Deep Learning Based System for Detection of Retinal Diseases

Capstone Project Proposal

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BE FOURTH YEAR-COE

CPG No. 235

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Thapar Institute of Engineering and Technology, Patiala

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DECLARATION

We hereby declare that the project's design principles and working prototype model are entitled - Deep Learning Based system for Detection of Retinal Diseases is an authentic record of our work carried out in the Computer Science and Engineering Department, TIET, Patiala, under the guidance of Dr. Nitigya Sambyal during the 7th semester (2022).

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

DR	Diabetic Retinopathy
ME	Macular Edema
T2DM	Type 2 Diabetes Mellitus
DCCTRG	Diabetes Control and Complications Trial Research Group
US	United States
NPDR	Non-Proliferative Diabetic Retinopathy
PDR	Proliferative Diabetic Retinopathy
CNN	Convolutional Neural Networks
HTML	HyperText Markup Language
CSS	Cascading Style Sheets
JS	JavaScript
SRS	Software Requirements Specification
MAs	Microaneurysms
PCP	Primary Care Physician/ Provider
IRMA	Intra Retinal Microvascular Abnormalities
ANN	Artificial Neural Network
WHO	World Health Organization

SECTION-1 INTRODUCTION

1.1 Project Overview

Nowadays every one in six people suffers from diabetes. High blood sugar can lead to many conditions including eye problems. The most common eye diseases are diabetic retinopathy, macular edema, glaucoma etc. The timely detection of these eye diseases is necessary to prevent irreversible vision loss.

Traditionally, the detection of eye disease is done by ophthalmologist who basically inspects the patient's retina for abnormalities like micoraneurysms, hard exudates, cotton wool spots etc. However due to unavailability of medical expert or errors in manual inspection the detection of disease may get delayed which then may result in vision loss.

To overcome the drawbacks of manual system, we have proposed a convolution neural network based automatic detection of eye diseases. A CNN can automatically look at a patient's retina image and determine the severity of disease in the patient. The focus of the model will be towards severity detection of the disease like diabetic retinopathy, macular edema etc. The model will be trained using fundus image set and will determine the severity of the diseases from healthy to most damaged retina

This automated process can reduce a lot of time, thereby screening the process of treating eye diseases at a large scale.To make the project available to everybody in a way that is quick, free of cost, and hassle-free, the DL modelis hosted as a free service on a website, which is made with CSS, JS, HTML etc. Such a system will help in highly accurate mass screening of patient's retina and can even assist doctor for disease detection.

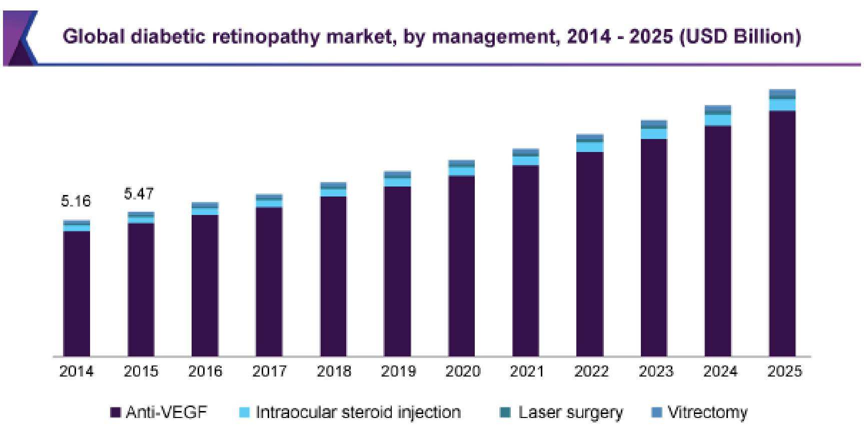


Fig 1.1: Global DR market growth trend

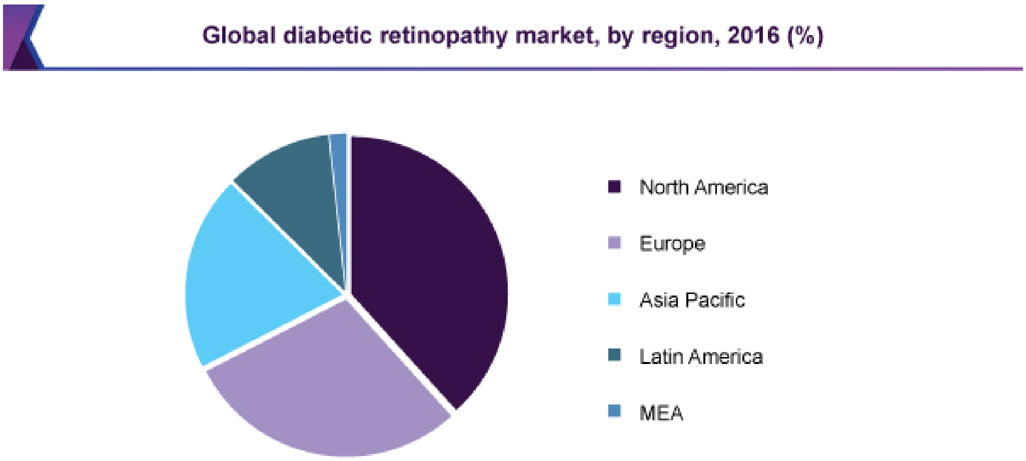


Fig 1.2: Global DR market distribution (%), by region, of year 2016

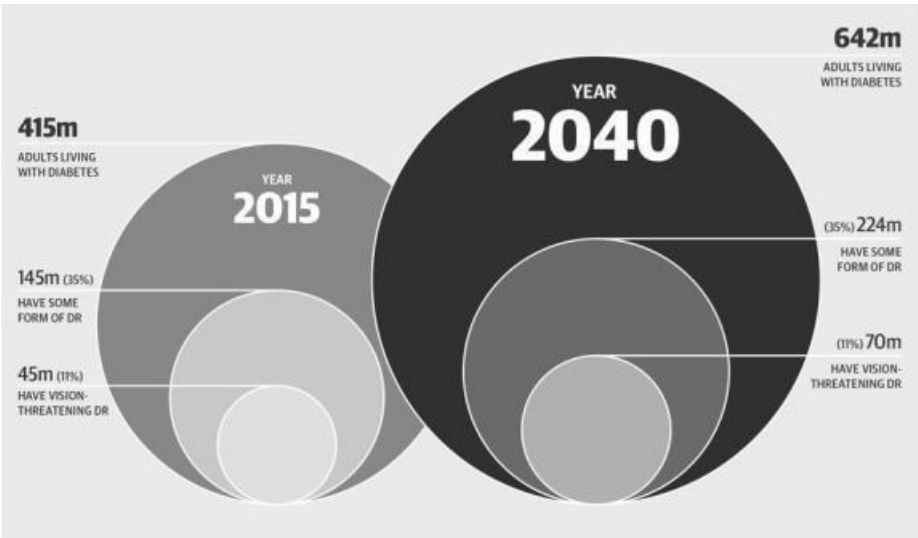


Fig 1.3: Future predictive and analytical vision of disease

1.2 Need Analysis

Diabetic eye diseases of the retina impacts sufferers with diabetes mellitus. Among them Diabetic Retinopathyis by far the primary cause of blindness in human beings between the ages of 20-64. Indexed amongst WHO's top ten list of priority eye diseases, it's a tremendously omitted micro-vascular problem in developing international locations, particularly India, where most number of type 2 Diabetes Mellitus sufferers are dwelling. Macular edema rarely causes a permanent loss of vision and can usually be easily treated, but the recovery is often a slow, gradual process. Though the condition is typically not considered serious, it can be a sign or symptom of a more serious health problem that may need to be addressed. The damage caused by glaucoma can't be reversed. But treatment and regular checkups can help slow or prevent vision loss, especially if you catch the disease in its early stages

The probability of developing DR or other eyes diseases is related to the period of the ailment. Type 2 diabeteshas an insidious onset and may get overlooked for years. As a result, patients may additionally already have DR, Macular edema or Glaucoma at the time of diagnosis. Type 1 diabetics, then again, when diagnosed earlyin the course of their disease, usually do not expand to retinopathy until years after the prognosis.

Even though technological improvements, powerful treatments are available nowadays to prevent the extremetiers, the wide variety of trained ophthalmologists capable of diagnosing retinal scans and the supply of desirable medical treatment facilities are still massively outnumbered by the global burden of problem. Globally, an expected 422 million adults were suffering from diabetes in 2014, in comparison to 108 million in 1980. The global incidence of diabetes has almost doubled since 1980, growing from 4.7% to 8.5% in the adult population. The increasing prevalence of diabetes along with the growing incidence of blindnessdue to diabetes is anticipated to propel the market growth over the forecast period.

Traditionally, the classification of DR involves weighting numerous features and then locating such features.This is highly time-consuming for clinicians. Retinal photograph with medical interpretations is a widely accepted screening tool for DR. Computers can obtain quicker classifications once trained. Automated gradingof DR has potential benefits such as increasing efficiency, reproducibility, reducing barriers to access, and improving patient outcomes by providing early detection and treatment. This does not absolve the doctor fromhis duty but merely provides a second opinion. Thus, to maximize the clinical utility of automated grading, analgorithm to detect DR is required. The project also enables patients to get checked for DR remotely. This can be vital in times when in-person evaluation cannot be done or is not preferred. Also – as the general problem being solved here is that of image processing of blood vessels – by making a few changes to the project's CNN model, we should be able to detect various other diseases involving blood vessel abnormalities, like blood clots, brain aneurysms, and abnormal blood vessel knot

1.3 Research Gaps

1. The current literature focuses mostly on diabetic retinopathy detection and not on macular edema detection which is a serious complication associated with it.
2. A single platform is not available where multiple retinal diseases can be detected.
3. The existing techniques for the detection of retinal diseases associated with diabetes have less accuracy.

1.4 Problem Description

Diabetes is a metabolic disease that causes high blood sugar. This in turn causes damage to the retina resulting in irreversible vision loss. In this project, we have proposed a deep learning-based system for the detection of eye diseases. This system will assist the medical experts and willallow early detection of eye diseases to control and possibly prevent irreversible vision loss.

1.5 Constraints

- Since the image will not be stored in the database for the user, the user would have to upload it again to see the results.
- The size of the image should be less than 10 MB.
- The website can take up to 15 seconds and at least a second to revert with results.

Assumptions

- Users will possess decent internet connectivity for the web app to work.
- A standard form of retina image is assumed.
- The user is familiar with an internet browser and handling the keyboard and mouse.
- User has access to a device with adequate hardware and software requirements to be

able to access the internet and store and upload images. If the device does not haveenough hardware resources available for the application,
for example, the users might have allocated them with other applications, there may be scenarios where the application does not work as intended or even at all.

- A modern browser able to run advanced HTML, CSS, and JS scripts.
- Retina images, alone are sufficient to determine the stage of DR that a patient is currently suffering from.

1.6 Standards

The SRS building process completely followed from the IEEE guide to building an SRS (830-1998- IEEE). CASE are tools used for constructing different software diagrams. For code implementation purpose google coding standards for conventions and layout is used. For testing and its documentation IEEE standards will be used as part of the future scope of the project.

Phase or activity group	Number	Standard Title
Requirement specification	IEEE 830 IEEE 1233 IEEE 1320	Recommended practice for software requirements specifications Guide for developing system requirements specifications Functional modelling language
Design	IEEE 1016 IEEE 1471	Software design descriptions Recommended practice for architectural description of software-intensive systems
Implementation, acquisition and tools	IEEE 1062 IEEE 1462 IEEE 1175	Software acquisition Guideline for the evaluation and selection of CASE tools Guide for CASE tool interconnections
Testing	IEEE 829 IEEE 1008 IEEE 1012 IEEE 1059 IEEE 1028 IEEE 1044	Software test documentation Software unit testing Software verification and validation Guide for software verification and validation plans Software reviews and audits Classification for software anomalies
Maintenance	IEEE 1219	Software maintenance

Table 1.1: IEEE Standards followed in the report

1.7 Approved Objectives

The main objectives of the project are as follow-

1. To study various models for eye disease detection.
2. To design and implement a deep learning model for detection of eye diseases.
3. To analyze the performance of the proposed model and compare it with existing models in the literature.
4. To design a deep learning-based web application for the detection of eye diseases.

1.8 Methodology

Data Collection

In the project, a fundus image set will be used for the detection of eye diseases. The dataset should be labeled for various eye diseases like diabetic retinopathy, macular edema, etc.

Pre-processing of data

The fundus images will be pre-processed and cleaned. Further data augmentation will be employed for image instances. The images will be split into training and test ratio for the training of the model.

Model Design and implementation

A deep learning-based model will be proposed for the detection of various eye diseases. Further, the model will be analyzed on various performance parameters like accuracy, sensitivity, precision, etc.

Comparative analysis

The proposed model will be compared with existing models in literature on the basis of performance parameters like accuracy, precision, sensitivity, etc.

Web Application

A web application will be developed based on the proposed model. The web application will assist medical experts in the automatic detection of eye diseases.

1.9 Project Outcomes and Deliverables

The main outcomes of the project are as follows-

A deep learning-based model for the detection of various eye diseases.

A web application that can assist ophthalmologists in the detection of eye diseases.

1.10 Novelty of Work

This interdisciplinary project combines DL, image recognition, medical procedures, and web development to concoct a product that helps patients get diagnosed more easily and quickly. There was never a single platform where multiple eye diseases could be detected. So, we will design a website where multiple retinal diseases can be detected. Only ML models were available for the detection of Macular Edema. We have used a deep learning model to detect Macular edema.

SECTION 2: REQUIREMENT ANALYSIS

2.1 Literature Survey

2.1.1 Theory Associated with Problem Area

2.1.1.1 Overview of the disease

Diabetic retinopathy is a diabetes complication that affects the eyes. It's caused by damage to the blood vessels of the light-sensitive tissue at the back of the eye (retina). At first, diabetic retinopathy might cause no symptoms or only mild vision problems. But it can lead to blindness. The condition can develop in anyone who has type1

or type 2 diabetes. The longer you have diabetes and the less controlled your blood sugar is, the more likely you are to develop this eye complication.

Macular edema is swelling in the part of the retina (the light-sensitive layer of tissue at the back ofyour eye). People with macular edema may have blurry vision, but treatment can help reduce the swelling and prevent vision loss. There are many different conditions that can cause macular edema. The most common one is diabetic retinopathy — an eye condition that causesvision loss in people with diabetes. When diabetic retinopathy causes macular edema, it’s called diabetic macular edema (DME).

2.1.1.2 Complications

DR is considered to be the result of vascular changes in the retinal circulation. In the early stages, vascular occlusion and dilations occur. It progresses into a PDR with the growth of new blood vessels. ME (the thickening of the central part of the retina) can significantly decrease visual acuity. These complications can lead to serious vision problems like Vitreous hemorrhage, Retinal detachment, Glaucoma, and Blindness.

2.1.1.3 Symptoms

The symptoms of complications might not occur in the early stages of DR and ME.

As the condition progresses, symptoms may include:

- Spots or dark strings floating in your vision (floaters)
- Blurred vision
- Fluctuating vision
- Impaired color vision
- Dark or empty areas in your vision
- Vision loss

Stages of DR and ME:

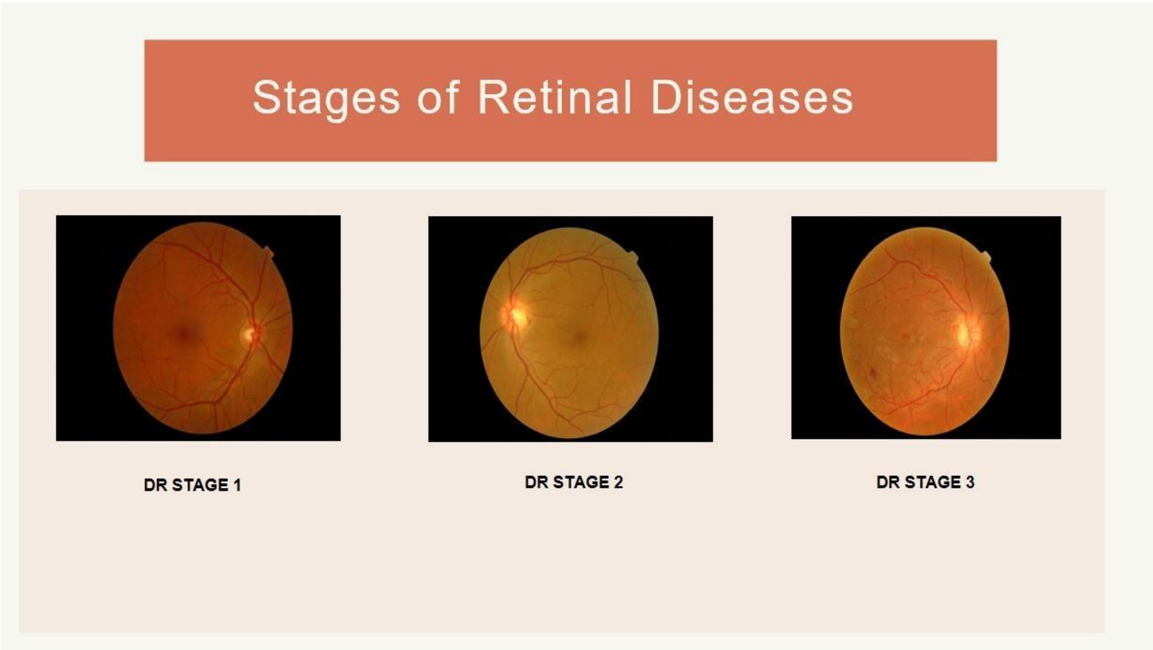


Fig. 2.1 Stages of DR

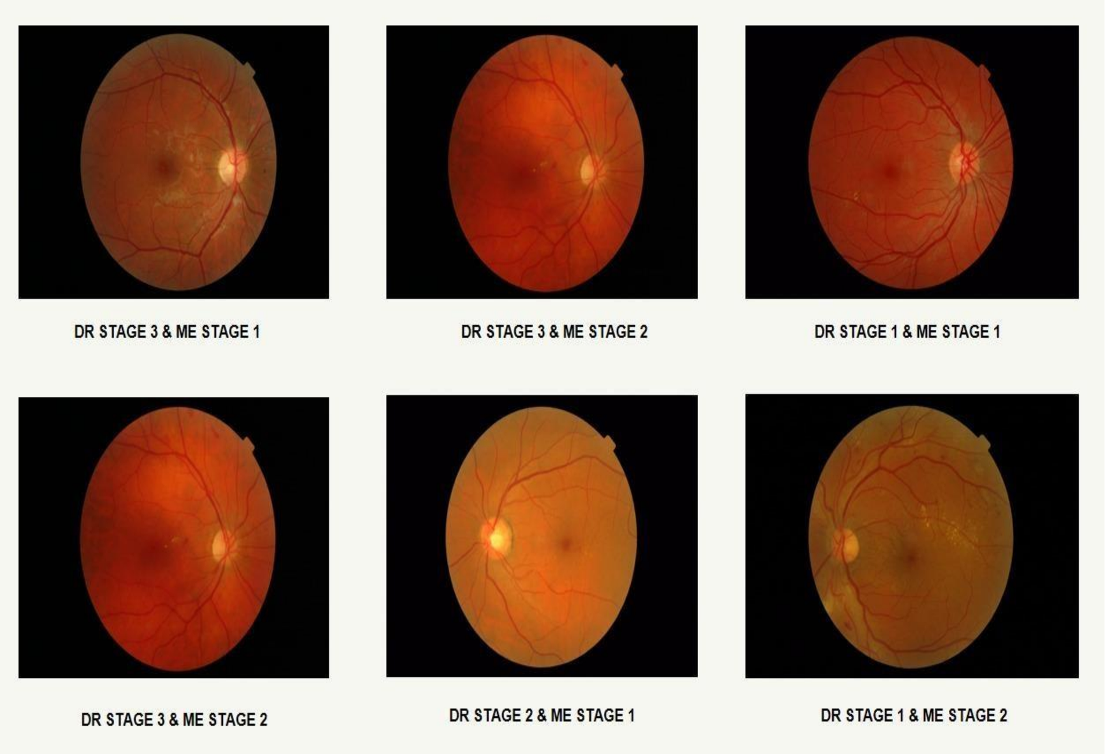


Fig. 2.2 stages of DR and ME

2.1.2 Existing Systems and Solutions

2.1.2.1 Fundus Photography

Fundus photography is the usage of a fundus camera to photograph the region of the eye. Although the equipment for fundus photography can be easily accessible a qualified ophthalmologist who can analyze the fundus images cannot. The population of diabetic patients is enormous yet the total number of ophthalmologists is only 29 per 1 million persons indicating the need for system that diagnoses eye diseases automatically [20].

2.1.2.2 Traditional Automated Works

Much more work has been done in using computers to make automatic diagnoses. Traditional methods often deploy various feature extraction modules to first extract useful information from the fundus images and after that the extracted features are passed to classifiers such as the SVM, random forest classifier, etc. Such handmade feature-based methods are time consuming and often yield false results [21].

2.1.2.3 Deep Convolutional Neural Networks

Automated methods to detect MAs and reliably grade fundoscopic eye images of patients have been active areas of research in computer vision. The first ANN explored the ability to classify patches of the normal retina without blood vessels, normal retinas with blood vessels, pathologic retinas with exudates, and pathologic retinas with MAs [22]. Now with the advancement of technology and having powerful CNN structures in hand, one can explore and extend the boundaries of research and development, in the field of eye disease classification.

2.1.3 Research Findings for Existing Literature

S. NO.	Name and Roll no.	Paper Title	Authors	Model/Technology	Dataset	Findings
1.	Arshdeep Singh 101903217	Computer-Assisted Diagnosis for Diabetic Retinopathy Based on Fundus Images Using Deep Convolutional Neural Network [5]	Yung-Hui Li , Nai-Ning Yeh, Shih-Jen Chen , and Yu-Chien Chung	DCNN, SVM classifier	Kaggle Dataset	This paper presents a novel algorithm based on DCNN used for the automated detection of DR. Unlike the traditional DCNN approach, the commonly used max - pooling layers is replaced with fractional max-pooling.

2.		Deep Learning Approach to Diabetic Retinopathy Detection [6]	Borys Tymchenko, Philip Marchenko, Dmitry Spodarets	Deep learning, Deep CNN, multi-target learning, ordinal regression, classification	EyePACs, 2015	Automated deep-learning based method for stage detection of DR by single photography of the human fundus
3.		Iris – Diabetic Retinopathy Detection	Noel J Philip , Romi Roji , Rosme Jose ,	CNN, transfer learning, GoogLeNet,	Kaggle dataset of 35,000	Use of CNNs on colour fundus images

		Software [7]	Rehna Cherian, Dr. Arun K.S	AlexNet, ImageNet	images with 4-class labels (normal, mild, moderate, severe).	to diagnose DR staging.
4.	Abhey Kumar Singla 101917089	Retinopathy and Mortality [8]	Emily Frith, Paul D Loprinzi	CNN	Data from the 2005–2008 National Health and Nutrition Examination Survey were used to identify 4,777 adults with complete data regarding screening for nonproliferative retinopathy using Early Treatment Diabetic Retinopathy Study grading criteria	Brief explanation on CNN, pooling layers and convolutional layers.
5.		Microaneurysm detection in fundus images using a twostep convolutional neural network [10]	Noushin Eftekhari, Hamid-Reza Pourreza, Mojtaba Masoudi, Kamaledin Ghiasi-Shirazi & Ehsan Saeedi	CNN	Retinopathy Online Challenge dataset and E-Ophtha-MA dataset	In this paper, an approach for automatic MA detection in retinal images based on deep-learning CNN is developed to address the

						previous works problems such as imbalanced dataset and inaccurate MA-detection
6.	Hitesh Garg 101903544	Automated Detection of Diabetic Retinopathy Using Deep Learning [11]	Carson Lam, MD, Darvin Yi, Margaret Guo, and Tony Lindsey	CNN	Kaggle dataset of 35,000 images with 5-class labels (normal, mild, moderate, severe, end stage) and Messidor-1 dataset of 1,200 color fundus images with 4-class labels (normal, mild, moderate, severe)	In this paper an automatic DR grading system capable of classifying images based on disease pathologies from four severity levels is introduced.
7.		Diabetic Retinopathy Detection Using Prognosis of Microaneurysm and Early Diagnosis System for NonProliferative Diabetic Retinopathy	Lifeng Qiao , Ying Zhu , and Hui Zhou	DCNN	https://ieee-dataport.org	This paper presents the Prognosis of MA and early diagnostics system for NPDR capable of effectively creating DCNNs for the semantic segmentation

		Based on Deep Learning Algorithms [12]				of fundus images which can improve NPDR detection efficiency and accuracy.
8.	Himanshu Mahajan 101903212	Automated Identification of Diabetic Retinopathy Using Deep Learning [13]	Rishab Gargeya , TheodoreLeng	Data-driven Deep Learning Algorithms	MESSIDOR 2 and E-Ophtha databases	A fully data-driven artificial intelligence grading algorithm can be used to screen fundus photographs obtained from diabetic patients and to identify, with high reliability, which cases should be referred to an ophthalmologist for further evaluation and treatment
9.		Deep Transfer Learning models for medical DR detection [9]	Nour Eldeen M. Khalifa, Mohamed Loey, Mohamed Hamed N. Taha, and Hamed Nasr Eldin T. Mohamed	CNN, ML, Deep transfer learning	APTOS 2019 dataset	The AlexNet model has proven to be most accurate in categorizing DR images, with accuracy of 97.9%.

Table 2.1: Research Findings for Existing Literature

2.1.4 Problem Identified

To automate the diagnosis of eye diseases and provide appropriate suggestions to patients by trained CNN model to grade the severities of fundus images.

The goal here is to develop an image classification model which analyze the images and successfully detect the eye disease that the patient is currently suffering from. This image classification model will accelerate the process of disease detection in patients. Currently doctors review the image and identify the disease.

2.1.5 Survey of Tools and Technologies Used

Kaggle: Kaggle allows users to collaborate with other users, find and publish datasets, use GPU integrated notebooks, and compete with other data scientists to solve data science challenges.

Dataset used: The 1200 eye fundus color numerical images of the posterior pole of the Messidor database were acquired by 3 ophthalmologic departments using a color video 3CCD camera mounted on a Topcon TRC NW6 non-mydriatic retinography with a 45 degree field of view. Images were captured using 8 bits per color plane at 1440*960, 2240*1488 or 2304*1536 pixels. Messidor was a research program funded by the French Ministry of Research and Defense within a 2004 TECHNO-VISION program.

2.2 Software Requirements Specification

2.2.1 Introduction

This section documents the specific requirements (functional and non-functional), performance requirements, design constraints and external interface requirements.

2.2.1.1 Purpose

This SRS documents key specifications, describes a prototype in terms of functional and non-functional requirements for the disease detection and classification portal. This information documented, helps the intended audience to design and develop the product. We will be launching an official prototype version and will make amendments in it according to the user needs.

2.2.1.2 Intended Audience and Reading Suggestions

The project is meant to help and empower anyone working in the health sector or aspiring to change the ways in which the health and medical sector deals with diabetes and its early detection and prevention. This project is also meant for those who want flexible and cost-effective means of diabetes detection. We aim to make the process of detection and prevention of diabetes easy and accessible to everyone, since the conventional ways of diabetes detection tend to be expensive. We have tried our best to come up with an efficient and accurate solution for the problem and hope that you are fascinated as well as satisfied by our approach.

2.2.1.3 Project Scope

The model will be able to detect eye diseases and successfully detect the Diabetic Retinopathy and Macular Edema and its stage for proper treatment. It would also be accessible from a web application in a reasonable time frame. The model will be a cost-effective solution for DR, and will be able to help improve patients' outcomes by providing early detection and treatment.

2.2.2 Overall Description

2.2.2.1 Product Perspective

Our objective with this project is to automate the diagnosis of eye diseases and provide appropriate suggestions to the patients by training a deep CNN model to grade the severity of fundus images. We have implemented the use of CNN and image processing to analyze the images and successfully detect the disease and its stage that the patient is currently suffering from.

2.2.2.2 Product Features

We will create and host an online platform or portal which can be used by various hospitals for its different patients. The user needs to have a registration ID and password. After signing in with valid credentials, they would have the option to upload the fundus image on our portal. This image would then be passed on to our trained model which uses CNN and image processing to analyze and dissect the eye disease and the stage that the patient is suffering from. The results would then be displayed on the portal.

2.2.3 External Interface Requirements

2.2.3.1 User Interfaces

The front end/ home page of the website directs the user to upload image and displays the categorized results.

2.2.3.2 Hardware Interfaces

User's PC will be connected to our website's database by the Internet via TCP/ IP protocol.

2.2.3.3 Software Interfaces

- The image is uploaded to website in compatible formats and is transferred to CNN using SQL query.
- Information is passed from one layer of CNN to other in form of functions representing images.
- The result category is transferred from CNN to front end by SELECT query.
- HTML code interfaces with the output of browser via an in-built compiler.

2.2.4 Other Non-Functional Requirements

2.2.4.1 Performance Requirements

- The website should revert results swiftly.
- Image upload should not take hefty time.
- Website should be accessible with a moderate internet connection.

2.2.4.2 Safety Requirements

The CNN model should only be deployed when a consistent and satisfactory accuracy has been achieved.

2.2.4.3 Security Requirements

- The website should be protected with standard protocols and updates against phishing, spam or other hacking attacks.
- Only valid image formats should be accepted from user.

2.3 Cost Analysis

The leading factors in determining cost in making this project would be:

a. The cost of hosting the website on the server and maintaining it efficiently.
b. Registering and buying an appropriate domain name for the website.

This would account to a total of – Rs. 2000 per year approximately. For the future purposes, we may add the Google Ads in the website for the purpose of generating revenue.

2.3 Risk Analysis

- Some new form of virus may be present in user’s image.
- CNN may not be able to categorize some special case of retina image.
- Delay in time to display results due to latency between front and back end

Section-3 METHODOLOGY ADOPTED

3.1 Investigative Techniques

Experimental research is research conducted with a scientific approach using two sets of variables. The first set acts as a constant, which you use to measure the differences of the second set.Experimental research gathers the data necessary to help you make better decisions.

Any research conducted under scientifically acceptable conditions uses experimental methods. The success of experimental studies hinges on researchers confirming the change of a variable is based solely on the manipulation of the constant variable. The research should establish a notable cause and effect.

Our investigative approach is experimental as it relies on the data of retina images with confirmed stages of DR and ME which are further used to train our model in order to classify future retina imagesin different stages of DR and ME. We depend on the accuracy and legitimacy of the data obtained by us. We work under the fact that retina images alone are sufficient to determine the stage of DR and MEthat a patient is suffering from. We know from various research papers that diabetes and the consequent stage of diabetic retinopathy and macular edema are directly related and are therefore correlated.

3.2 Proposed Solution

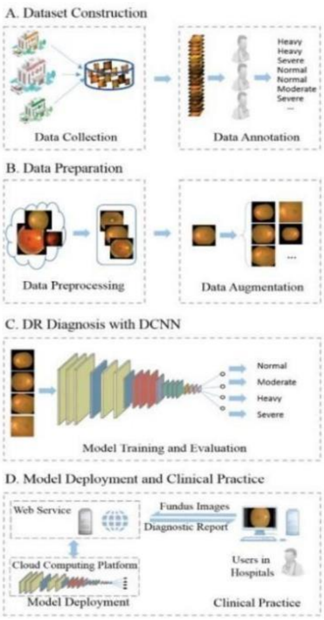


Fig 3.1: Flow Chart

Millions of people suffer from eye disease, the leading cause of blindness among working-age adults.Currently, the technicians capture images and then rely on highly trained doctors to review those images and provide a diagnosis.

The goal here is to scale their efforts through technology to gain the ability to automatically screen images for disease and provide information on how severe the condition may be.

We shall be achieving this by building a CNN model that can automatically look at a patient’s eye image and estimate the severity of blindness in the patient. This automation process can reduce a lot of time, thereby screening at a large scale.

Hospitals and doctors can register on the portal to access the service.

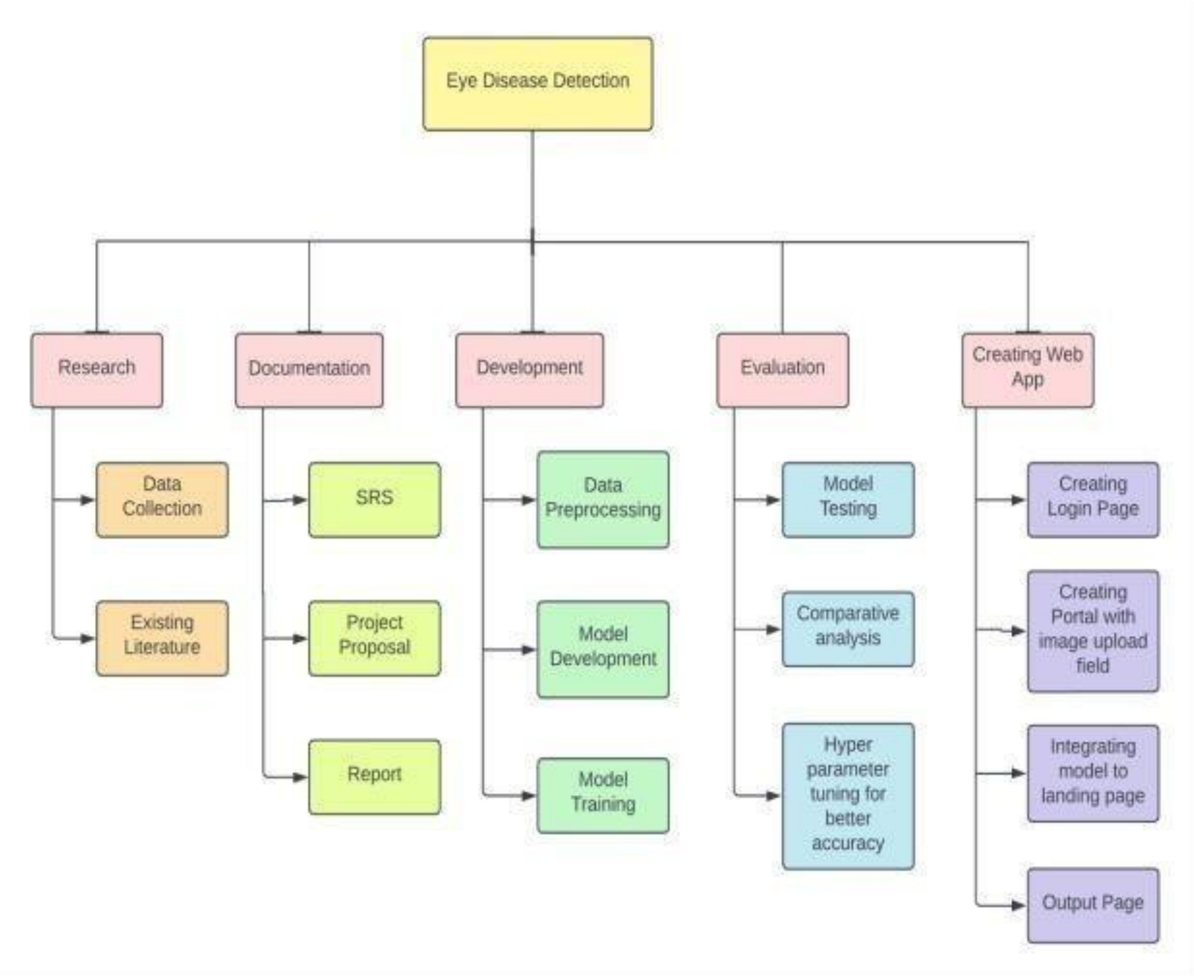


Fig 3.2 Work Breakdown Structure

3.3 Tools and Technology

Kaggle: Kaggle allows users to collaborate with other users, find and publish datasets, use GPU-integrated notebooks, and compete with other data scientists to solve data science challenges.

Dataset used: The 1200 eye fundus color numerical images of the posterior pole of the Messidor database were acquired by 3 ophthalmologic departments using a color video 3CCD camera mounted on a Topcon TRC NW6 non-mydriatic retinography with a 45 degree field of view. Images were captured using 8 bits per color plane at 1440*960, 2240*1488 or 2304*1536 pixels. Messidor was a research program funded by the French Ministry of Research and Defense within a 2004 TECHNO-VISION program

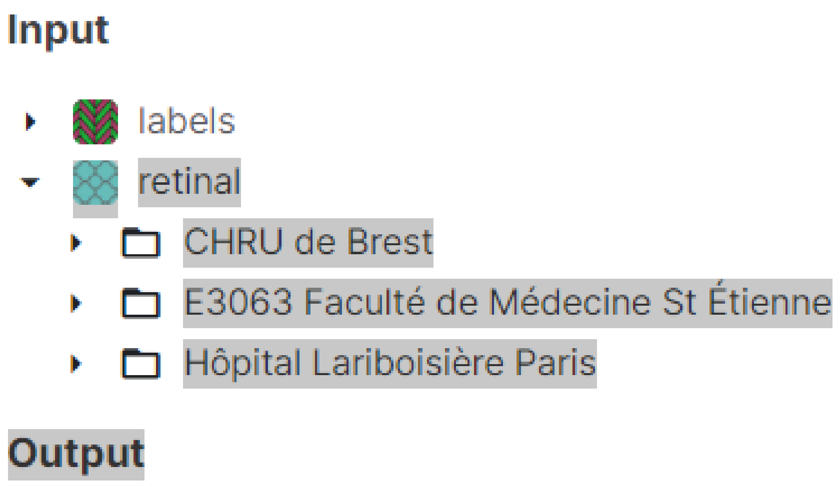


Fig 3.3 Dataset

Image Preprocessing and Augmentations:

Image cropping and resizing was used. Spuriouscorrelations between the output class label and several image meta-features, e.g., resolution, crop type, zoom level, or overall brightness. Image Augmentations were used – (optical distortion, piecewise affine transform, horizontal flip, vertical flip, random rotation, random shift, random scale, a shift of RGB values, random brightness and contrast, additive Gaussian noise, blur, sharpening, embossing, random gamma, and cutout).

Deep Learning:

Deep learning is a type of machine learning, which is a subset of artificial intelligence. Machine learning is about computers being able to think and act with less humanintervention; deep learning is about computers learning to think using structures modeled on the human brain. Concepts like CNN, ANN, Batch Normalization, Dropout, Max Pooling, Adam Optimizer, and Activation functions – relu and softmax were used.

Model Architecture:

Task learning Model (as it parallelly does training for Regression, Classification, Ordinal Regression)**;** CNN Architecture –Sequential Model from Keras, ResNet50, VGG16.

Data Science Tools and Libraries:

Python, Warnings, Pandas, Numpy, OS, Sklearn, Seaborn,Matplotlib, CV2 (OpenCV), Keras, etc.

SECTION-4 Design Specifications

4.1 System Architecture

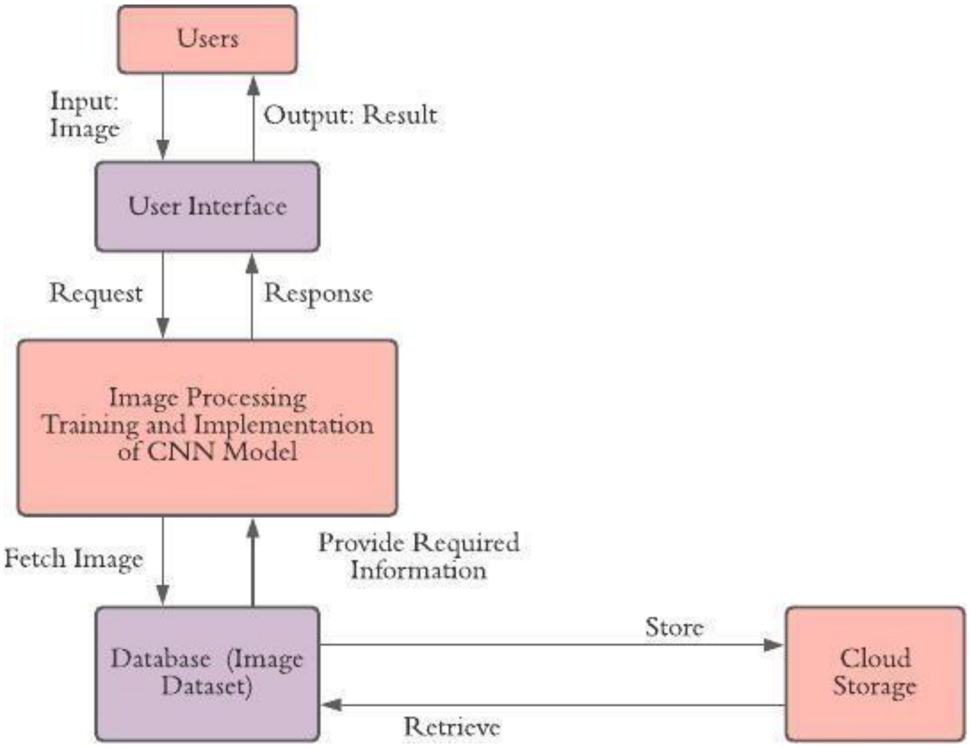


Fig 4.1: Three tier diagram

4.2 Design Level Diagrams

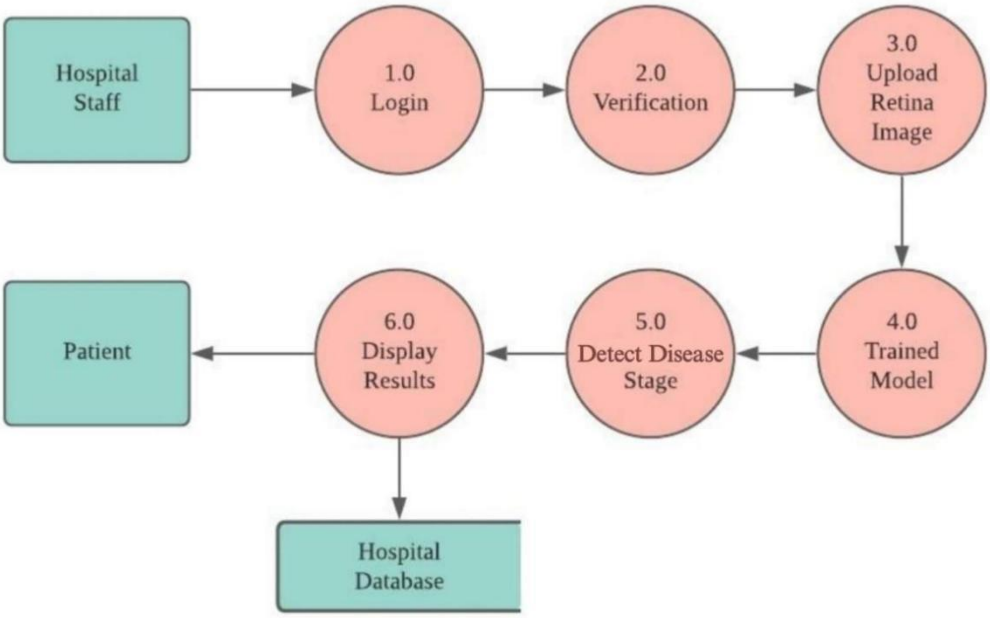


Fig 4.2: Data Flow Diagram

4.3 User Interface Diagrams

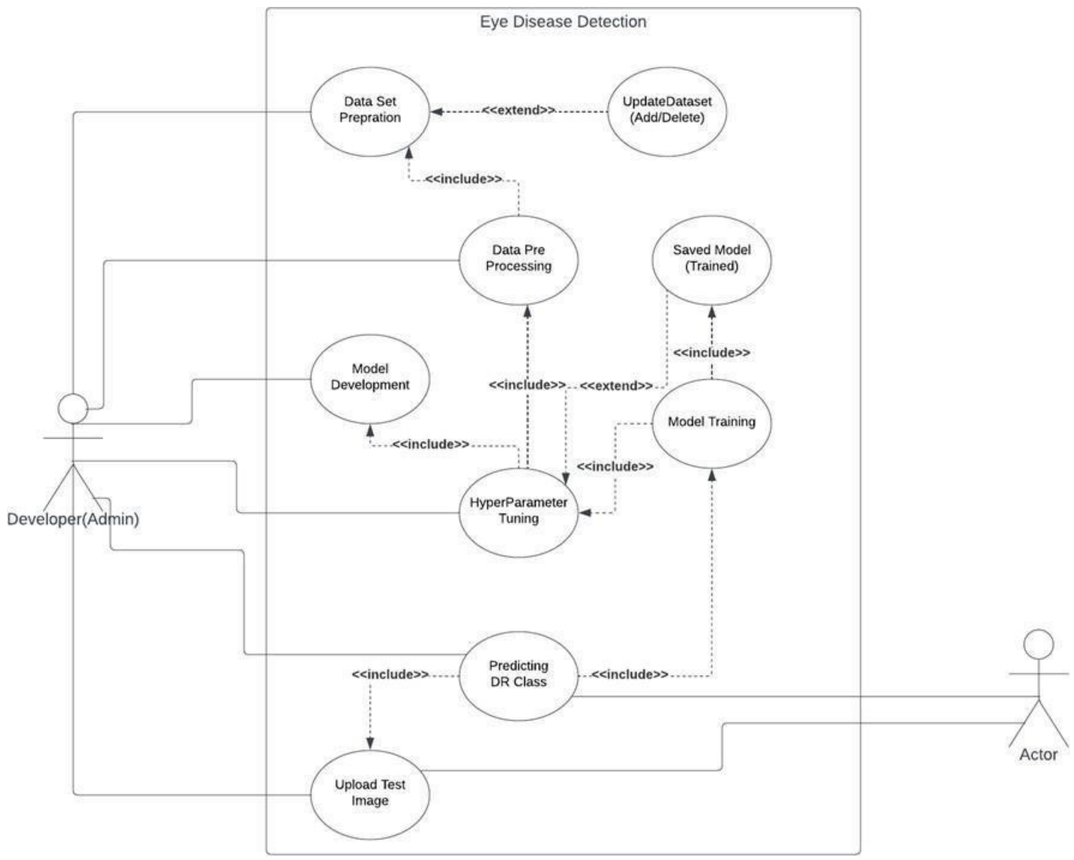


Fig 4.3: Use Case Diagram

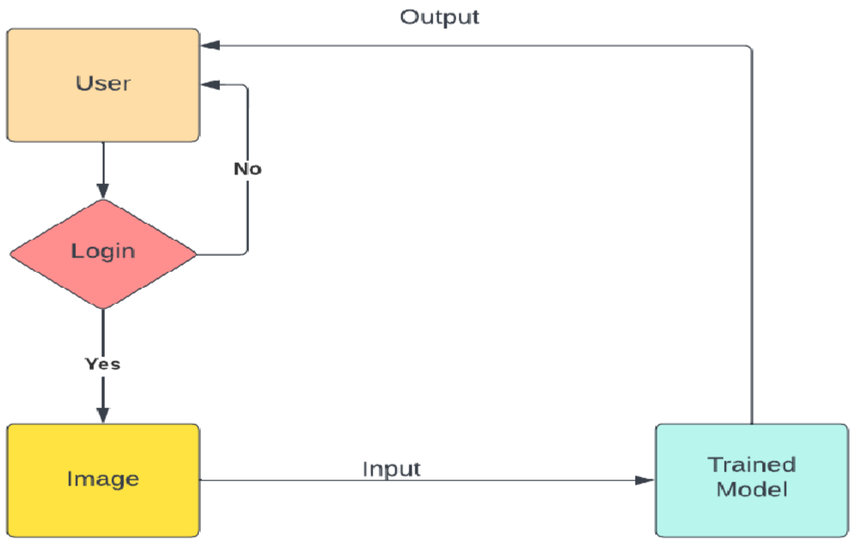


Fig 4.4 Block Diagram

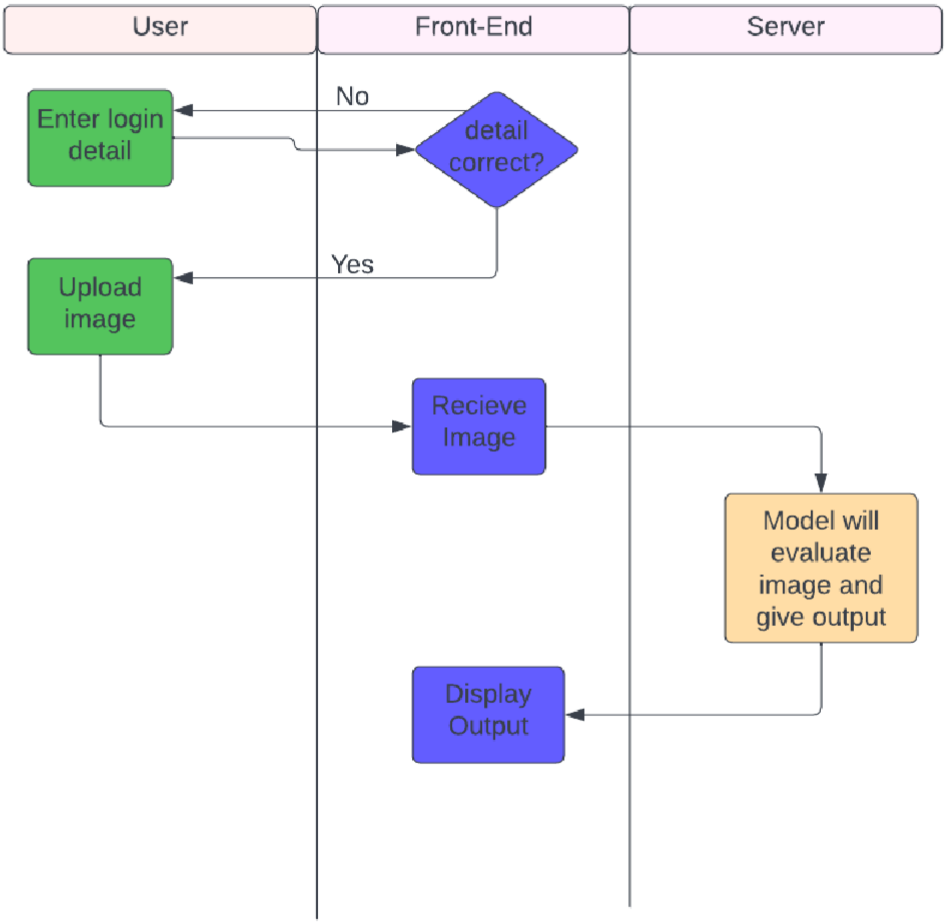


Fig 4.5 Swimlane Diagram

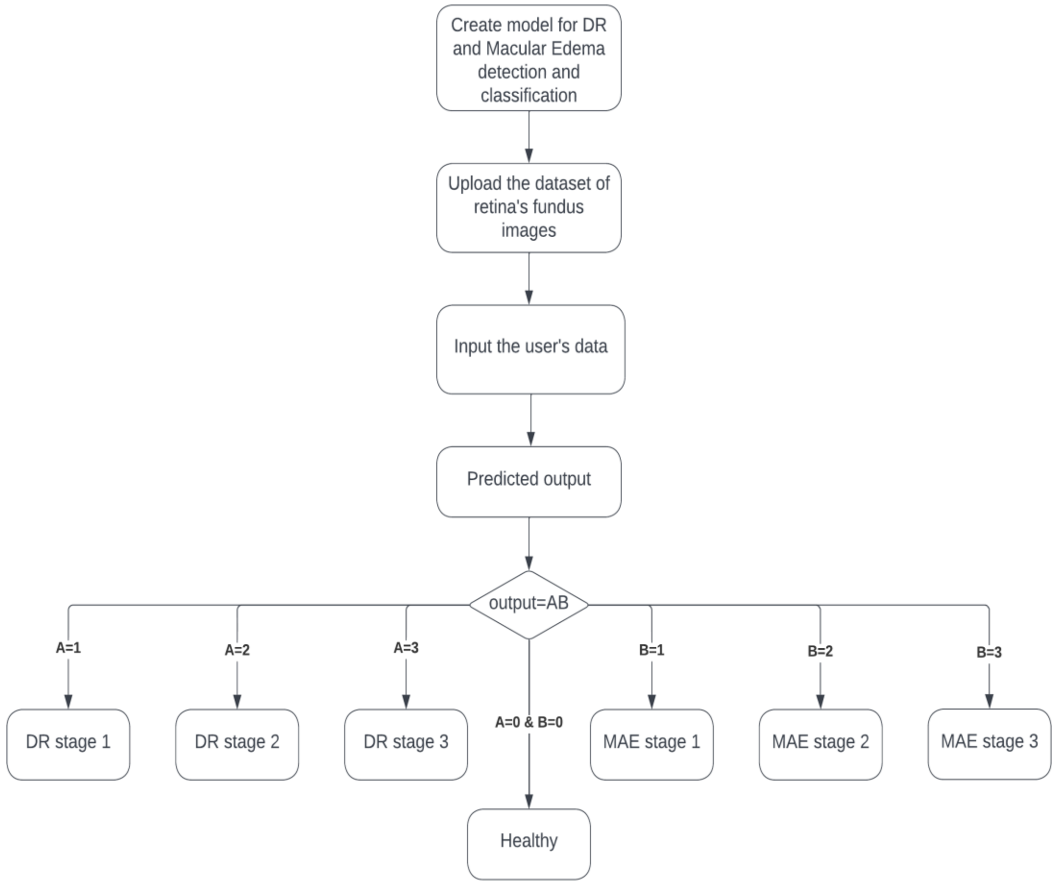
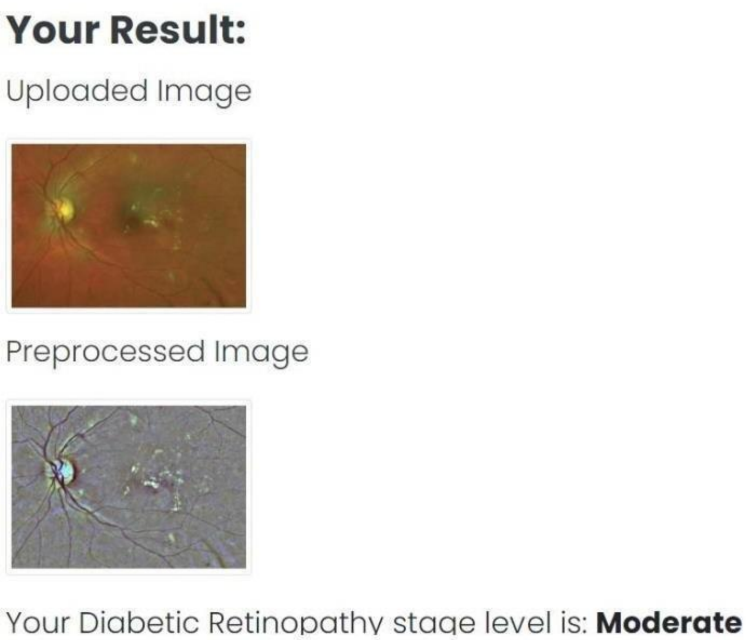


Fig 4.5 Activity Diagram

4.4 Snapshots of working prototypes


Check your DR stage level
70% accurate results
Choose File
No file chosen...
Check your result


Your Result:
Uploaded Image
Preprocessed Image
Your Diabetic Retinopathy stage level is: Moderate

SECTION-5 CONCLUSIONS AND FUTURE SCOPE

5.1 Work Accomplished

S. No.	Activity	Month / Week
1	Gathering Team Members	Plan
2	Team Meeting	Plan
3	Basic Idea	Plan
4	Mentor Search	Plan
5	Implementation of Idea	Plan
6	meeting	Plan
7	Improving Idea	Plan
8	Implementation of Improved Idea	Plan
9	Research on Project Idea	Plan
10	Analysis of Requirement	Plan
11	Creation of Proposal	Plan
12	Creation of PPT	Plan
13	Gathering of Dataset	Plan
14	Deep research on project	Plan
15	Learning required tools & technologies	Plan
16	Processing Dataset	Plan
17	Coding of the Model	Plan
18	Model Training over Dataset	Plan
19	Model Testing	Plan
20	Adjustments in model for better accuracy	Plan
21	Final Testing	Plan
22	Final Report	Plan

Months: January, February, March, April, May, June, July, August, September, October, November; Weeks: 1 2 3 4 per month.

Table 5.1 Work accomplished

5.2 Conclusions

DR and ME cannot be cured. To prevent vision loss, laser analysis is usually very effective if it is done before it adversely harms the retina. Our model will help in the early detection of DR and ME at a very reasonable cost. The model that we shall be developing can be tagged as a great detector to detect whether a person has eye disease or not automatically by using the eyes' fundus photographs. It will correctly identify the eye disease and its stage.

5.3 Environmental, Economic, and Social Benefits

Automated identification of DR and ME, which is the primary cause of blindness and visual loss for those aged 18-65 years, from images of the retina, has enormous potential to increase the quality, cost-effectivenes,s and accessibility of preventive care for people with diabetes

The current challenge is to make early detection more accessible by reducing the cost and manpower required while maintaining or improving DR and ME detection quality. This challengecan be met by automated detection of DR and ME in retinal images. To examine 100,00 patients screening of retinal images by a human grader can take a long time if he/ she can evaluate 8-12 patients per hour whereas the automatic system will be very beneficial to examine them within a very less time as compared to the human grader.

Automatic disease detection has the potential to provide cost savings, especially in low-income populations and rural patients with high transportation costs. Generally, charges of $30 - $60 for screening retinal photography are common which may increase depending on the region where it is performed.

Multiple patient barriers to DR and ME screening exist, including poor access to care, lack of time,high out-of-pocket expenses, and insufficient patient knowledge and awareness of DR and ME especiallyamong low-income populations, and ethnical minorities. These barriers are further magnified amongdeveloping countries.

Automatic DR and ME detection has the potential to increase access to care in remote areas, save the patient time and travel and screening costs, and to identify those who have the immediate needfor retinal evaluation versus those who do not.

5. 4 Future Work Plan

The automated screening system which will be developed would significantly reduce the time required to determine diagnoses, saving effort and costs for ophthalmologists and result in the timelytreatment of patients. We shall be achieving this by building a CNN model that can automatically look at a patient's eye image and estimate the severity of blindness in the patient.

The project is constantly evolving. Implementation-wise expects to increase the accuracy of themethod as much as possible which can be beneficial for DR detection. Here is an abbreviated list of steps we will take to achieve our objectives:

- Larger datasets for model development
- Image quality assessment
- Experiments with other deep-learning models
- Development of a neural model which will be capable of exact discovery of MAs, Hemorrhages, and Cotton-wool Spots.

5.5 Results and Discussion

The model successfully achieved the following goals:

 1. The DL model achieved an accuracy of 75%.

 2. Website UI works as intended.

 3. User data is securely stored in the database and can be easily retrieved upon user request.

The website works with an average internet connection.

Users can successfully upload images and ultssee res online.

5.6 Work Plan

able 5.2 Work Plan

Section 6: Implementation and Experimental Results

6.1 Experimental Setup

The project was simulated on a laptop with 8 GB of internal RAM. The project runs on localhost and is also deployed.

Here are the steps to simulate the project:

1. The project runs on localhost or the provided server.
2. The user is logged into their account.
3. User uploads fundus image.
4. The image has been preprocessed with the DL model.
5. The eye analysis results are then displayed to the user.

6.2 Experimental Analysis

6.2.1 Libraries

The first and most important part of designing a neural network is importing the necessary libraries and modules. Important libraries used in this project include NumPy, pandas, matplotlib, TensorFlow, keras, openCv, and sklearn. We will also include the important modules and classes from these libraries to create the mode

6.2.2 Data

6.2.2.1 Dataset Collection

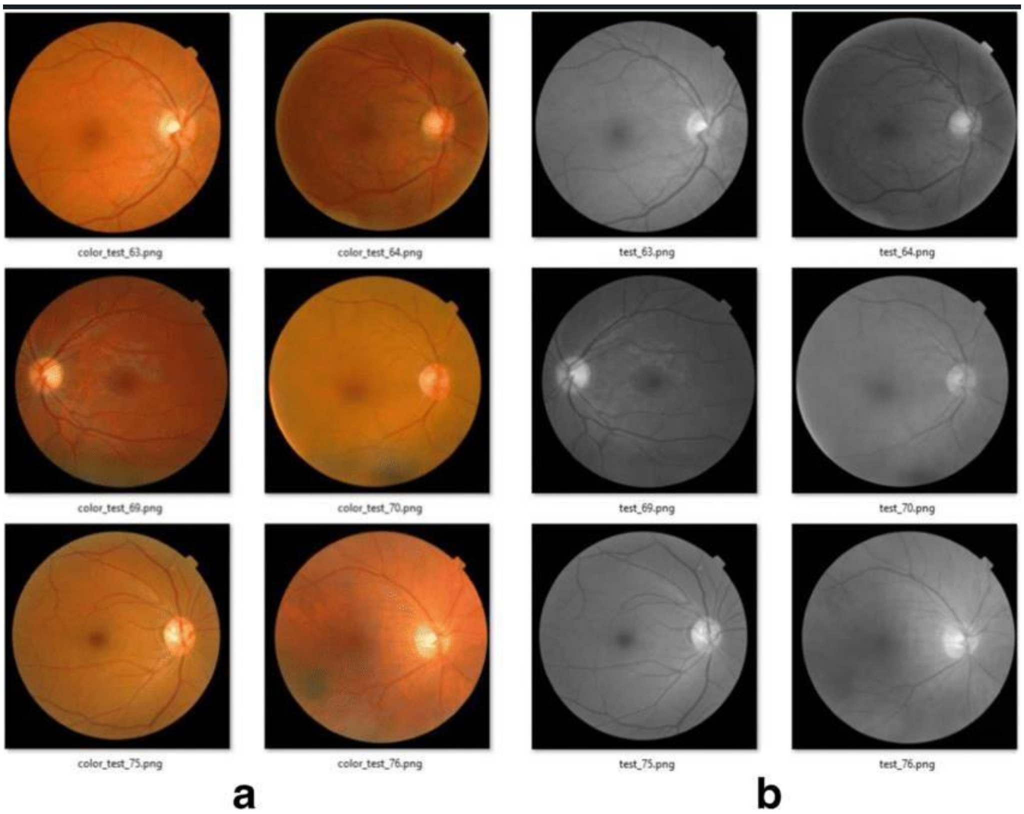


Fig 6.1- Images of Messidor dataset

The dataset used here is the Messidor dataset, which is a large set of retina images. Images, like real datasets, can contain artifacts, be out of focus, and be underexposed or overexposed. Images were collected from multiple clinics over time using different cameras, thus introducing further variation.

The messidor dataset has the following categories- Healthy, DR stage-1, DR stage-2, DR stage-3, ME stage-1, ME stage-2, ME stage-3.

6.2.2.2 Data Pre-processing

The biggest challenge after importing the data is preparing it and making it suitable for training. This includes handling missing data (if any), categorical values, text values, spelling errors, image, and video processing. Demonstrates various fundus image scaling, outlier detection, and more. One of the issues we face in this project is the capture device. Since the technology required to manufacture such devices is mature and open, various companies have developed dozens of such products, each producing fundus images with specific criteria. doing. To ensure that the machine learns the true characteristics of DR and ME, rathe than device-specific information, fundus images obtained from various sources must be processed and converted intoa consistent format by following the steps.

1. Size Normalization

The first step is to scale the different images to a consistent scale so that all fundus images from different sources have the same dimensions. Black borders on either side of the fundus image are first removed by summing the image horizontally and vertically and discarding areas corresponding to values below a selected threshold. The image is then scaled to a fixed size. Here the final image dimensions are 128*128.This work was done using the CV2 library, a library based on image processing tools.

2. Noise Filtering

The dataset consists of many input image from different sources, so it is too noisy. This should be addressed so that the model isnot affected by noisy images. CV2 library provides a Gaussian blur filter. This is an effect widely used in graphics software, usually to reduce noise and detail in images. The effects of filters are:

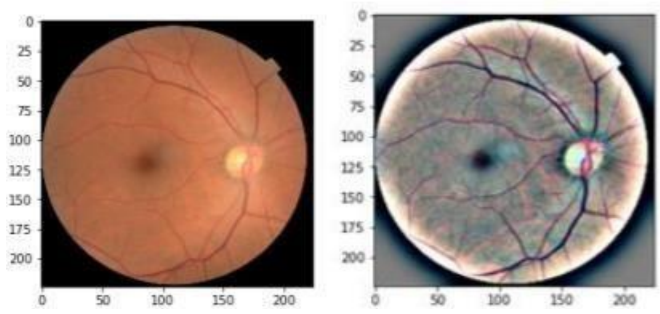


Fig 6.2- Original Image After Filtering

3. Scaling

After the size of each image is normalized, we need to scale its pixel intensities. This is because different devices produce images with different color temperatures and can have different lighting conditions. Divide the image matrix of his RGB channels of the fundus image by 255. This means that all pixel intensities are in the range (0-255), with 0 representing the darkest intensity and 255 representing the lightest intensity. Alternatively, a normalization technique such as CV2.NORM_MINMAX can be used to limit the pixel area of the image matrix. Normalization techniques can be used to improve images with very low overall contrast. These techniques effectively help make datasets more stable than before, benefiting models such as neural networks.

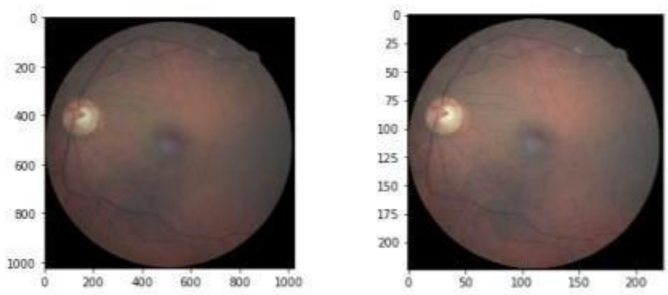


Fig 6.3- Original Image After Scaling

6.2.2.3 Data Augmentation

Successful training of a neural network requires sufficient training data. Unfortunately, this requirement is rarely met in most neural network applications. For medical imaging applications, lack of data is a greater concern due to the cost of annotation and disparity in incidence among diseases. Certain data augmentation techniques must be implemented to mitigate data scarcity and take full advantage of available data. Specifically, data can be enriched in the following ways:

Flip the image horizontally
Flip the image vertically
Rotate the image randomly
Randomize increase/decrease
Distort the image randomly

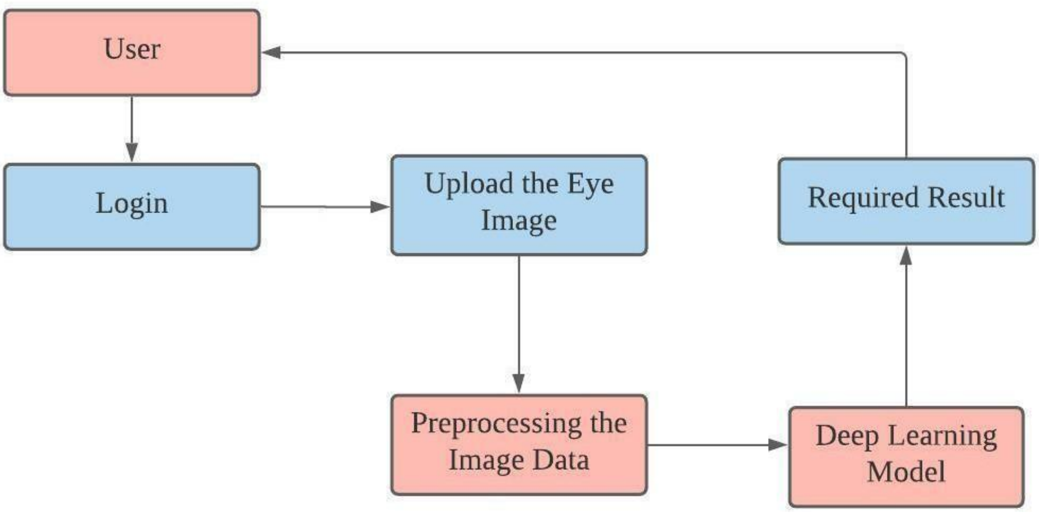
In this study, due to a large number of images, the data were well-balanced from the start, so the data augmentation process is less rigorous, to begin with. Models can be trained with or without the augmentation process. Using augmentation on these input images yielded better training data.

6.2.3 Performance Parameters

The parameters considered in the project are model speed and accuracy. The time to run and display the model is reported to be about 6 seconds, and the test accuracy is about 75%.

6.3 Working of Project

Fig 6.4-Project Working Flow



A working prototype is a web application that is used to determine stages of DR and ME.

The following points will walk you through the workflow.

User must be logged into the website.

 2. The user then uploads fundus images to her website to determine if there is DR or ME. If so, what stage is it in now?

 3. The image goes through a preprocessing stage where resizing, cropping and Gaussian blur are applied.

 4. The neural network model we use is a CNN model that helps classify the input image into one of seven labels.

The processed images are passed through a deep learning model and classified into one of the seven labels above.

 6. The desired result is then displayed to the user on his website.

6.3.2 Algorithmic Approaches used

The model created here to develop this project is based on the sole knowledge of neural networks and the use of highly complex but powerful structured CNNs. A neural network is a computational model formed by connecting so-called simple computational units in a specific pattern. In principle, given enough neurons, the behavior of any function can be mimicked. CNN is a special type of neural network proposed by LeCun et al. [34]. Due to its excellent performance on image-oriented tasks, it is now the mainstream model for image-related tasks.

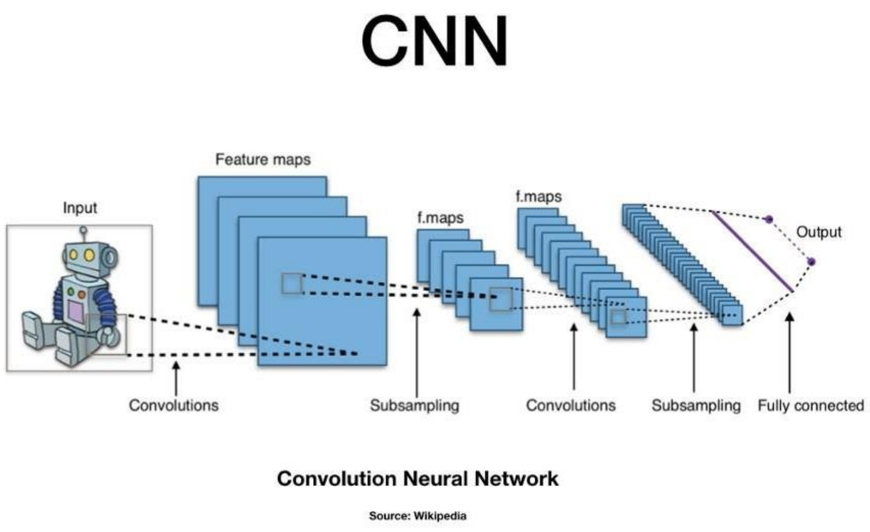


Fig-6.5 Convolution Neural Network

CNN is a DL algorithm that takes an input image, assigns learnable weights and distortions to different aspects/objects in the image, and can distinguish them from each other. ConvNet requires much less preprocessing compared to other classification algorithms. Primitive methods require manually constructing filters, but given enough training, convents have the ability to learn these filters. The role of the Conv Net is to make the image into a manageable format without losing functionality that is essential forgood prediction.

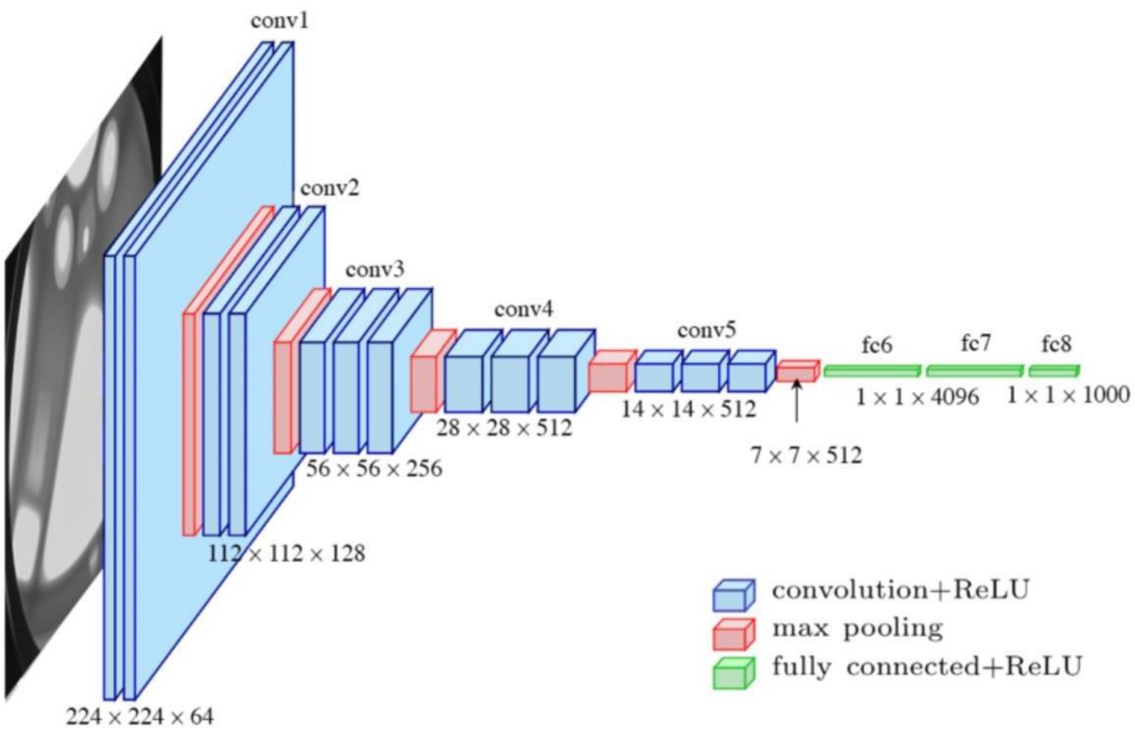


Fig-6.6 CNN Architecture

Convolution Layer

The purpose of the convolution operation is to extract high-level features such as edges from the input image. A convolutional mesh need not be limited to a single convolution layer. Traditionally, the first conv layer is responsible for capturing low-level features such as edges, colors, and gradient orientation. As layers of convolutions are added, the architecture also adapts to higher-level functions and provides a network. Someone who has a good understanding of the images in the dataset.

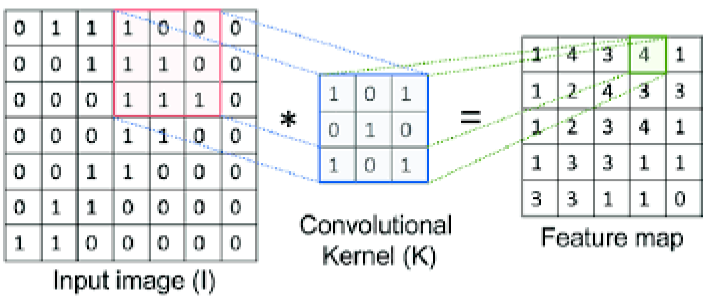


Fig-6.7 Convolutional Operation

Pooling Layer

Similar to convolutional layers, pooling layers serve to reduce the spatial size of convolutional functions. This helps reduce the computational power required to process the data through dimensionality reduction. It is also useful for extracting dominant traits.

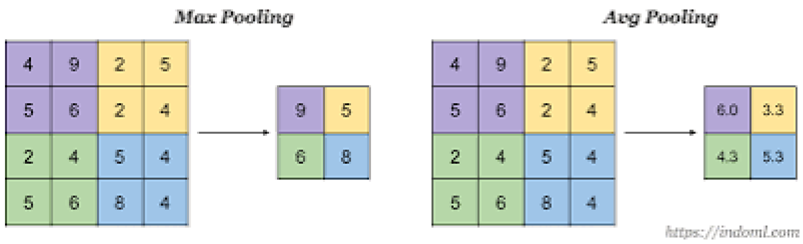


Fig-6.8 Pooling Operation

Fully Connected Layer

The FC layer is a simple feedforward neural network.The FC layer forms the last few layers of the network. The input to the fully connected layer is the output of the last pooling or convolutional layer, which is flattened before being fed to the FC layer.

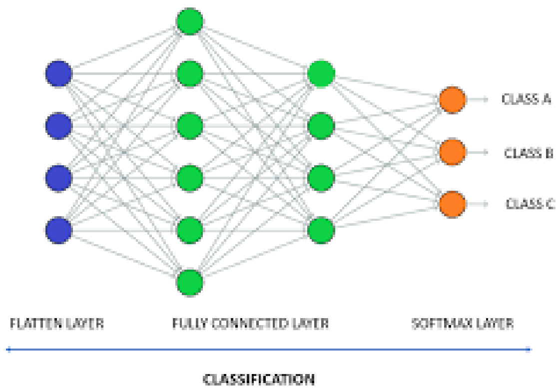


Fig-6.9 Fully Connected Layer

Various CNN architectures were available that were essential for building algorithms. Some of these are listed below

1.Le

2.Alex

3.VGG

4.Google Net

5.Efficient Net

6.Res Net

7.ZF Net

6.3.3 Project Deployment

To meet the needs of clinical application, we have developed a system for diagnosing DR and ME via the Internet.The model is first deployed to a cloud computing platform and diagnostics are computed. A web server is then used to package the model and serve the user interface to users at various hospitals over the Internet. It uses Django as the backend and the interface is rendered using HTML, CSS and JS.

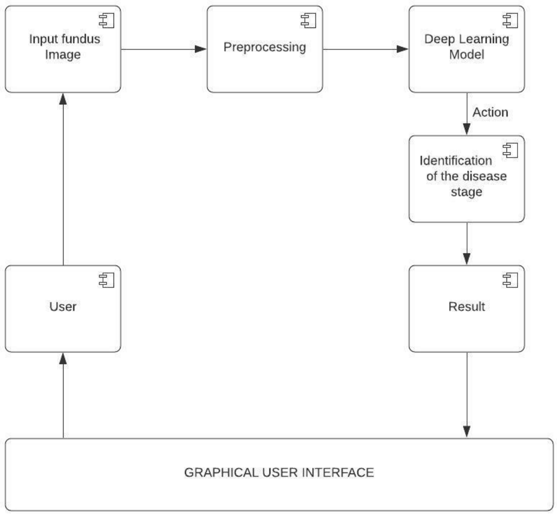


Fig 6.10 Component diagram

A component diagram of the product showing the key units of the system as components. The User component uploads an image to the Input Fundus Image component and feeds it to the Preprocessing component. The processed images are then fed into a deep learning model. The deep learning model identifies the DR and ME stages and the Result component displays the specified result.

6.4 Testing Process

6.4.1 Splitting dataset into train-test model

For training, testing, and validation purposes, we split the given dataset into training,testing, and valid subsets. The split is 90:10 for both training and testing, and 20% of the training data is used for validation purposes. This split is basically done to test the model on a hidden full data set. The predicted results are then compared with the original true values to validate the accuracy and performance of the model. For the above purpose, we will use the train_test_split function from the sklearn library. Another approach would have been to use the Stratified KFold cross-validation method, but since we've already dealt with the im-balanced data, we can move on to sklearn's simpler train_test_split function.

6.4.2 Test Plan

We plan to run a full alpha test on the website to ensure that all components work independently and the website connects seamlessly after integration. Run unit tests to see if your code does what you want it to do and meets your specs. First, we verify that our DL model with convolutional networks can process retinal images well and that our classification algorithm can accurately determine the stages of DR and ME. After testing the accuracy of the model, we will further check whether the model is correctly integrated into our website and whether our website can maintain a database of registered users. Finally, check if the website as a whole works smoothly.

6.4.3 Features to be tested

1. DL model for image classification
2. Integrating model into website
3. User registration
4. User login

5. Uploading retinal fundus photo
6. DR and ME stage prediction by model
7. Display User result

6.4.4 Test Strategy

1.Approach: Since we split the samples into a training set and a test set, we train the DL model and then test it on the rest of the samples. This gives us an idea of how well the model trained.

2. Pass/Fail Criterion - If the model correctly classifies 65% of the test cases, consider this the pass criteria for the DL model. An accuracy of less than 65% is the criteria for failure.

3.Suspension Criteria -The test is suspended when all test samples have been unambiguously processed and assigned a DR or ME level for each.

4. Test Performance – The test report consists of various accuracy metrics such as Precision Matrix, Recall , and F-Score, representing different aspects of algorithm accuracy.

6.4.5 Test Techniques

1. Black Box Testing - The tester interacts with the user interface, providing input and examining the returned output. You don't have to deal with the complexity of the underlying code.

2. White box testing - Testers examine the internal logic and structure of the code to see if individual components work well.

3. Functional Testing– Includes testing of the application against business needs. It includes all test types designed to ensure that all parts of the software behave as expected using the use cases provided by the design team. Testing methods include unit testing, integration testing, systes testing, and acceptance testing, in order.

4. Non-functional Testing - Non-functional testing methods include any kind of testing that focuses on the operational aspects of software. Testing methods include performance testing, security testing, usability testing, and compatibility testing.

6.4.6 Test Cases

1. Trained model should be able to accurately classify all the test cases into whether they have DR, ME, or not. Consequently, if DR or ME does exist then the model should be able to classify the exact stage of DR and ME.
2. The website should be able to register new users and maintain its database.
3. The website should be able to let an existing user log into the website.
4. The users should be able to upload their fundus images into the portal.
5. The DL model integrated into the website should be able to correctly classifythe DR or ME of the patient and display it on the portal.

6.4.7 Test Result

1. The accuracy of the image classification DL model was 75%. This means that we were able to correctly classify 75% of the test images.
2. The trained and tested model has been successfully integrated into our website for registered users to use easily.
3. The website not only allows existing users to access the website but also allows new users to register.
4. There is a well-maintained database of all existing users.

SECTION-7 Project Metrics

7.1 Challenges Faced

As part of the project, we faced many challenges and learned different ways to overcome them.

1. The initially selected database was too large to handle without a dedicated server. To address this issue, an alternative database with a small number of samples was used.
2. We realized that fundus images cannot be directly processed by the algorithm and therefore requires special pre-processing before being input into the algorithm. The image was preprocessed and loaded into the model.
3. Initially,our model was highly unreliable and inaccurate.We had to tune the hyperparameters to fix the ambiguity.
4. Since there were no other existing models to detect and classify multiple eye diseases, we had to read a lot of research papers to formulate a model that could do these tasks accurately.

5. There was little difficulty in figuring out how to integrate the model as a working entity into the website.

7.2 Relevant Subjects

Subject Code	Subject Name	Description
UML501, UCS538	Machine Learning, Data Science	Deep learning and machine learning models
UCS503	Software Engineering	To make SRS
UCS542	UI & UX Specialist	To deploy the model
UCS662	Test Automation	Testing the final product
UTA015	Innovation and Entrepreneurship	For coming up with the idea and cost analysis.

7.3 Interdisciplinary Knowledge Sharing

Besides using the subject knowledge taught in the course curriculum, the team gathered much information as well as knowledge from other sources necessary to carry out this project. Various other areas covered in this project include web development, knowledge of neural networks, and the use of highly complex but powerful structured convolutional neural networks, which is the main requirement of the project.

The team also explored how vision in the human eye is related to different stages of diabetes, and how abnormal blood vessels associated with DR stimulate the growth of scar tissue, which causes floating spots and leads to different stages of eye diseases. It can lead to severe vision loss.

The convolutional neural network is a special type of neural network that performs well on image-oriented tasks and is now the predominant model for image-related tasks. Therefore, we used CNN for image classification in different stages of eye diseases.

7.4 Peer Assessment Matrix

The legend followed is 5 – Excellent, 4 – Good, 3 – Satisfactory, 2 – Unsatisfactory, 1 – No performance. The row represents the person evaluating, and column represents the person being evaluated.

		Evaluation of			
		Arshdeep Singh	Himanshu Mahajan	Abhey Kumar Singla	Hitesh Garg
Evaluation by	Arshdeep Singh	5	5	5	5
	Himanshu Mahajan	5	5	5	5
	Abhey Kumar Singla	5	5	5	5
	Hitesh Garg	5	5	5	5

Table 7.2: Peer Assessment Matrix

7.5 Role Playing and Work Schedule

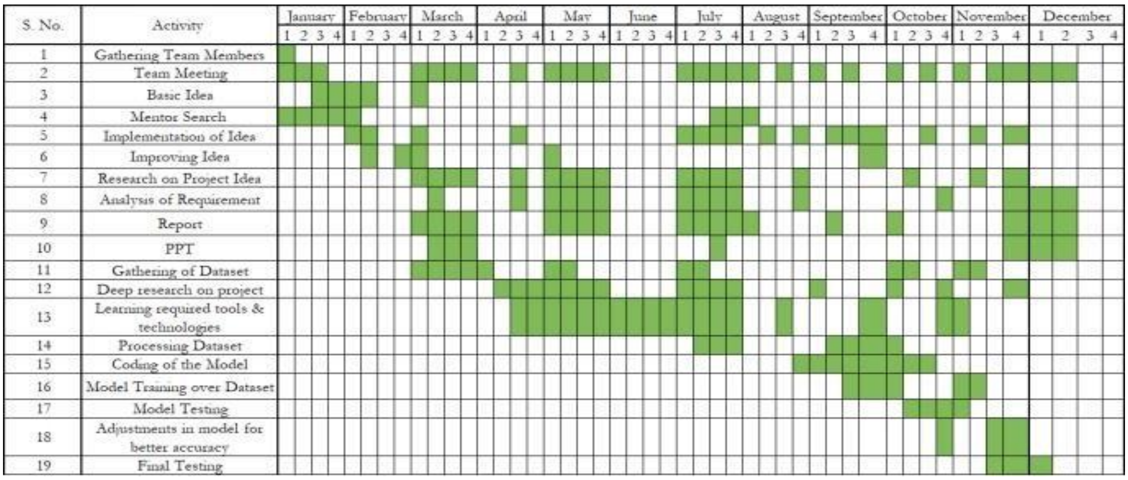


Fig 7.3: Work Schedule

Name	Task
Arshdeep Singh	Dataset Collection, Literature survey, Web portal, Documentation, Database management.
Himanshu Mahajan	Dataset Collection, Literature survey, Web portal, Documentation, Database management.
Abhey Kumar Singla	Documentation, Dataset Pre-processing, Model design, and training.
Hitesh Garg	Documentation, Dataset Pre-processing, Model design, and training.

7.4 Student Outcomes Description and Performance Indicators

Table 7.4: Student Outcomes Description and Performance Indicators

SO	SO Description	Outcome
1.1	Ability to identify and formulate problems related to computational domain	Identified problem of low detection rate of onset of DR, macular edema and its consequences. The challenge is to make a project that enables testing instantaneously, reliable and at low costs.
1.2	Applying mathematical concepts to obtain analytical and numerical solutions	Mathematics was majorly used in building and tuning CNN.
1.3	Applying basic principles of science towards solving engineering problems	A human doctor can evaluate a fundus image for eye diseases We used machine learning principles to enable that detection without the need of human contribution.
2.1	Use appropriate methods, tools and techniques for Data collection	A dataset of fundus images obtained from Kaggle. DL used to categorize user inputted image into the relevant eye diseases.
2.2	Analyze and interpret results with respect to assumptions, constraints and theory	Analyze that images are causing the model to become over trained, so rotating images randomly to prevent that from happening.
3.1	Design software system to address desired needs in different problem domains	Hosted the project online on an efficient website with ability to upload images to make sure it is available to a large set of population with minimal resources.
3.2	Can understand scope and constraints such as economic, environmental, social, political, ethical, health andsafety, manufacturability, and sustainability.	The team understands the scope of the project as one with the social, economic, health and safety benefits. Different constraints have been evaluated and solutions are being researched for them.
4.1	Fulfil assigned responsibility in multidisciplinary teams	The whole project was divided among four team members to make effective use of the shared knowledge.
4.2	Can play different roles as a team player	Each member was easily able switch from one responsibility to another responsibility as the need arose.
5	Develop appropriate models to formulate solutions.	Prototype building is required to get a clear vision about the project.
6.1	Showcase professional responsibility whileinteracting with papers and professional communities.	All of the members were punctual in attending the group meetings to discuss the upcoming responsibilities. The team was regular at arriving at the evaluation destination for panel and mentor evaluation as well.
6.2	Able to evaluate the ethical	It is a project which will make DR detection on the onset of

	dimensions of a problem	disease easy. People with undetected DR will benefit most from this project.
7.1	Produce a variety of documents such as laboratory or project Reportsusingappropriate formats	The team has been successful in preparing and presenting the project documentation in appropriate format.
7.2	Deliver well-organized and effective oral presentation	The team has been able to effectively communicate the idea behind the project.
8.1	Aware of environmental and societal impact of engineering solutions.	The project is a part to help diagnose diseases which often have an insidious onset, or go undiagnosed due to financial constraints or other reasons.
8.2	Examine economic trade-offs in computing systems	The project is made with cost-effectiveness mind. Users can use the service for free and the only expense of the project to admins is website hosting and maintaining.
9.1	Able to explore and utilize resource to enhance self-learning.	The team relied on different research papers and websites like medium, Quora, YouTube, Kaggle, Wikipedia to help with theoretical concepts and implementation of the project.
9.2	Recognize the importance of life-long learning	Project helped in cooperation within the team and the documentation helped us in following industry level practices.
10	Write code in different programming languages	The code was written in python, html, CSS, with use of many relevant libraries.
11.1	Apply different data structures and algorithmic techniques.	Used arrays, strings etc. as per the requirements.
11.2	Use software tools necessary for computer engineering domain.	TensorFlow, Google Colab and other Python libraries are extensively used.

7.5 Brief Analytical Assessment

Q 1: What sources of Problems? Information did your team explore to arrive at the list of possible project.

Ans: The group was aware of the understanding of the Capstone requirement and some of the problems that need to be explored. Team explored the literature, mostly the technical journals and technical magazines from IEEE. The interfacing issues have been refreshed through textbooks or internet resources. However, the scope has been decided after consulting our mentor.

Q 2: What analytical, computational and or experimental methods did your project team use to obtain solutions to the problems in the project?

Ans: Constructing a simple and effective model was the most challenging task. We collected the fundus data samples and built models to train the data. CNN is extensively used for building models.

Q 3: Did the project demand demonstration of knowledge of fundamentals, scientific and/ or engineering principles? If yes, how did you apply?

Ans: In this technical project, we have used the principles CNN and Web Development. Other skills used are software integration techniques. Design and documentation principles were taught in the subject of Software Engineering and Software Design.

Q 4: How did your team share responsibility and communicate the information of schedule with others in the team to coordinate design and manufacturing dependencies?

Ans: The team of four divided the project into subtasks, each completing one subtask at a time. We used WhatsApp and Google Meet to communicate and coordinate tasks, due dates, and other things. Also, we met at the library to share updates on projects and discuss future improvements.

Q 5: What resources did you use to learn new materials not taught in class for the course of the project?

Ans: The team used various online guides and turned to the Internet to learn more about the topics we were working on. Various courses on YouTube, Udemy, and Google have been mentioned to learn how to create and implement various models, and we have read several IEEE articles and technical reports to learn new material not taught in the classroom.

Q 6: Does the project make you appreciate the need to solve problems in real life using engineering and could the project development make you proficient with software development tools and environments?

Ans: It would be a complete YES. This project covers a real problem we solved with our engineering program. Working on this project, the team recognized the need to solve real problems and motivated the team to solve new problems in various areas. The group became familiar with various new technologies such as CNNs, APIs, and various Python libraries

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