), which browsers interpret and render into visual representations. As the cornerstone of web development, HTML works in conjunction with CSS (Cascading Style Sheets) and JavaScript to define the structure, presentation, and behavior of web content, ensuring compatibility across different browsers and devices.

CSS

CSS (Cascading Style Sheets) complements HTML by providing a mechanism for defining the visual presentation and layout of web pages and web applications. Introduced in the late 1990s as a separate language from HTML, CSS allows developers to specify styling attributes such as colors, fonts, spacing, borders, and animations to enhance the aesthetic appeal and usability of web content. By separating the content from its presentation, CSS promotes maintainability and consistency across web projects, enabling efficient updates and customization. CSS employs a cascading style rule mechanism, where styles can be applied at different levels, from inline styles within HTML elements to external style sheets linked to multiple documents. This flexibility facilitates the creation of responsive designs that adapt seamlessly to various screen sizes and device orientations, ensuring a consistent user experience across desktops, tablets, and smartphones.

FLASK

Flask stands as a lightweight and extensible web framework for Python, designed to facilitate the development of web applications with minimal boilerplate code and maximum flexibility. Created by Armin Ronacher in 2010, Flask follows the principle of simplicity, offering a straightforward yet powerful toolkit for building web services, APIs, and full-fledged web applications. Its modular architecture and reliance on Werkzeug and Jinja2 libraries provide essential components for URL routing, request handling, and template rendering, allowing developers to focus on application logic rather than infrastructure. Flask embraces the concept of microframeworks, encouraging the use of third-party extensions for additional functionality such as authentication, database integration, and caching. With its lightweight nature and minimalistic approach, Flask caters to a wide range of use cases, from small-scale prototypes to large-scale production deployments, making it a popular choice among Python developers for web development projects.

3.5 ANALYSIS

The analysis phase defines the requirements of the system, independent of how these requirements will be accomplished. This phase defines the problem that the customer is trying to solve. The deliverable result at the end of this phase is a requirement document. Analysis object model is represented by class and object diagrams. Analysis focuses on producing a model of the system, called the Analysis model, which is correct, complete, consistent, and verifiable. The analysis model is composed of three individual models: The Functional Model represented by use cases and scenarios, the Analysis Object Model, represented by class and object diagrams, and the Dynamic Model, represented by state chart and sequence diagrams. The analysis model represents the system under development from the user's point of view. The analysis object model is a part of the analysis and focuses on the individual concepts that are manipulated by the system, their properties and their relationships.

3.5.1 Entity Objects

The Analysis object model consists of entity, boundary and control objects. Entity objects represent the persistent information tracked by the system. Participating objects form the basis of the analysis model.

3.5.2 Boundary Objects

Boundary object is the object used for interaction between the user and the system. Moreover, it is an interface used to communicate with the system. Boundary objects represent the system interface with the actors. In each use case, each actor interacts with at least one boundary object. The boundary object collects the information from the actor and translates into an interface model from that can be used by the objects and by the control objects.

3.5.3 Control Objects

Control objects are responsible for coordinating entity objects and boundary objects. A control object is creating at the beginning of the use cases and ceases to exist at its end. Control objects usually do not have a concrete counterpart in the real world. Control object is a responsible for collecting information from the boundary objects and dispatching it to entity object. Here only authorized users can operate, and details obtained are verified. The control objects in this project are admission, result, placement, company and eligibility details.

3.5.4 Object Interaction

Interaction diagrams model the behaviour of use cases by describing the way groups of objects interact to complete the task. The two kinds of interaction diagrams are sequence and collaboration diagrams. Sequence diagrams generally show the sequence of events that occur.

3.5.5 Object Behaviour

State chart diagrams are used to describe the behaviour of a system. They define different states of an object during its lifetime. Each diagram usually represents objects of a single class and tracks the different states of its objects through the system and these states are changed by events. State chart diagram describes the flow of control from one state to another state. State chart diagrams are very important for describing the states. States can be identified as the condition of objects when an event occurs.

4. SYSTEM DESIGN

System Design is the process of defining the architecture, components, modules, interfaces, and data for a system to satisfy specified requirements. In System design, developers:

- Define design goals of the project
- Decompose the system into smaller sub systems
- Design hardware/software strategies
- Design persistent data management strategies
- Design global control flow strategies
- Design access control policies and
- Design strategies for handling boundary conditions.

System design is not algorithmic. It is decomposed of several activities. They are:

- Identify Design Goals
- Design the initial subsystem decomposition
- Refine the subsystem decomposition to address the design goals.

System Design is the transform of analysis model into a system design model. Developers define the design goals of the project and decompose the system into smaller subsystems that can be realized by individual teams. Developers also select strategies for building the system, such as the hardware/software platform on which the system will run, the persistent data management strategy, the goal control flow the access control policy and the handling of boundary conditions. The result of the system design is model that includes a clear description of each of these strategies, subsystem decomposition, and a UML deployment diagram representing the hardware/software mapping of the system.

4.1 Design Goals

Design goals are the qualities that the system should focus on. Many design goals can be inferred from the non-functional requirements or from the application domain.

User friendly: The system is user friendly because it is easy to use and understand.

Reliability: Proper checks are there for any failure in the system if they exist.

4.2 System Architecture

As the complexity of systems increases, the specification of the system decomposition is critical. Moreover, subsystem decomposition is constantly revised whenever new issues are addressed. Subsystems are merged into alone subsystem, a complex subsystem is split into parts, and some subsystems are added to take care of new functionality. The first iterations over the subsystem decomposition can introduce drastic changes in the system design model.

4.3 System Design

The project aims to develop a system for analyzing fundus images provided by users to detect the presence of glaucoma. Employing advanced image processing techniques and convolutional neural networks (CNNs), the system preprocesses and analyzes the images to identify characteristic signs of glaucoma. Through a user-friendly interface, the system delivers prompt and accurate results, enabling early detection of the condition. By providing a reliable tool for assessing eye health, the project endeavors to empower individuals to take proactive measures in managing their vision and seeking timely medical intervention when necessary.

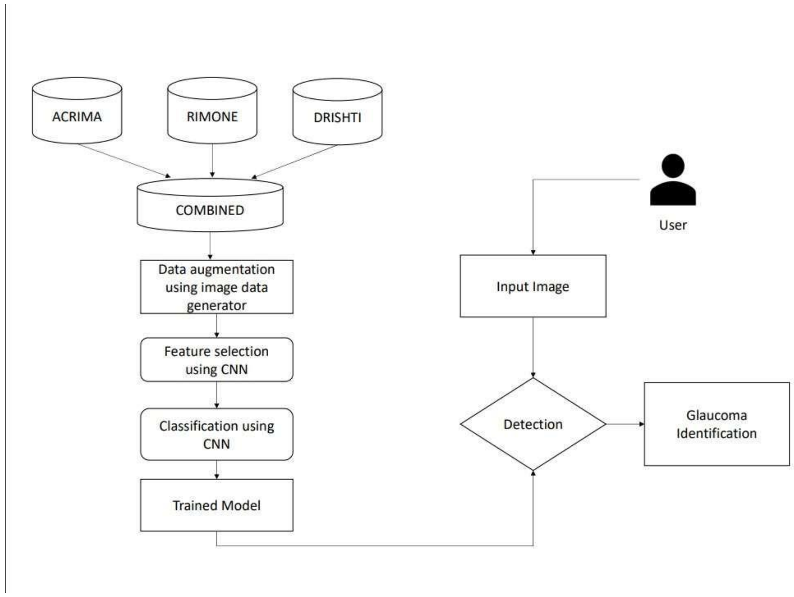


Fig. 4.3.1 System's Block Diagram

4.4 UML Diagrams

A UML diagram is a diagram based on the UML (Unified Modelling Language) with the purpose of visually representing a system along with its main actors, roles, actions, artifacts or classes, in order to better understand, alter, maintain, or document information about the system.

UML is a modern approach to modelling and documenting software. In fact, it's one of the most popular business process modelling techniques. It is based on diagrammatic representations of software components. As the old proverb says: "a picture is worth a thousand words". By using visual representations, we are able to better understand possible flaws or errors in software or business processes.

Mainly UML has been used as a general-purpose modelling language in the field of software engineering. However, it has row found its way into the documentation of several business processes or workflows. For example, activity diagrams, a type of UML diagram, can be used as a replacement for flowcharts. They provide both a more standardized way of modelling workflows as well as a wider range of features to improves readability.

4.4.1 Use Case Diagram

In the Unified Modelling Language(UML), a use case diagram can summarize the details of your system's users(also known as actors) and their interactions with the system. To build one, use a set of specialized symbols and connectors. An effective use case diagram can help the team discuss and represent:

- Scenarios in which system or application interacts with people, organizations, or external systems.
- Goals that your system or application helps those entities (known as actors) achieve.
- The scope of the system.

UML use case diagrams are ideal for:

- Representing the goals of system-user interactions.
- Defining and organizing functional requirements in a system.
- Specifying the context and requirements of a system.
- Modelling the basic flow of events in a use case.

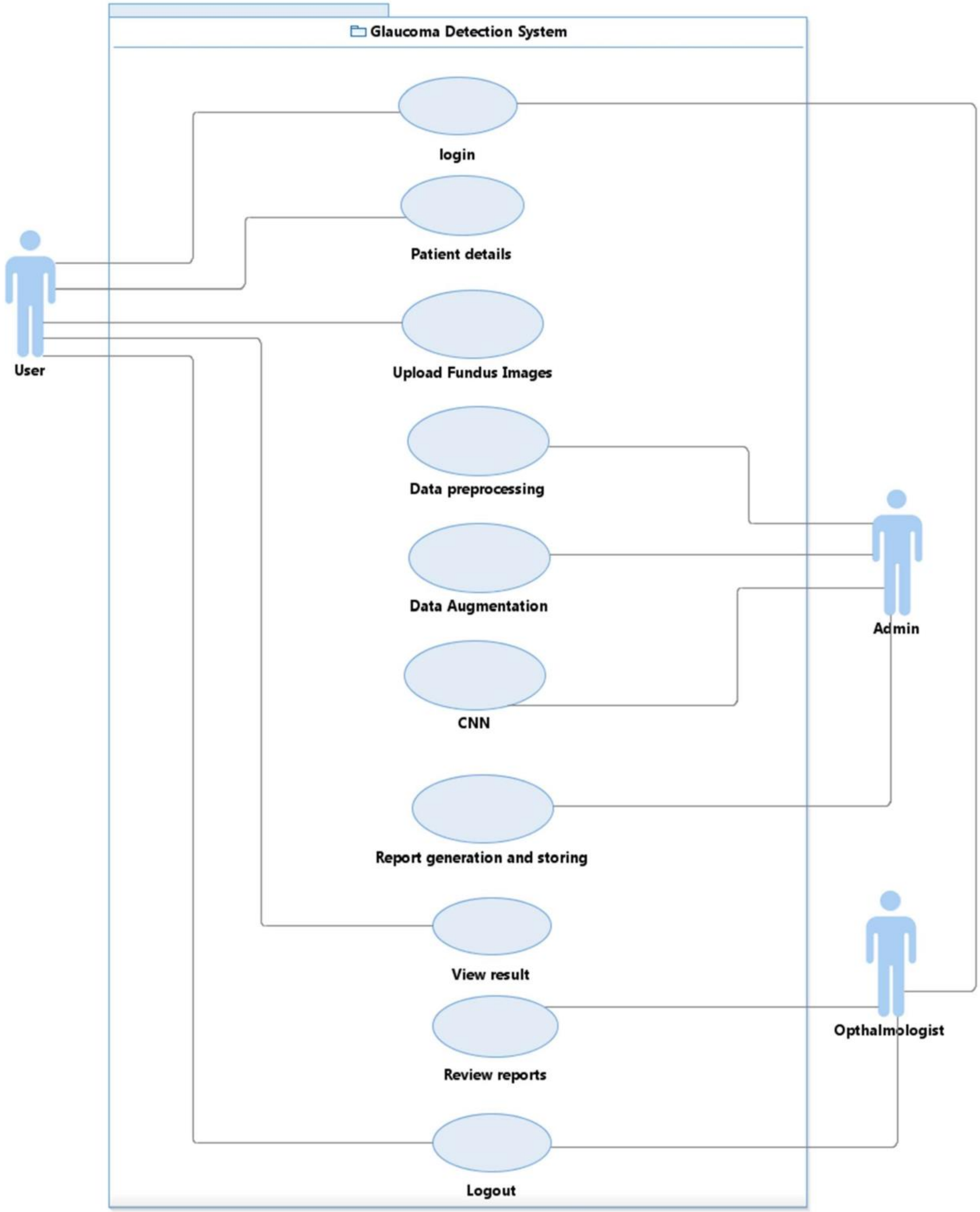


Fig. 4.4.1.1 Use Case Diagram

4.4.2 Class Diagram

Class diagrams are one of the most useful types of diagrams in UML as they clearly map out the structure of a particular system by modelling its classes, attributes, operations, and relationships between objects. It is a static diagram that represents the static view of an application. Class diagram is not only used for visualizing, describing, and documenting different aspects of a system but also for constructing executable code of the software application.

The class shape itself consists of a rectangle with three rows. The top row contains the name of the class, the middle row contains the attributes of the class, and the bottom section express the methods or operations that the class may use. Classes and subclasses are grouped together to show the static relationship between each object.

The purpose of the class diagram can be summarized as:

- Analysis and design of the static view of an application.
- Describe responsibilities of a system.
- Base for component and deployment diagrams.
- Forward and reverse engineering.

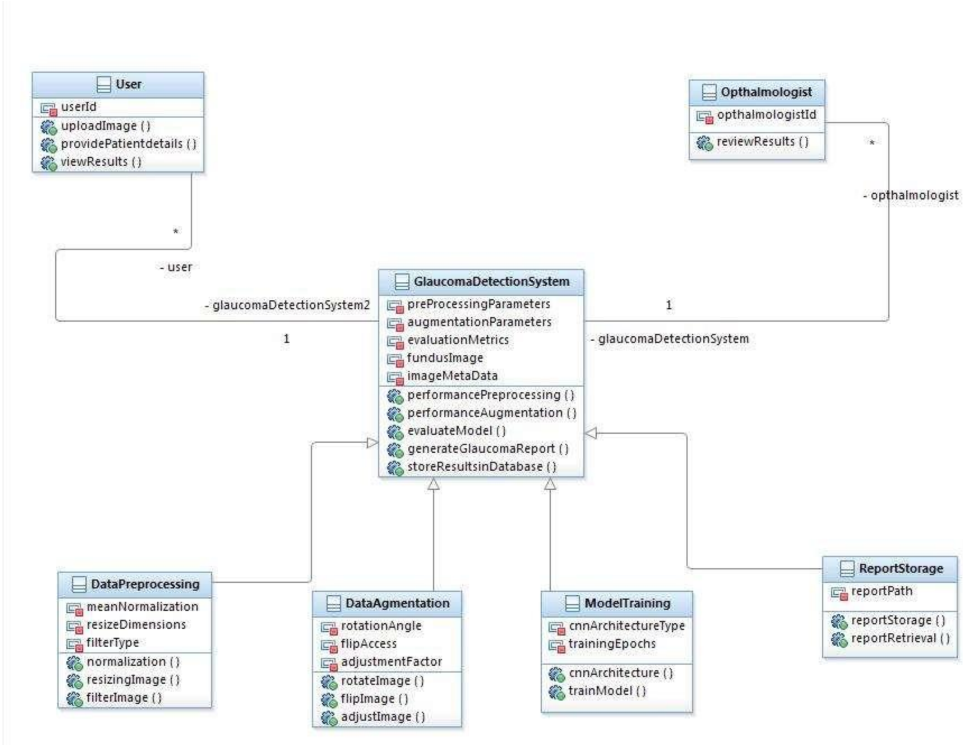


Fig. 4.4.2.1 Class Diagram

4.4.3 Activity Diagram

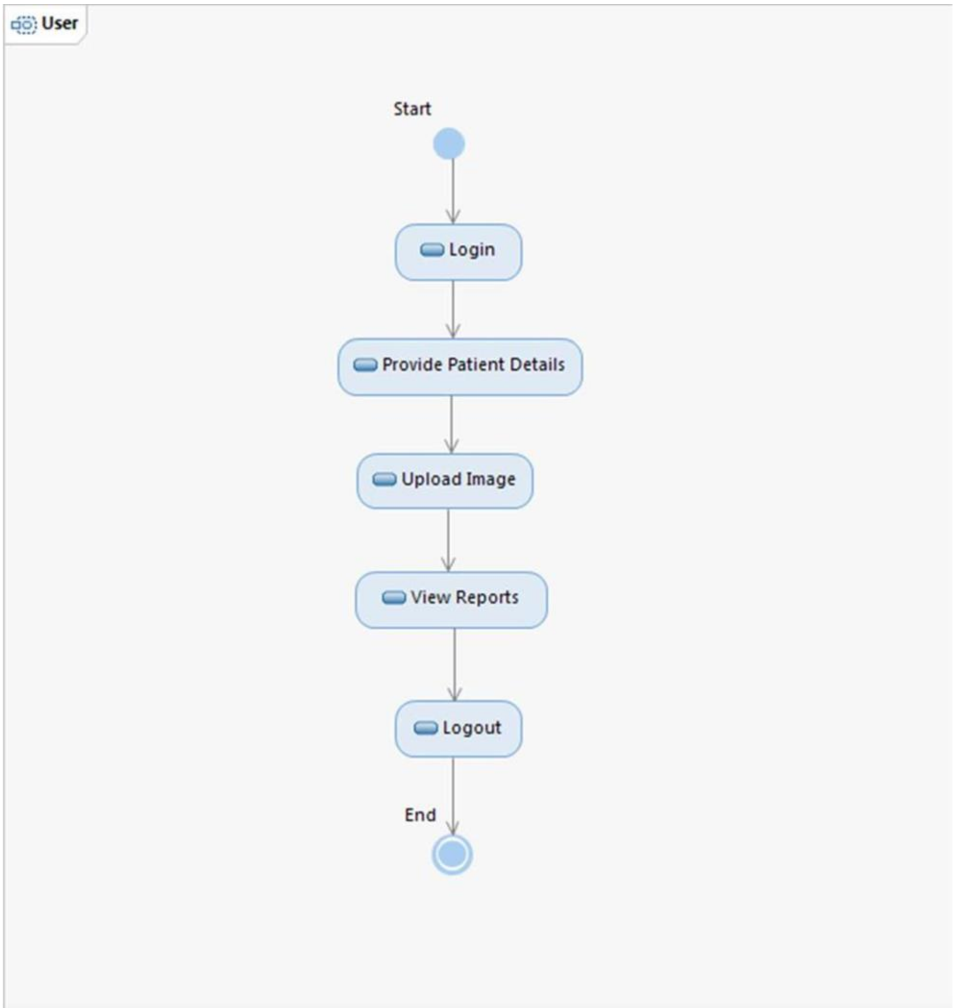
Activity diagram is basically a flowchart to represent the flow from one activity to another activity. The activity can be described as an operation of the system.

The control flow is drawn from one operation to another. This flow can be sequential, branched, or concurrent. Activity diagrams deal with all type of flow control by using different elements such as fork, join, etc. Activity is a particular operation of the system. Activity diagrams are not only used for visualizing the dynamic nature of a system, but they are also used to construct the executable system by using forward and reverse engineering techniques.

The purpose of an activity diagram can be described as

- Draw the activity flow of a system.

- Describe the sequence from one activity to another.
- Describe the parallel, branched and concurrent flow of the system.



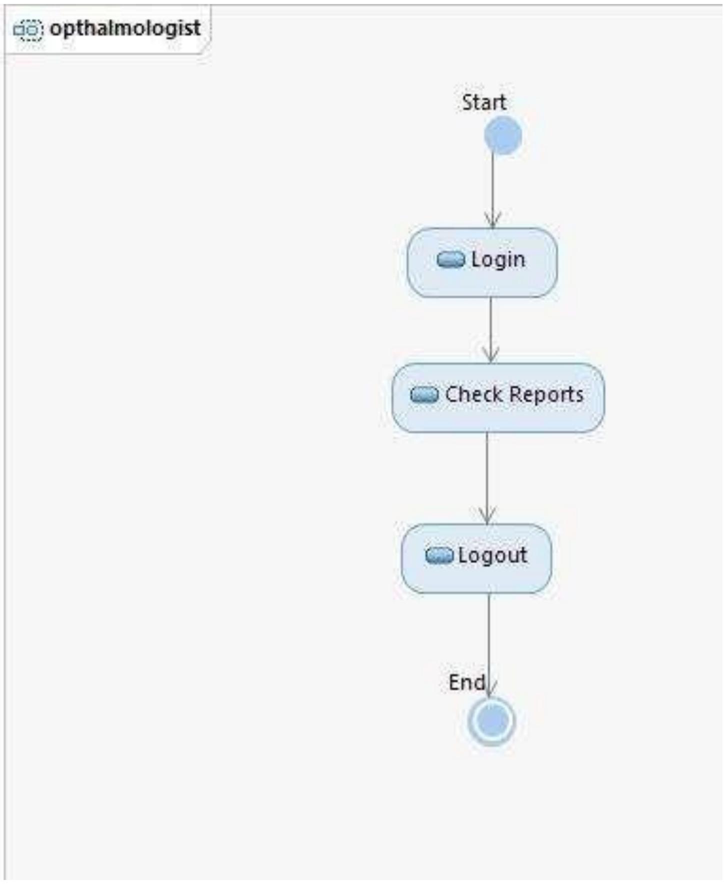


Fig. 4.4.3.1 Activity Diagram

4.4.4 Sequence Diagram

A sequence diagram is the most commonly used interaction diagram. It simply depicts interaction between objects in a sequential order i.e. the order in which these interactions take place. We can also use the terms event diagrams or event scenarios to refer to a sequence diagram. Sequence diagrams describe how and in what order the objects in a system function. These diagrams are widely used by businessmen and software developers to document and understand requirements for new and existing systems.

Sequence diagrams can be useful references for businesses and other organizations. Purpose of sequence diagrams are:

- Represent the details of a UML use case.

- Model the logic of a sophisticated procedure, function, or operation.
- See how objects and components interact with each other to complete a process.
- Plan and understand the detailed functionality of an existing or future scenario.

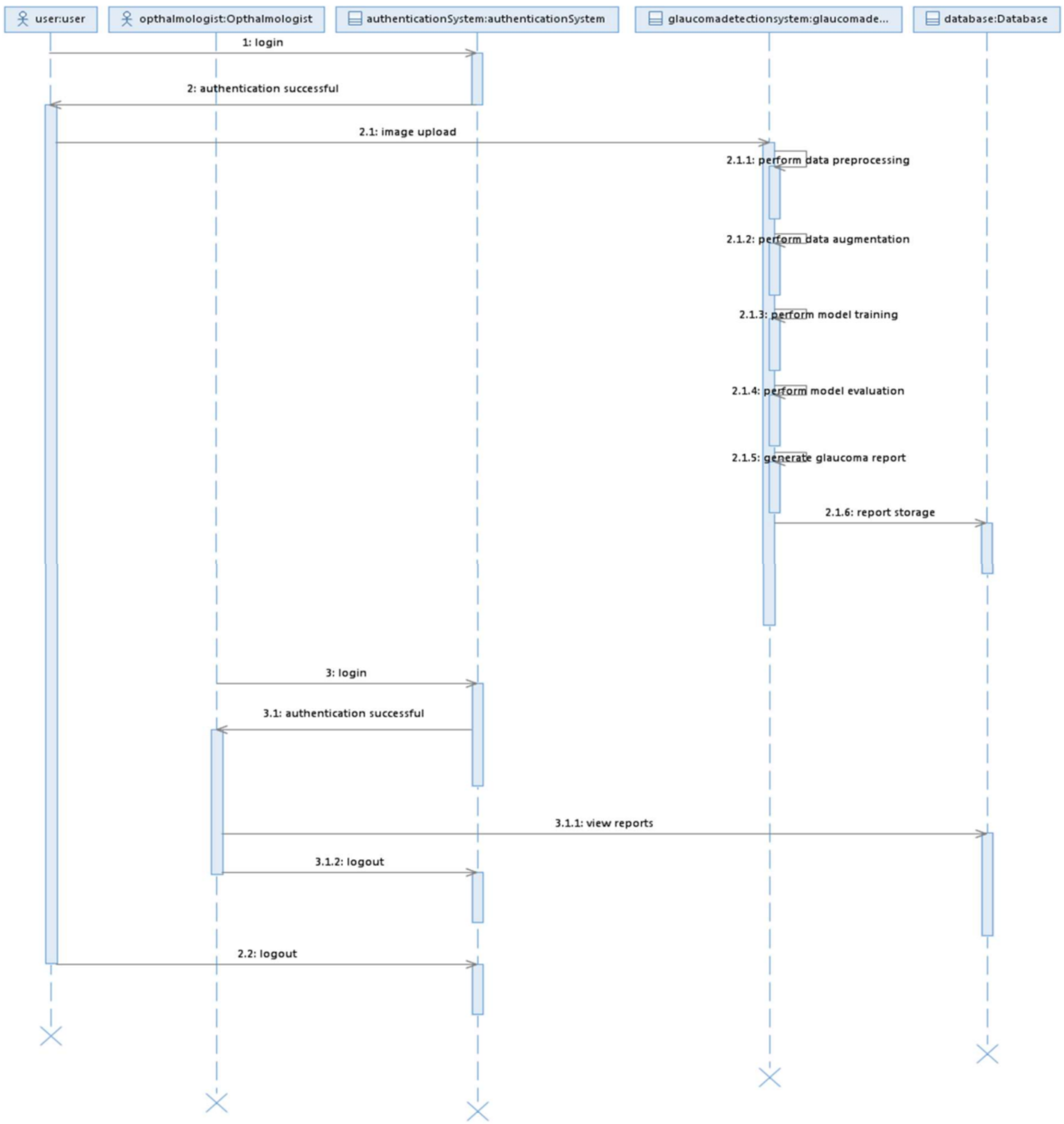


Fig. 4.4.4.1 Sequence Diagram

5. IMPLEMENTATION

The objective of the coding or programming phase is to translate the design of the system produced during the design phase into code in a given programming language, which can be executed by a computer and that performs the computation specified by the design.

The coding phase affects both testing and maintenance. The goal of coding is not to reduce the implementation cost, but the goal should be to reduce the cost of later phases.

5.1 Coding Approach

There are two major approaches for coding any software system. They are Top-Down approach and bottom up approach.

In developing a glaucoma detection system, we can utilize the Bottom-Up approach, particularly suited for object-oriented systems. During the initial phase of system design, we break down the project into several subsystems, each handling a specific aspect of the detection process. These subsystems include Image Upload and Management, Patient Authentication and Management, Image Processing and Analysis, and Report Generation.

Following the system design phase, we proceed with modeling objects for each subsystem independently. For instance, the Image Upload and Management subsystem may involve objects such as PatientProfile, ImageUploader, and ImageRepository, while the Image Processing and Analysis subsystem could include objects like ImageProcessor and GlaucomaDetector. Each object encapsulates the functionality and behavior related to its respective subsystem.

In the implemented system, patients can log in with valid credentials, upload fundus images for analysis, and access their results and reports. Administrators can oversee the process, manage patient accounts, and access all reports. Through the system, reports are generated based on the analysis of uploaded fundus images, aiding both medical professionals and patients in glaucoma detection and management.

5.2 Information Handling

Any software system requires some amount of information during its operation selection of appropriate data structures can help us to produce the code so that objects of the system can better operate with the available information decreased complexity.

5.3 Programming Style

Programming style deals with act of rules that a programmer must follow so that the characteristics of coding such as Traceability, Understandability, Modifiability, and Extensibility can be satisfied. In this current system, we followed the coding rules for naming the variables and methods.

5.4 Verification and Validation

Verification is the process of checking the product built is right. Validation is the process of checking whether the right product is built. During the Development of the system, Coding for the object has been thoroughly verified from different aspects regarding their design, in the way they are integrated etc. The various techniques that have been followed for validation discussed in testing the current system.

Validations applied to the entire system at two levels:

Form level Validation:

Validations of all the inputs given to the system at various points in the forms are validated while navigating to the next form. System raises appropriate custom and pre-defined exceptions to alert the user about the errors occurred or likely to occur.

Field level Validation:

Validations at the level of individual controls are also applied wherever necessary. System pops up appropriate and sensuous dialogs wherever necessary. In this project**,** validations are performed on each individual control. If any one of text field is not filled or any wrong, click occurs then system will generate appropriate exceptions.

5.5 Implementation of Project

- **Pre-Processing and Data augmentation**
  - Preparing data for main processing or for further analysis through preliminary processing is known as data pre-processing. It is a technique for converting unclean data into clean data sets. The term refers to the modifications made to our data before we feed it to the algorithm. It may also be used to represent any first or preliminary processing stage where several steps are required to prepare data. The idea of transforming unclean data into data cleansing. Before the technique is applied, the collection is pre-processed to check for noisy data, missing values, and other anomalies. the procedure for structuring unstructured data such that it may be interpreted. It is also an important phase in data mining because to the difficulty to handle raw data. Data mining and machine learning should not be used without first assessing the quality of the data. Information from an open-source eye illness database was utilised to find and gather the datasets for the project. There were fundus photos that showed glaucoma in three datasets (Drishti, Rim-One, and Acrima datasets).
  - Data augmentation is a feature offered by the Keras deep learning neural network library. By using the ImageDataGenerator class, we enhanced our data. We used zooming, sheer, channel shift, rotation, width shift, and height shift, among other techniques. More picture data were produced after the augmentation technique was applied.
  - **Image Data Generator**
    - The Keras ImageDataGenerator receives the original data inputs and alters them at random before producing a result that solely contains the newly transformed data. The information is missing. In order to broaden the model's applicability, additional data is added using the Keras ImageDataGenerator module. Data augmentation uses an image data generator to conduct random

operations on data, including translations, rotations, scale modifications, and vertical flips. In the field of real-time data augmentation, Keras ImageDataGenerator is used to create batches that contain data from tensor images. By giving the appropriate parameters and the necessary input to the ImageDataGenerator resize class, we can use it.

- The picture data generator class has a number of methods, including:
- flow_from_directory – This function generates batchesof augmented databased on a directory path.
- Apply to transform - used to apply picture transformations to the values given as arguments and gets the parameters to transform variables and x.
- Fit - takes as inputs x, a seed with a default value of none, rounds (the number of rounds to be performed), and a boolean value for enhancing. The data synthesizer is adapted using this method to the supplied data sample.

- **Feature Extraction**
    - With the use of feature extraction for image data, the visually appealing elements of a picture are presented as a small feature vector. This was previously accomplished using specialised, feature extraction, feature identification, and feature matching algorithms. The flexibility of deep learning to accept raw image data as input and skip the feature extraction procedure makes it a popular tool for image and video analysis at the moment. Any computer vision program that uses picture registration, object recognition, or classification must accurately reflect the image features, regardless of the approach. This representation may be implicit in the early layers of a deep network or explicit.

- **Classification**
    - A form of supervised machinelearning method, classification involves grouping a given set of input data into classes using one or more factors.

In order to categorise fresh observations into groups or classes, classification prediction modelling uses data or observations as training input.

- **CNN**
  - The convolution neural network is referred to as a machine learning subnet. It is one of many models of artificial neural networks that are used for various tasks and sets of data. For tasks like image identification and pixel data processing, deep learning algorithms use a specific kind of network design called a CNN. In deep learning, CNN is preferred over all other forms of neural networks for detecting and classifying objects. As a result, they are ideal for computer vision (CV) activities and for applications like face recognition and self -driving auto systems where accurate object detection is crucial. A particular type of neural network called a CNN can be used to find important information that may be present in both time-series data and image data. For image-based applications like object classification, pattern recognition, and image identification, this makes it very helpful. A CNN uses linear algebraic concepts like matrix multiplication to find patterns in an image. CNN may also categorise audio and signal data.
  - CNNs have architecture resembling those of the interconnections in the human brain. The neurons in CNNs are organized differently, yet they are similar to the billions of neurons seen in the human brain. The frontal lobe of the brain, which processes visual stimuli, is actually modeled by the way CNN's neurons are organized. By overcoming the problem with standard neural networks' partial image processing that requires us to give them low-resolution images by using this design, the full visual field is protected. CNN performs better than earlier networks when given inputs that contain both speech and/or visual signals.
  - Convolutional layer
    - The convolutional layer, the life of a CNN, is where the core of processing happens. Among other things, it requires a filter,

input data, and a feature map. A feature detector, sometimes referred to as kernels or filters, will examine the image's receptive fields to determine whether the attribute is present. This technique is referred to as convolution. A section of the image is represented by a 2-D array of weights acting as the feature detector.

- Max pooling layer:
  - In the convolution process known as "Max Pooling," the Kernel extracts the most value from the region it convolves. The Convolutional Neural Network is simply informed by max pooling that we will only transmit that information ahead if it is the input with the highest possible amplitude.
- Dense layer
  - A neural network's thick layer, which has many connections, is its typical layer. It's the most prevalent and often used layer. Before returning the outcome, the dense layer applies the following operation to the input.

- output = activation (dot (input, kernel) + bias)
  - Flattening
    - The technique of flattening involves transforming data into a 1 - dimensional vector for input into the layer underneath. To create a single, comprehensive feature vector, the convolutional layer's output is flattened. An image is processed more effectively by a neural network in particular architectures, such as CNN, if it is in 1D format rather than 2D.
- **Advantages of CNN**
  - The ability of CNNs to automatically extract features from data is their primary advantage over other deep learning algorithms.
  - Convolutional neural networks perform at the cutting edge when it comes to unstructured data with intricate spatial patterns, including image data.

- Image data performance is at the cutting edge.
- The capacity to function with incomplete knowledge.
- There is no need to pre-process or feature the data.
- The proposed CNN'S - convolutional layer uses a filter of 32 size and a kernel of 3x3. This kernel is helpful so that image of size 256x256 can be processed faster. 2 convolutional layers are used in the current model. It performs a dot product of the matrix of learning parameters or kernel and the given image. The convolutional layer is followed by a max pooling layer. ReLU activation function is used in convolutional and dense layer. Batch normalization is performed.
- The dropout layer used is at ignore rate of 25%. The last output layer uses the softmax activation function. The softmax function is a good choice as it returns the chances of getting each class and it shows the higher value to the target class.

6. TESTING

Testing is the process of finding differences between the expected behaviour specified by system models and the observed behaviour of the system. Testing is a critical role in quality assurance and ensuring the reliability of development and these errors will be reflected in the code, so the application should be thoroughly tested and validated.

Unit testing finds the differences between the object design model and its corresponding components. Structural testing finds differences between the system design model and a subset of integrated subsystems. Functional testing finds differences between the use case model and the system.

Finally, performance testing, finds differences between non-functional requirements and actual system performance. From modelling point of view, testing is the attempt of falsification of the system with respect to the system models. The goal of testing is to design tests that exercise defects in the system and to reveal problems.

6.1 Testing Activities

Testing a large system is a complex activity and like any complex activity. It has to be broke into smaller activities. Thus, incremental testing was performed on the project i.e., components and subsystems of the system were tested separately before integrating them to form the subsystem for system testing.

6.2 Testing Types

Unit Testing

Unit testing focuses on the building blocks of the software system that is the objects and subsystems. There are three motivations behind focusing on components. First unit testing reduces the complexity of overall test activities allowing focus on smaller units of the system, second unit testing makes it easier to pinpoint and correct faults given that few components are involved in the rest. Third unit testing allows parallelism in the testing activities, that is each component are involved in the test.

Third unit testing allows parallelism in the testing activities that is each component can be tested independently of one another. The following are some unit testing techniques.

- **Equivalence testing**:

  It is a black box testing technique that minimizes the number of test cases. The possible inputs are partitioned into equivalence classes and a test case is selected for each class.

- **Boundary testing:**

  It is a special case of equivalence testing and focuses on the conditions at the boundary of the equivalence classes. Boundary testing requires that the elements be selected from the edges of the equivalence classes.

- **Path testing:**

  It is a white box testing technique that identifies faults in the implementation of the component the assumption here is that exercising all possible paths through the code at least once. Most faults will trigger failure. This acquires knowledge of source code.

Integrating Testing

Integration testing defects faults that have not been detected. During unit testing by focusing on small groups on components two or more components are integrated and tested and once tests do not reveal any new faults, additional components are added to the group. This procedure allows testing of increasing more complex parts on the system while keeping the location of potential faults relatively small. I have used the following approach to implements and integrated testing.

Top-down testing strategy unit tests the components of the top layer and then integrated the components of the next layer down. When all components of the new layer have been tested together, the next layer is selected. This was repeated until all layers are combined and involved in the test.

Validation Testing

The systems completely assembled as package, the interfacing have been uncovered and corrected, and a final series of software tests are validation testing. The validation testing is nothing but validation success when system functions in a manner that can be reasonably expected by the customer. The system validation had done by series of Black-box test methods.

System Testing

1. System testing ensures that the complete system compiles with the functional requirements and non-functional requirements of the system, the following are some system testing activities.
2. Functional testing finds differences between the functional between the functional requirements and the system. This is a black box testing technique. Test cases are divided from the use case model.
3. Performance testing finds differences between the design and the system the design goals are derived from the functional requirements.
4. Pilot testing the system is installed and used by a selected set of users – users exercise the system as if it had been permanently installed.
5. Acceptance testing, I have followed benchmarks testing in a benchmark testing the client prepares a set of test cases represent typical conditions under which the system operates. In our project, there are no existing benchmarks.

Installation testing, the system is installed in the target environment.

Black Box Testing also known as Behavioural Testing, is a software testing method in which the internal structure/design/implementation of the item being tested is not known to the tester. These tests can be functional or non-functional, though usually functional. This method is named so because the software program, in the eyes of the tester, is like a black box; inside which one cannot see. This method attempts to find errors in the following categories:

- Incorrect or missing functions
- Interface errors
- Errors in data structures or external database access
- Behaviour or performance errors
- Initialization and termination errors

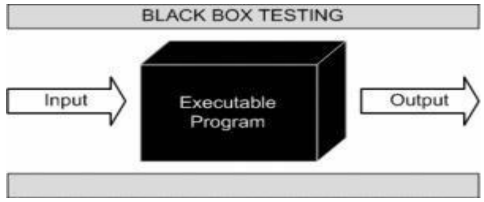


Fig. 6.2.1 Black Box Testing

6.3 Test cases

Test Case #	Test Case Description	Test Data	Expected Result	Actual Result	Pass/Fail
1	Register and then login with valid credentials	Enter registered credentials	Login successful and the next page is displayed.	Successfully logged in and displayed next page with valid credentials, and for incorrect credentials it displayed error message	PASS
2	Insert an fundus imagewhich is healthy	image	Display Negative	Display Negative	PASS
3	Insert an fundus image which has glaucoma disease	image	Display Positive	Display Positive	PASS

- **Register and then login with valid credentials**

  If the credentials are correct the user is successfully logged in to the website.

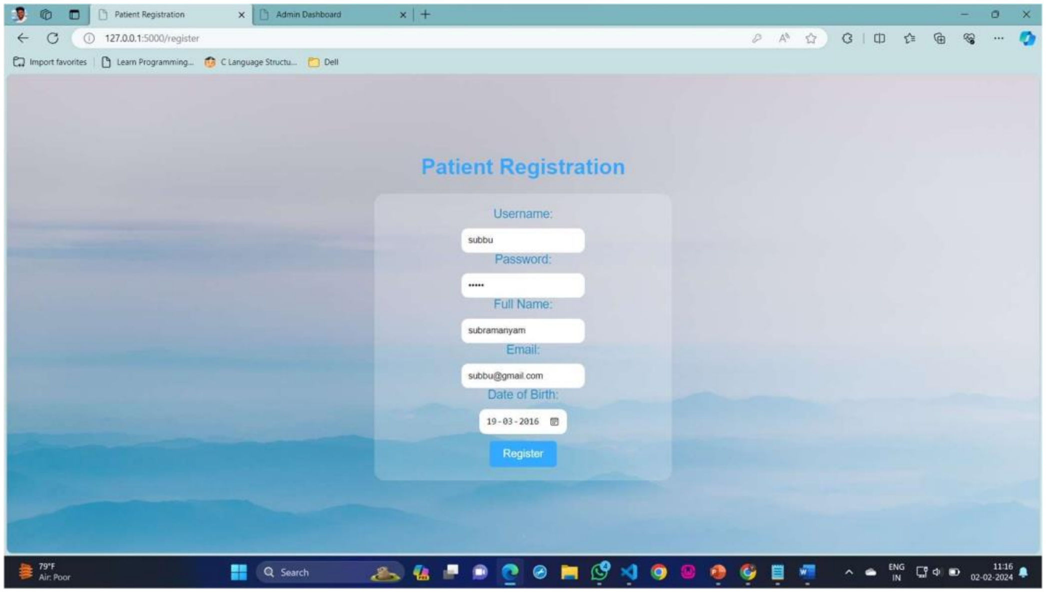


Fig. 6.3.1 Registration of new user

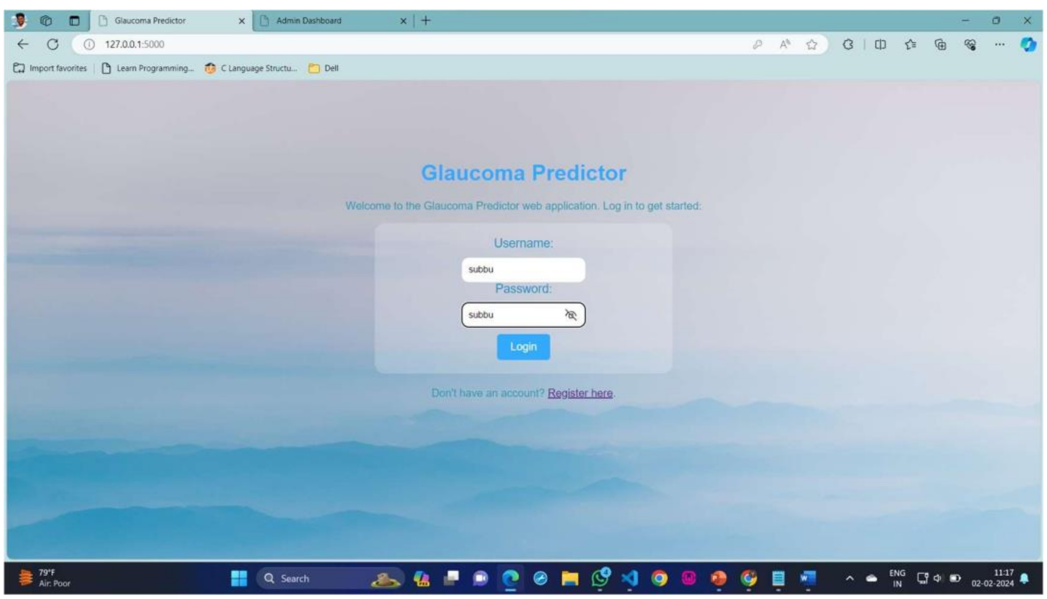


Fig. 6.3.2 Login In for user

- **Insert an fundus image which is healthy**

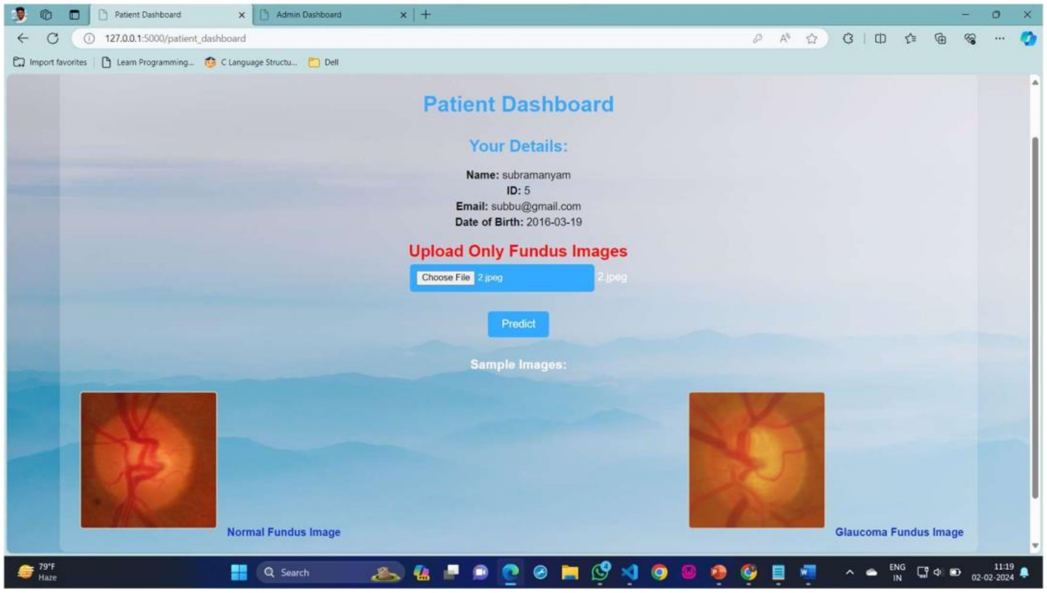


Fig. 6.3.2 uploading an image

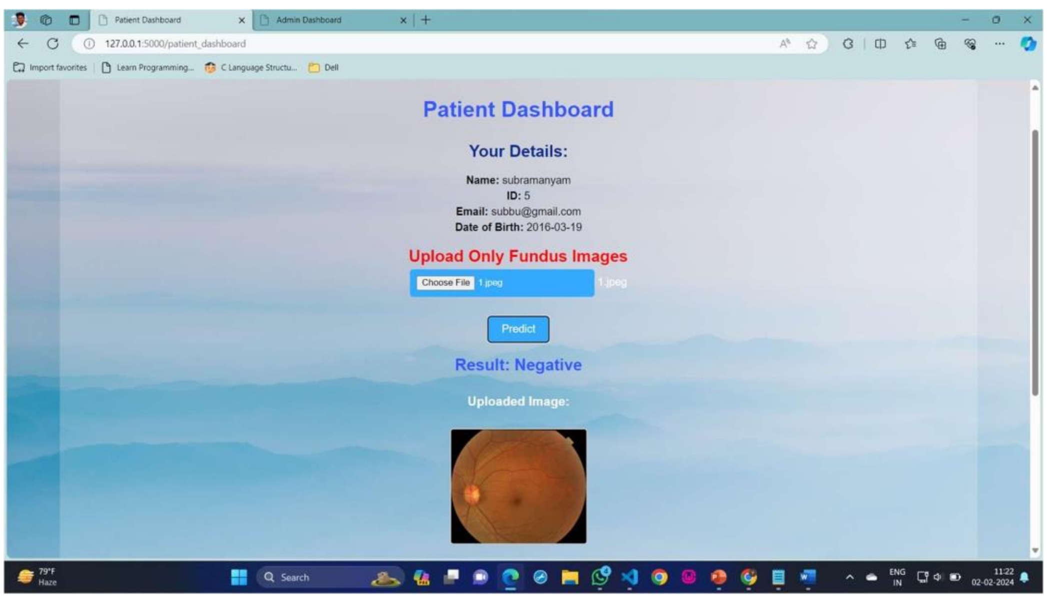


Fig. 6.3.3 Result

- **Insert an fundus image which is not healthy**

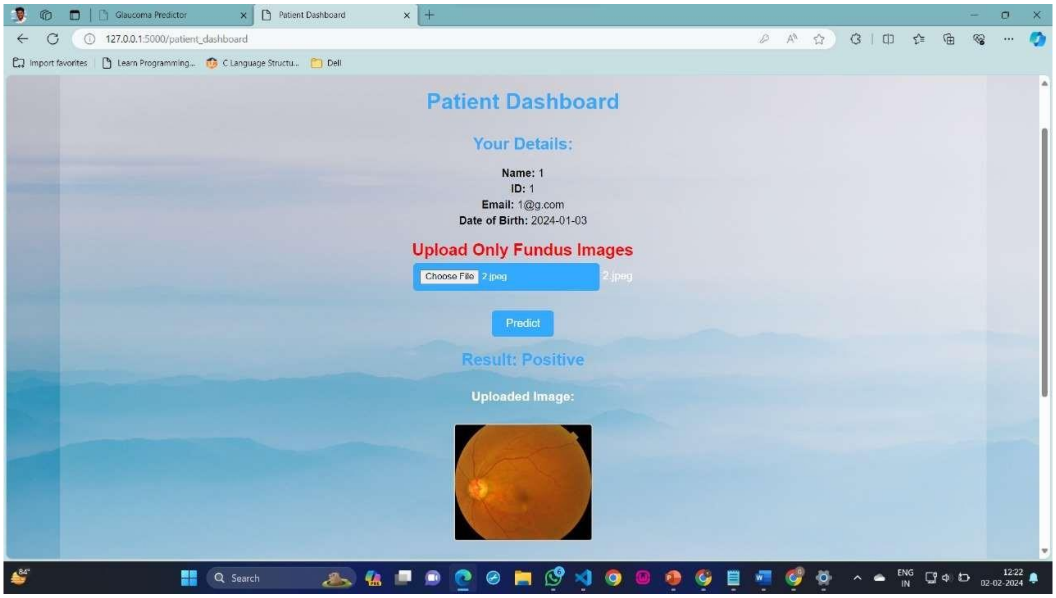


Fig. 6.3.4 Result

7. RESULTS

7.1 Home Page

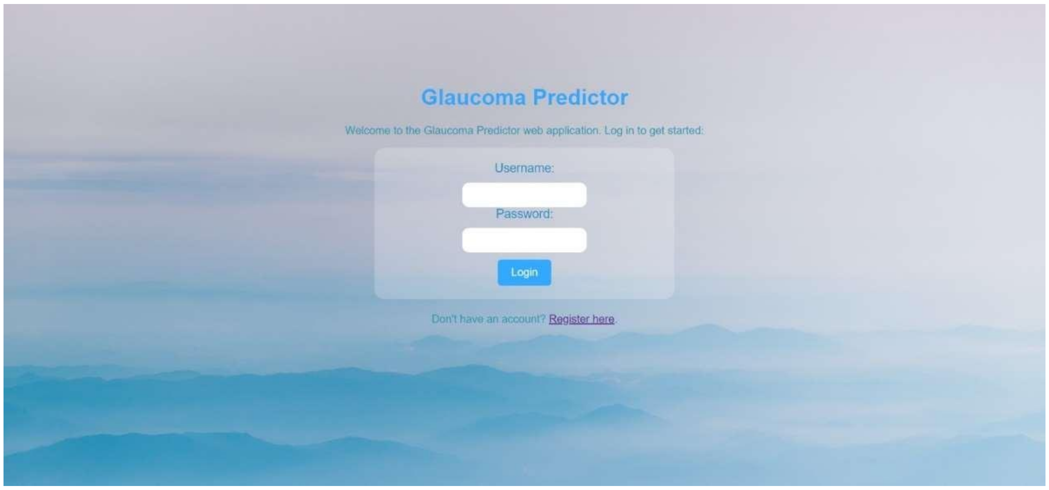


Fig. 7.1.1 Start Page

7.2 Registration Page

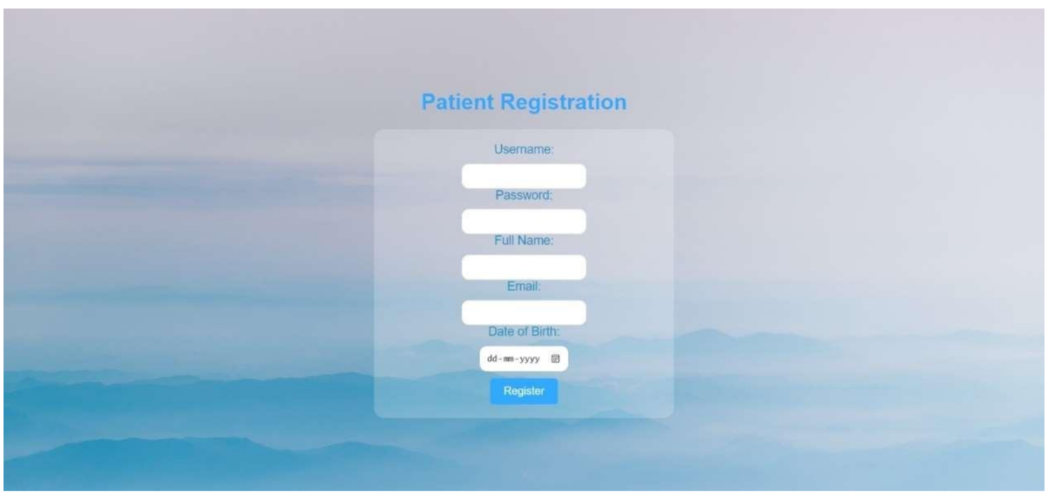


Fig. 7.2.1 Registration Page

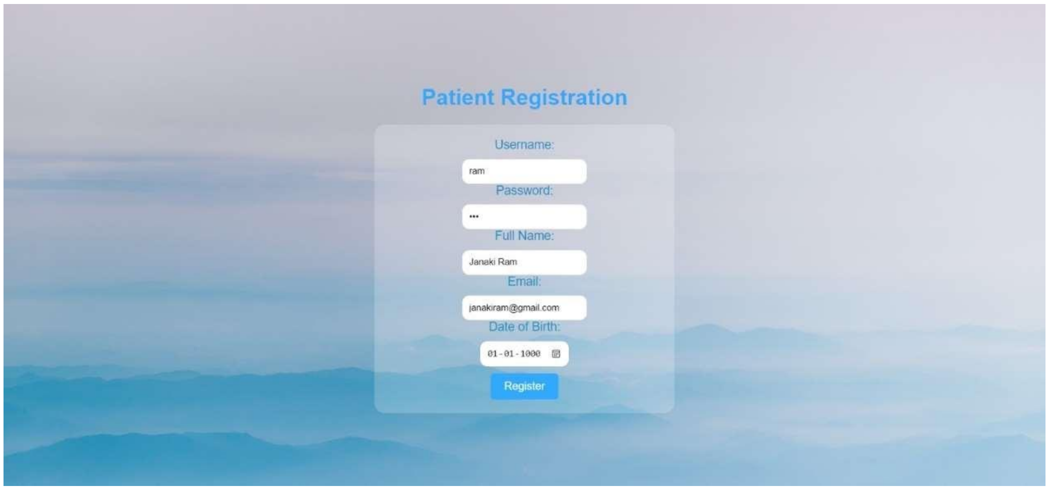


Fig. 7.2.2 User is Registering

7.3 Dashboard Page

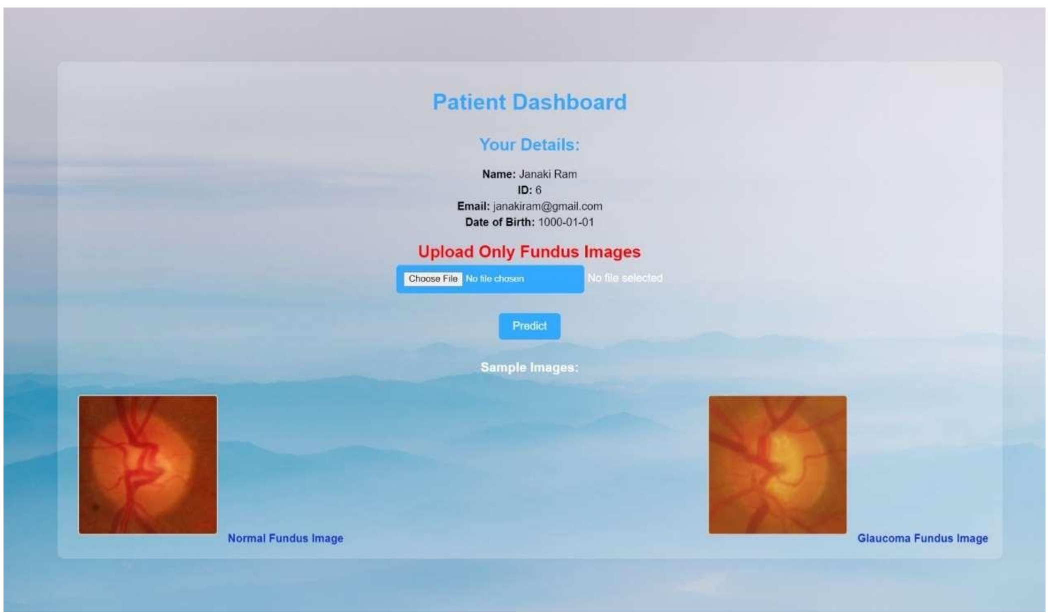


Fig. 7.3.1 Dashboard Page

There are several different performance metrics that can be used to evaluate a model's performance. Performance is evaluated using the Specificity, Confusion Matrix, Accuracy, Recall, Precision, and F1 score. The confusion matrix provides a detailed explanation of values such as False Negatives, False Positives, True Positives, and True Negatives. With the use of all the training data, a neural network is trained for one cycle every epoch. In a given period, we only ever use a given piece of information. A pass is when two passes are combined, one forward and one backward. One or even more batches in each epoch are used to train the neural network using a portion of the dataset. We refer to the process of going through one batch of training samples as an "iteration." In order to train the model effectively, there are 150 epochs overall distributed across 32 batches.

7.4 Evaluation Metrics

For Evaluation of the model, we are using metrics like accuracy, F1score, recall, precision. A machine will always produce an outcome and we have no idea it is the correct one or not unless someone hints that out in our model. For calculating these metrics, we can use the confusion matrix which consist of four characteristics.

7.4.1 Accuracy

The model's accuracy is a measure of its performance across all classes. When each course is equally important, it helps. In order to calculate it, divide the total of forecasts by the total of guesses. Be aware that the accuracy could be misleading. When the data are unbalanced is one instance. Accuracy is simply the percentage of correctly classified items when it comes to multiclass classification.

$$Accuracy = \frac{True\ Positive + True\ Negative}{True\ Positive + False\ Positive + True\ Negative + False\ Negative} \times 100$$

7.4.2 Recall

The recall is calculated as the fraction of Positive observations that were correctly classified as Positive in comparison to all Positive samples. When recall is higher, there are more positive samples discovered. Recall is not affected by the quantity of incorrect sample classifications. Furthermore, if the model correctly classifies all positive data as positive, Recall equals 1.

$$Recall = \frac{True\ Positive}{True\ Positive + False\ Negative}$$

7.4.3 Precision

The proportion of correctly classified Positive cases to all Positive samples is used to determine accuracy (either incorrectly or correctly). Precision describes how precisely the model labels a random pick as positive. Whether the model makes many inaccurate Positive classifications or only a few accurate Positive classifications, the denominator rises and the precision falls.. Yet, when the model makes numerous accurate Positive classifications in the first scenario, the precision is high (maximize True Positive). The model makes less inaccurate Positive classifications in the second scenario (minimize False Positive). The precision is useful in determining how accurate the model is when it declares that a instance is true.

$$Precision = \frac{True\ Positive}{True\ Positive + False\ Positive}$$

7.4.4 Sensitivity

Sensitivity is used to evaluate model performance because it allows us to see how many positive instances the model was able to correctly identify. A model with high sensitivity will have few false negatives, which means that it is missing a few of the positive instances.

$$Sensitivity = \frac{True\ Positive}{True\ Positive + False\ Negative}$$

7.4.5 Specificity

When sensitivity is used to evaluate model performance, it is often compared to specificity. Specificity measures the proportion of true negatives that are correctly identified by the model.

$$Specificity = \frac{True\ Negative}{True\ Negative + False\ Positive}$$

7.4.6 F1-score

The harmonic mean of precision and recall is the F1 score. It functions as a statistical instrument for performance evaluation. An F-score can range from zero to 1.0, which represents flawless recall and accuracy, and from zero to zero when neither recall nor precision are present. The F1 score is a common performance metric for classification and is frequently chosen over, for example, accuracy when data is imbalanced, for instance when samples belonging to one class are detected in significantly more samples than samples belonging to the other class.

$$F1\_score = 2X \quad \frac{Precision\ x\ Recall}{Precision + Recall}$$

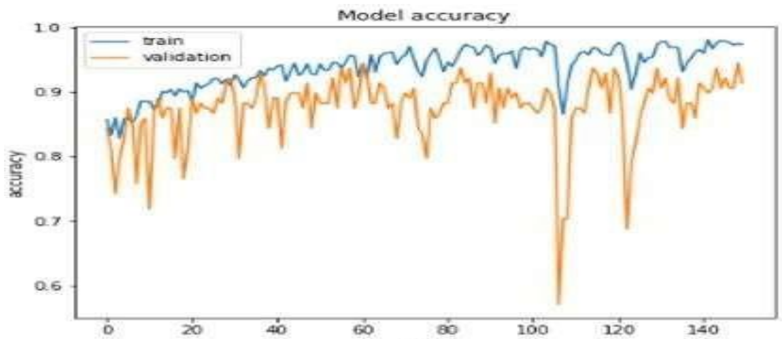


Figure 7.4.1: The proposed model’s accuracy

From the figure, we can observe many troughs and depths in the plotted graph. Since we are having 150 epochs, the accuracy at each epoch is plotted in the graph and we can see that after 100 epochs there is a sudden drop in accuracy and when we increase the epochs there we can see a steady increase in the model's accuracy. This will give us a better insight into the model's performance.

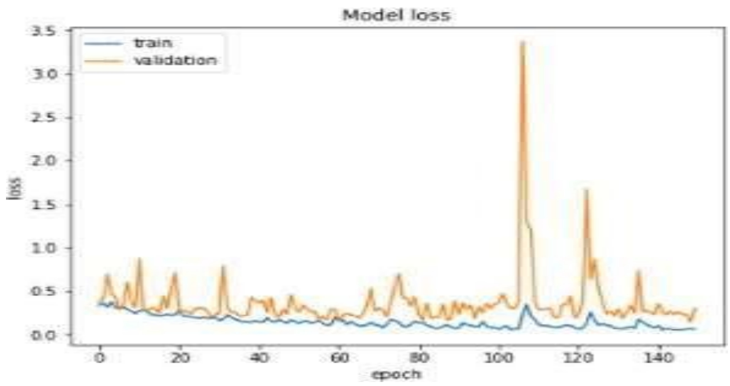


Figure 7.4.2: The model's loss at each epoch

The figure depicts the different values of loss at each epoch. As we have discussed earlier, there is a sudden drop in the accuracy as the loss function value is varied. This graph of loss function helps us to predict the issues that occur with learning. These issues can lead to underfitting or an overfitted model.

Table 7.1: Classification report

	Precision	**Recall**	**F1-Score**	**Support**
Glaucoma	0.984615	0.984615	0.984615	65
Normal	0.984848	0.984848	0.984848	66
Accuracy	**0.984733**	**0.984733**	**0.984733**	**0.984733**
Macro avg	0.984732	0.984732	0.984732	131
Weighted avg	0.984733	0.984733	0.984733	131

The classification report here instigates the fact that this model which achieved an accuracy of 98.47% with an integrated dataset is to be noted and this is the first ever model to achieve this. All the existing studies have achieved the results by working on small datasets whereas the proposed model has a large dataset. The CNN here can process even on low quality images. The dataset created is a balanced dataset with proportionate number of glaucoma and normal images.

Table 7.2: Comparison of Proposed method with Existing methods

Model	Accuracy
Proposed model	98.47
ResNet-50 [24]	94.5
EC-Net [24]	97.2
Efficient-net CNNs model [9]	88
CNN model [3]	94
Inception V3 [14]	90.4
ODG-Net [1]	95.75
KNN [10]	95.91
googleNet [18]	83
DENet [35]	91.83

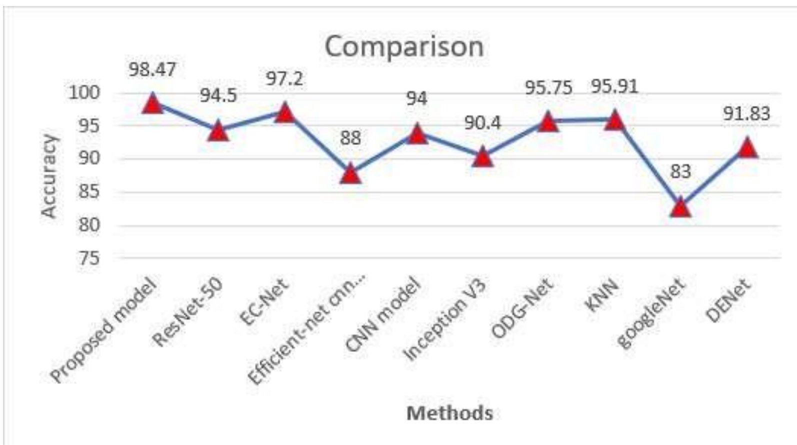


Figure 7.1.3: Comparative study of Performance measure.

8. SAMPLE CODE

8.1 Source Code

```
from google.colab import drive
drive.mount('/content/drive')

"""# Importing necessary libraries"""

import matplotlib.pyplot as plt
import numpy as np
import os
import shutil
import pathlib
from tensorflow import keras
import seaborn as sns
import random
from keras.models import load_model
from keras.preprocessing import image
from tensorflow.keras.preprocessing.image import load_img, img_to_array
current_dir = os.getcwd()
print(current_dir)
dristhi_dir = current_dir + '/drive/MyDrive/datasets/Dristhi/'
train_glaucoma_dir = dristhi_dir + "Training/Images/GLAUCOMA"
train_normal_dir = dristhi_dir + "Training/Images/NORMAL"
test_glaucoma_dir = dristhi_dir + "Test/Images/glaucoma"
test_normal_dir = dristhi_dir + "Test/Images/normal"
dristhi_glaucoma_images = os.listdir(train_glaucoma_dir)+os.listdir(test_glaucoma_dir)
dristhi_normal_images = os.listdir(train_normal_dir)+os.listdir(test_normal_dir)

# Look at the number of samples in each dataset
print("Dristhi dataset contains :")
print(f"\t{len(dristhi_glaucoma_images)} images representing an eye with glaucoma")
print(f"\t{len(dristhi_normal_images)} images representing a normal eye")

print("Sample Dristhi glaucoma images:")
plt.subplots(figsize=(15, 10))
for i in range(1, 5):
   plt.subplot(1, 4, i)
```

```
    plt.imshow(load_img(f"{os.path.join(train_glaucoma_dir, dristhi_glaucoma_images[i - 1])}"))
plt.show()

print("\nSample Dristhi normal images:")
plt.subplots(figsize=(15, 10))
for i in range(1, 5):
    plt.subplot(1, 4, i)
    plt.imshow(load_img(f"{os.path.join(train_normal_dir, dristhi_normal_images[i - 1])}"))
plt.show()
                rimOne_dir = current_dir + '/drive/MyDrive/datasets/RIM-
ONE_DL_images/partitioned_randomly/'
train_glaucoma_dir = rimOne_dir + "training_set/glaucoma"
train_normal_dir = rimOne_dir + "training_set/normal"
test_glaucoma_dir = rimOne_dir + "test_set/glaucoma"
test_normal_dir = rimOne_dir + "test_set/normal"
rimOne_glaucoma_images = os.listdir(train_glaucoma_dir)+os.listdir(test_glaucoma_dir)
rimOne_normal_images = os.listdir(train_normal_dir)+os.listdir(test_normal_dir)

# Look at the number of samples in each dataset
print("Rim One dataset contains :")
print(f"\t{len(rimOne_glaucoma_images)} images representing an eye with glaucoma")
print(f"\t{len(rimOne_normal_images)} images representing a normal eye")

print("Sample Rim-One glaucoma images:")
plt.subplots(figsize=(15, 10))
for i in range(1, 5):
    plt.subplot(1, 4, i)
                plt.imshow(load_img(f"{os.path.join(train_glaucoma_dir,
rimOne_glaucoma_images[i - 1])}"))
plt.show()

print("\nSample Rim-One normal images:")
plt.subplots(figsize=(15, 10))
for i in range(1, 5):
    plt.subplot(1, 4, i)
    plt.imshow(load_img(f"{os.path.join(train_normal_dir, rimOne_normal_images[i - 1])}"))
plt.show()

"""# 1.3. ACRIMA dataset
* Country: Spain
```

* No. of patients: unknown
* No. of images: 705
* Diseases present: Glaucoma and healthy eyes
* Instrument used: TRC retina camera (Topcon, Japan)

```
acrima_dir = current_dir + "/drive/MyDrive/datasets/acrima/Database"
glaucoma_dir = acrima_dir + "/glaucoma"
normal_dir = acrima_dir + "/normal"
normal_images = os.listdir(normal_dir)
glaucoma_images = os.listdir(glaucoma_dir)
print("Acrima dataset contains : ")
print(f"\t{len(glaucoma_images)} images representing an eye with glaucoma")
print(f"\t{len(normal_images)} images representing a normal eye")
print("Sample glaucoma images:")
plt.subplots(figsize=(15, 10))
for i in range(1, 5):
   plt.subplot(1, 4, i)
   plt.imshow(load_img(f"{os.path.join(glaucoma_dir, glaucoma_images[i - 1])}"))
plt.show()
print("\nSample normal images:")
plt.subplots(figsize=(15, 10))
for i in range(1, 5):
   plt.subplot(1, 4, i)
   plt.imshow(load_img(f"{os.path.join(normal_dir, normal_images[i - 1])}"))
plt.show()
os.mkdir('/content/combine')
## define your paths for glaucoma####
g_path1 = '/content/drive/MyDrive/datasets/acrima/Database/glaucoma'
            g_path2 = '/content/drive/MyDrive/datasets/RIM-
ONE_DL_images/partitioned_randomly/training_set/glaucoma'
            g_path3 ='/content/drive/MyDrive/datasets/RIM-
ONE_DL_images/partitioned_randomly/test_set/glaucoma'
g_path4='/content/drive/MyDrive/datasets/Dristhi/Training/Images/GLAUCOMA'
g_path5='/content/drive/MyDrive/datasets/Dristhi/Test/Images/glaucoma'
g_dest='/content/drive/MyDrive/combine/glaucoma'

os.mkdir(g_dest)
g_list=[g_path1,g_path2,g_path3,g_path4,g_path5]
```

```
for i in g_list:
  shutil.copytree(i, g_dest, dirs_exist_ok=True)
print(len(os.listdir('/content/drive/MyDrive/combine/glaucoma')))

##################################################
#normal
n_path1='/content/drive/MyDrive/datasets/acrima/Database/normal'
        n_path2='/content/drive/MyDrive/datasets/RIM-
ONE_DL_images/partitioned_randomly/training_set/normal'
        n_path3='/content/drive/MyDrive/datasets/RIM-
ONE_DL_images/partitioned_randomly/test_set/normal'
n_path4='/content/drive/MyDrive/datasets/Dristhi/Training/Images/NORMAL'
n_path5='/content/drive/MyDrive/datasets/Dristhi/Test/Images/normal'
n_dest='/content/drive/MyDrive/combine/normal'
os.mkdir(n_dest)
n_list=[n_path1,n_path2,n_path3,n_path4,n_path5]

for i in n_list:
  shutil.copytree(i,n_dest, dirs_exist_ok=True)
print(len(os.listdir(n_dest)))
base_dir = '/content/drive/MyDrive/datasets/combine'
base_dir = pathlib.Path(base_dir)
glaucoma = [fn for fn in os.listdir(f'/content/drive/MyDrive/combine/glaucoma/')]
normal = [fn for fn in os.listdir(f'/content/drive/MyDrive/combine/normal')]
data=[glaucoma,normal]
dataset_classes =['glaucoma','normal']
image_count = len(list(base_dir.glob('*/*.jpg')))+len(list(base_dir.glob('*/*.png')))
print(f'Total images: {image_count}')
print(f'Total number of classes: {len(dataset_classes)}')
count = 0
data_count = []
for x in dataset_classes:
  print(f'Total {x} images: {len(data[count])}')
  data_count.append(len(data[count]))
  count += 1
sns.set_style('darkgrid')
sns.barplot(x=dataset_classes, y=data_count)
plt.show()
```

9. CONCLUSION

Permanent blindness is brought on by the complication of glaucoma, which is connected to optic nerve damage. The use of glaucoma detection will expand thanks to this method of medical image processing technology. The computer-generated results from this work will help to raise the bar for clinical judgment when it comes to glaucoma identification. Because there are more normal fundus photos in the dataset, this algorithm can detect the glaucomatous images correctly. The proposed methodology uses an image data generator for data augmentation. The original images have increased due to augmentation and a large dataset is prepared. Later the augmented images have been sent for feature selection using CNN. The images are classified using binary classification as it has two outcomes. The proposed system achieved an accuracy of 98. 47% which is noteworthy in this field.

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Glaucoma Detection using CNN

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***Abstract*— The word "glaucoma" refers to both the progressive loss of retinal cells within optic nerve, and the gradual loss of vision caused by optic neuropathy. A condition that affects eye vision is called glaucoma. This condition is thought to be permanent and causes visual impairment. There are no early warning signs of this glaucoma in them. The effect is so subtle that we could not even observe that your vision has changed. Today, several models have been created to accurately detect glaucoma. Thus, we describe an architecture built on deep learning and convolutional neural network for enhanced glaucoma detection. CNN can be used to differentiate among the patterns created for glaucoma and non-glaucoma. This Glaucoma Detection Web Application, patients' retinal pictures are given and it detects the glaucoma significance and provide the results.**

Keywords— Glaucoma, Retinal cells, Deep learning, Optic neuropathy, Visual deterioration, Convolutional Neural Network.

I. INTRODUCTION

Vision is a major aspect of human perception, contributing significantly to the overall quality of life. However, certain ocular conditions, such as glaucoma, pose a substantial threat to vision health. Glaucoma, characterized by the progressive loss of retinal cells within the optic nerve, is a relentless and permanent disease that outcomes in a gradual deterioration of vision. Unfortunately, the challenges related with this disease is the nonappearance of early warning signs, making timely detection crucial for effective intervention. In recent years, the medical imaging field has witnessed remarkable advancements, particularly in the application of different techniques in deep learning for disease diagnosis. This project focuses on addressing the imperative need for accurate and early recognition of glaucoma by the utilization of Convolutional Neural Network (CNN). A CNN offers a robust framework for analysing complex patterns within medical images, allowing for the discrimination among glaucomatous and non-glaucomatous conditions.This research aims to present an innovative architecture designed for improved glaucoma detection, leveraging the hierarchical structure provided by CNN. From training the model to recognize subtle patterns indicative of glaucoma, we seek to advance the effectiveness and precision of diagnosis, enabling prompt medical intervention and vision preservation. The proposed methodology holds the potential to revolutionize glaucoma detection by providing a reliable tool for healthcare professionals to assess whether a patient is affected by glaucoma at an early stage when intervention can be most effective.

II. RELATED WORKS

In [1] Methods are divided into 2 categories as experimental and deep learning hand crafted features for the vertical optic disk ratio segmentation such methods achieving the end-to-end testing and training most of those lack of sufficient training data accuracy of the 5 experts from tier 2 is 88.4%, 87.7%, 90.0%, 87.0% and 92.7%, accuracy by 0.9% and 0.2%, with and without the pathological area localization subnet[1] the LAG database can be achieved from the Chinese glaucoma study alliance (CGSA).
In [2] This model has no preprocessing, and augmentation of data was done. A publicly available huge data set used for training model. The system was able to producing auto-cropping images used by the DCGAN model and classified labels are associated with images. In [3] Presented a system on deep learning algorithm. The final output image was categorized using ResNet and GoogleNet neural networks and fine-tuned using transfer learning after being pre-processed into three separate channels (red, green, and blue). Data augmentation is used to improve the number of fundus photographs. The drawback of this system is, it is expensive and time-consuming and may be utilized for only premature identification. In [4] described web-applicable computer-aided analysis of glaucoma by deep learning. The authors established a system for computer assisted diagnosis of glaucoma, including CNNs and Grad-Class Activation Mapping. This system has applied using a small-sized fundus dataset image. In [5] Presented an intelligent artificial glaucoma adept system that divides the optic cup and optic disc into separate segments. CNN is used as the central component of a deep Learning model. The suggested method segments the optic disc and cup using two neural networks cooperating with each other. The important steps in the CAD system: Pre-processing Segmentation Classification U-net modified Optical disc and cup segmentation G-Net model trained and validated on RGB images. In [6] Proposed a methodology that advances the explainable in mutual convolutional and regular neural network. They observed that retinal structures are static in nature and are reasoning for improved performance on the combined model dynamic changes on the retinal specificity and sensitivity of these models range

between 85 to 95% [11]. In [7] they suggested a photo segmentation and transfer learning based diagnostic tool for glaucoma identification. This model has two subsystems, Segmentation Subsystem using U-Net and the Direct Classification Subsystem consists of a light-weighted network MobileNet v2. Compared to the results generated by the heavier networks for individual datasets, the suggested light-weighted method performed well for mixed datasets. In [8] they presented a model that advances the explainable effects of study population labelling and training on glaucoma detection. The differences between the glaucoma definitions and labelling employed in numerous datasets, particularly between the DIGS/ADAGES, MCRH/Iinan, and ACRIMA datasets, are the study's weaknesses an additional performance metric and race - stratified sensitivity for all datasets. In [9] the methodology that advances the attention guided 3D-CNN structure for glaucoma discovery and structural functional association. Volumetric images methods are utilized to determine the significance of glaucoma. VFT used to evaluate vision loss due to glaucoma and other optic nerve diseases. The researchers also use biased cross information loss to avoid biased training by the class size imbalance in the data. Training is performed with a batch of size 12 through 100 epochs. In [10] researchers presented a deep convolution neural network-based technique for the early identification of Glaucoma. This model resulted in a higher dice value for optical cup segmentation, which is difficult because of the blood vessels' presence. The limitation of this model is that the dice value on the DRISHTI dataset is comparatively less than others.

III.METHODOLOGY

Most of the proposed models used ground truths and modified ground truths for the significance of glaucoma. Some researchers have used UNet for Image Segmentation, which slows down the middle covers of the model. Nearly of the existing methods used imbalanced data where, imbalance data caused disturbance in the results or final detection. So, balancing should be applied. Very few researchers used many parameters, it'll definitely effect the evaluation of the model. It is also liable on the dataset they have taken. In our proposed model, consisting of a combined dataset of ACRIMA, DRISTI and RIMONE. The proposed methodology uses an image data generator for data augmentation. The original images features have increased due to augmentation and a large dataset is virtually prepared. The dataset is split into 80:10:10 for training data, testing and validation data. Later, the augmented images have been sent for selection of feature by CNN. The images are classified using binary classification as it has two outcomes, positive and negative. This ideal can predict the glaucomatous eye accurately.

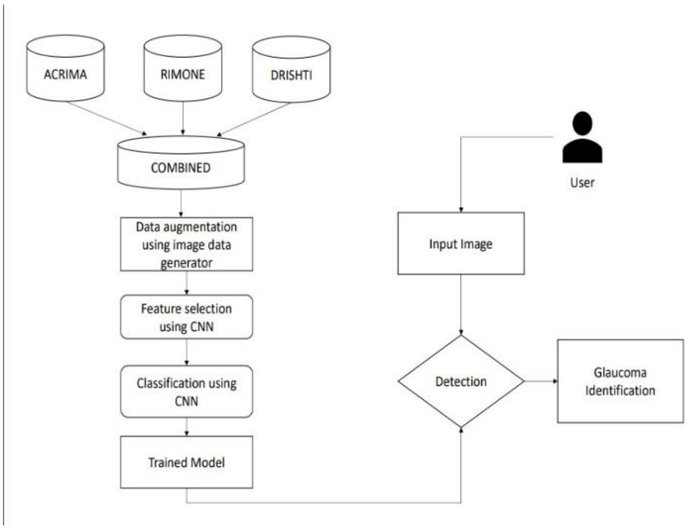

Figure.1 System Design

The datasets that are used in this model are RIMONE, DHRISTI and ACRIMA. We have taken 3 different datasets to increase the model to train and improve the detection algorithm accuracy.

DRISTHI: Acquired with a retinal fundus camera, the dataset includes 101 retinal fundus images, of which 31 are normal and 70 are glaucomatous. The "normal/abnormal" labels and soft segmented maps of "disc/cup" produced by IIIT Hyderabad researchers in collaboration with Aravind Eye Hospital in Madurai, India, serve as the truth for comparing the applied techniques. Moreover, the photographs in the data repository were taken under various brilliance and difference conditions while patients of different ages were visiting the hospital.

RIMONE: This dataset contains 313 healthy images and and 172 glaucoma images. These images were captured in three Spanish hospitals: Hospital Universitario de Canarias (HUC), in Tenerife, Hospital Univ ersitario Miguel Servet (HUMS), in Zaragoza, and Hospital Clínico Universitario San Carlos (HCSC), in Madrid. This dataset has been seperated into test and training sets, with two variants:

- Partitioned randomly: the training and test sets are built randomly from all the images of the dataset.
- Partitioned by hospital: the images taken in the HUC are used for the training set, while the images taken in the HUMS and HCSC are used for testing.

ACRIMA This database consists of 705 retinal images (where as 396 glaucoma affected images and 309 healthy images). These were collected at the FISABIO Oftalmología Médica in Valencia, Spain, from glaucoma affected patients and normal patients. All images from this database were annotated by glaucoma experts with several experience.

IV.RESULTS

In this section, we will explain the results that we achieved from this model. Many different performance metrics that may be used to assess a model's performance. Performance is evaluated using the Specificity, Confusion Matrix, Accuracy, Recall, Precision, and F1 score. The confusion matrix represents a clear explanation of values such as False Negatives and False Positives, True Positives, True Negatives. Neural network is trained for one cycle every epoch. In a given period, we only ever use a given piece of information. A pass is when two passes are combined, one forward and one backward. One or even more batches in each epoch to train the neural network using a part of the dataset. We refer to the process of going through one batch of training samples as an "iteration." For the model training, there are 150 epochs overall distributed across 32 batches.

We are using measures like accuracy, F1score, recall, precision. For calculating these metrics, using the confusion grid which consist of four characteristics. The model's accuracy is a measure of its performance across all classes. When each course is equally important, it helps. To calculate it, divide the total of forecasts by the whole of guesses. Be aware that the accuracy could be misleading. When data are unbalanced is one instance. Accuracy is the percentage of accurately classified items when it comes to multiclass classification.

$$\text{Accuracy} = \frac{TP+TN}{TP+FP+TN+FN} \times 100$$

TN = True negative.
TP = True positive.
FP = False positive.
FN = False negative.

Recall is intended as a fraction of Positive observations that were correctly classified as Positive in contrast to all Positive samples. When recall is higher, there are more positive samples discovered. Furthermore, if the model correctly classifies all positive data as positive, Recall equals 1.
Precision describes how precisely the model labels a random pick as positive. Whether the model makes many inaccurate Positive classifications or only a few accurate Positive classifications, the denominator rises and the precision falls. Yet, when the model makes numerous accurate Positive classifications in the initial scenario, the precision is high (maximize True Positive). This is useful in determining how accurate when it declares that an instance is true.
Sensitivity is to evaluate the model's performance as it observes how many positive instances it was able to identify correctly. A system with more sensitivity will have a few false negatives, which resembles that it is missing some optimistic instances. Specificity measures the proportion of true negatives that are identified by the model. When sensitivity is used to evaluate model performance, compared to specificity. Specificity.
F1-score functions as a statistical instrument for performance evaluation. An F-score can range from zero to 1.0, which represents flawless recall and accuracy, and from zero to zero when neither recall nor precision are present. Common performance metric for classification, for instance when samples belonging to one class are detected in significantly more samples than samples belonging to the other class.

$$\textbf{F1\_Score} = 2 \times \frac{\textit{precision x Recall}}{\textit{precision+Recall}}$$

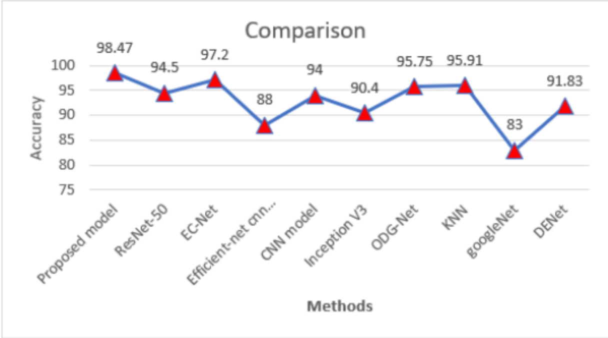

Figure.2 Accuracy comparison

In the **Fig.2**, the accuracy rate of different methods with the proposed model are represented in graph. This proposed model has an accuracy of 98.47%.

Model accuracy:

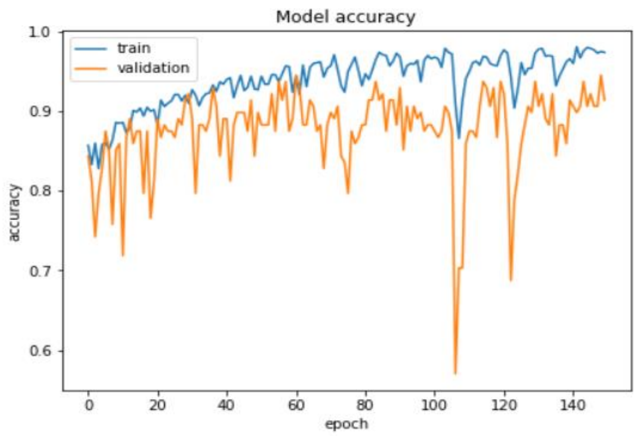

Figure.3 Model Accuracy graph

From the **figure.3**, we can observe many troughs and depths in the plotted graph. Since we are having 150 epochs, the accuracy at each epoch is plotted in the graph and after 100 epochs, a sudden drop in correctness and when we increase the epochs there, we can see a steady increase in the model's accuracy. This will give us a better insight into the model's performance.

Model loss:

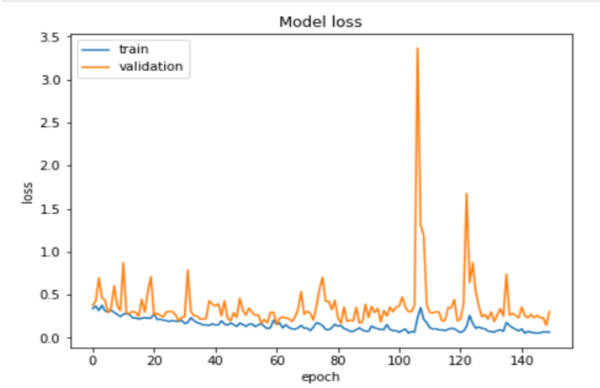

Figure.4 Model loss graph

figure.4 represents the dissimilar values of loss at each epoch. As discussed earlier, there is a sudden drop in the accuracy as the loss function value is varied. This graph of degrade function helps us to forecast the issues that occur with learning. These issues can lead to underfitting or an overfitted model.

CLASSIFICATIONS:

Table.1 Classification report

	Precision	F1-Score	Support
Glaucoma	0.984	0.984	65
Normal	0.984	0.984	66
Accuracy	0.984	0.984	0.984
Macro Average	0.984	0.984	131
Weighted Average	0.984	0.984	131

The classification report from **Table.1**, represents the achieved accuracy of 98.47% with an integrated dataset is to be noted and the existing studies have achieved the results by working on small datasets whereas the presented system has a large dataset, which is combined of three different datasets including the data augmentation and preprocessing that aids to progress the training of the model. The CNN that we implemented here can process even on low quality images. The dataset created is a balanced dataset with proportionate number of glaucoma and normal images.

Table.2 Comparison of Proposed method with Existing methods

Model	Accuracy
Proposed model	98.47
ResNet-50	94.5
EC-Net	97.2
Efficient-net CNNs model	88
CNN model	94
Inception V3	90.4
ODG-Net	95.75
KNN	95.91
Google Net	83
DENet	91.83

V. RESULTS

The output consists of the diagnosis of glaucoma, indicating whether the fundus image suggests the presence or absence of the condition.

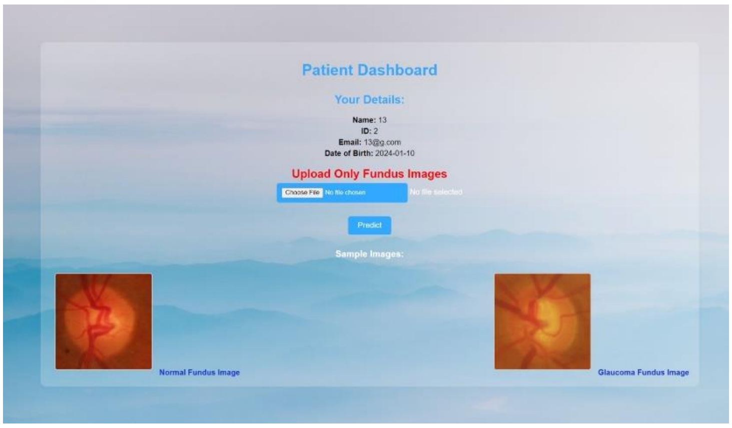

Figure.5 This is the patients dashboard.

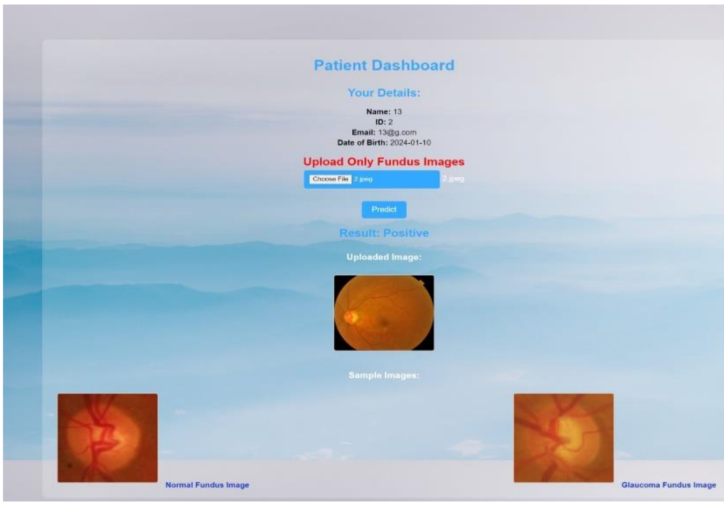

Figure.6 Image is uploaded by the user, the result is shown as positive.

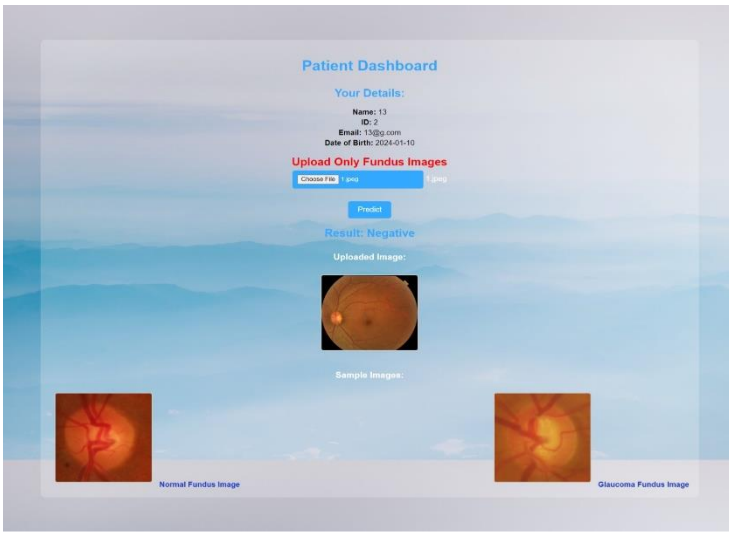

Figure.6 Image is uploaded by the user, the result is shown as negative.

VI.CONCLUSION

Permanent blindness is brought on by the complication of glaucoma, which is connected to optic nerve damage. The computer-generated outcomes from this work will help to raise the bar for clinical judgment when it comes to glaucoma identification. There are more normal fundus photos in the dataset, this algorithm can detect the glaucomatous images accurately. The proposed methodology uses an image data generator for data augmentation. The original images have increased due to augmentation and a huge dataset is prepared. Later the augmented images have been sent for feature selection using CNN. The images are classified using binary classification as it has two outcomes depending on the input image. This model had achieved a 98. 47%. Accuracy.

Advancements in image processing technology are poised to revolutionize the detection and management of various eye conditions, particularly glaucoma. This breakthrough methodology promises to significantly enhance clinical judgment in identifying glaucoma by leveraging computer-generated results. By harnessing the power of image processing, the precision and competence of glaucoma discovery are expected soar. This algorithm demonstrates remarkable proficiency in accurately identifying glaucomatous images, thus raising the standard for clinical diagnosis. Central to this method is the employment of an image data generator for augmentation, thereby expanding the primary data to facilitate comprehensive analysis. The augmented images are subsequently subjected to feature selection using advanced techniques, such as CNN. Through binary classification, wherein outcomes are categorized into two distinct possibilities, the system achieves an exceptional accuracy rate of 98%.

Building on this model, future research endeavors aim to broaden the possibility of application by improving the architecture of convolutional neural networks to sense a spectrum of eye conditions, including cataracts, retinal detachment, and diabetic retinopathy. By harnessing the potential of advanced technology and by taking the different huge datasets or with their own specific datasets of different ages, these initiatives hold the promise of revolutionizing ophthalmic diagnosis and treatment, ultimately enhancing patient outcomes and quality of life.

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