PROJECT DOCUMENTATION

Deep Learning Fundus Image Analysis for EarlyDetection of DiabeticRetinopathy

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DEEP LEARNING FUNDUSIMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

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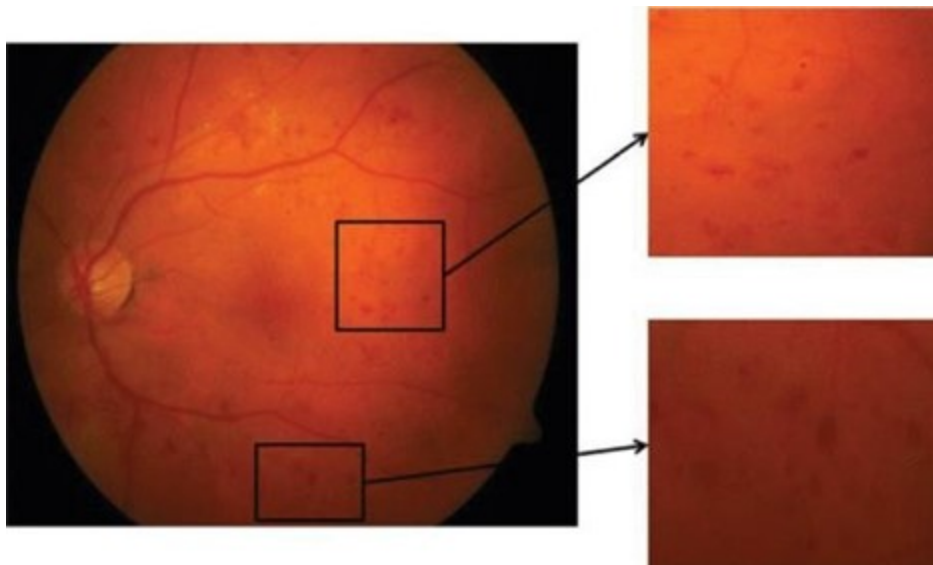
DEEP LEARNING FUNDUSIMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

1. INTRODUCTION :-

The main causing of visual loss in the world is diabetic retinopathy. In the initial stages of this disease, the retinal microvasculature is affected by several abnormalities in the eye fundus such as the microaneurysms and/ordot hemorrhages, vascularhyper permeability signs,exudates, andcapillary closures . Micro-aneurysm dynamics primarily increase the risk that the laser photo coagulation requires progression to the level . Diabetic retinopathy lesions are commonly accepted to be reversed and the progression of the retinopathy can only be slower during the early stages of the disease. The identification by repeated examination of patients affected of these initial lesions (mainly Micro aneurysms and small blood cells) is expected as a new possibility of improving retinopathy treatment. Floating and flashes, blurred vision, and loss of suddenvision can be common symptoms of diabetic retinopathy .

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1.1 Project Overview :-

Diabetic Retinopathy (DR) is a common complication of diabetes mellitus, which causes lesions on the retina that affect vision. If it is not detected early, it can lead to blindness. Unfortunately, DR is not a reversible process, and treatment only sustains vision. DR early detection and treatment can significantly reduce the risk of vision loss. The manual diagnosis process of DR retina fundus images by ophthalmologists is time, effort and cost-consuming and prone to misdiagnosis unlike computer-aided diagnosis systems.

Transfer learning has become one of the most common techniques that has achieved better performance in many areas, especially in medical image analysis and classification. We used Transfer Learning techniques like Inception V3,Resnet50,Xception V3 that are more widely usedas a transferlearning method in medical image analysis and they arehighly effective.

1.2 Purpose :-

The Proposed work intendsto automate the detection and classification of diabetic retinopathy from retinal fundus image which is very important in ophthalmology. Most of the existing methodsuse handcrafted featuresand those are fed to the classifier for detection and classification purpose. Recently convolutional neural network (CNN) is used for this classification problem but the architecture of CNN is manually designed. In this work,a genetic algorithmbased technique isproposed to automatically determine the parameters of CNN and then the network is used for classification of diabetic retinopathy. The proposed CNN model consistsof a series of convolutionand pooling layer used for feature extraction. Finally support vector machine (SVM) is used for classification. Hyper-parameters like number of convolution and pooling layer,number of kernel and kernel size of convolution layer are determined by using the genetic algorithm. The proposed methodology is tested on publicly available Messidor dataset. The proposed method has achieved accuracyof 0.9867 and AUC of 0.9933. Experimental result shows that proposed auto-tuned CNN performs significantly better than the existing methods.Use of CNN takes away the burden of designing the image featuresand on the other hand genetic algorithm based methodology automates the designof CNN hyper-parameters.

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2. LITERATURE SURVEY:-

ABSTRACT

EXISITING PROBLEM:-

Diabetic Retinopathy (DR) is a degenerative disease that impacts the eyes and is a consequence of Diabetes mellitus, where high blood glucose levels induce lesions on the eye retina. Diabetic Retinopathy is regarded as the leading cause of blindness for diabetic patients, especially the working-age population in developing nations. Treatment involves sustaining the patient's currentgrade of vision since the disease is irreversible. Early detection of Diabetic Retinopathy is crucial in order to sustain the patient's vision effectively. The main issue involved with DR detection is that the manual diagnosis process is very time, money, and effort consuming and involves an ophthalmologist's examination of eye retinal fundus images. The latter also proves tobe more difficult, particularly in the early stages of the disease when disease features are less prominentin the images. Machine learning-based medical image analysishas proven competency in assessing retinal fundus images, and the utilization of deep learning algorithms has aided the early diagnosis of Diabetic Retinopathy (DR). This paper reviews and analyzes state-of-the-art deep learning methods in supervised, self-supervised, and Vision Transformer setups, proposing retinal fundus image classification and detection. For instance, referable, nonreferable, and proliferative classifications of Diabetic Retinopathy are reviewed and summarized. Moreover, the paper discusses the available retinal fundus datasets for Diabetic Retinopathy that are used for tasks such as detection, classification, and segmentation. The paper also assesses research gaps in the area of DR detection/classification and addresses various challenges that need further study and investigation.

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REFERENCES:-

Survey 1 :

AUTHORS: Mohammad Z. Atwany , Abdulwahab H. Sahyoun , And MohammadYaqub(March 22).

TITLE: 'Deep Learning Techniques for Diabetic Retinopathy Classification: A Survey.'

METHODS: This paper reviews and analyzes state-of- theart deep learning methods in supervised, self-supervised, and Vision Transformer setups, proposing retinal fundus image classification and detection. For instance, referable, nonreferable, and proliferative classifications of Diabetic Retinopathy are reviewed and summarized. Moreover, the paper discusses theavailable retinal fundus datasets for Diabetic Retinopathy that are used for tasks such as detection, classification, and segmentation.

Survey 2 :

AUTHORS: Mohamad HazimJohari , HaslizaAbu Hassan , Ahmad Ihsan Mohd Yassin (July2018).

TITLE: 'Early Detection of Diabetic Retinopathy by Using Deep Learning Neural Network.'

METHODS: This project presents a method to detect diabetic retinopathy on the fundus images by using deep learning neural network. Convolution Neural Network (CNN) has been used in the project to ease the process of neural learning. The data set used were retrieved from MESSIDOR database and it contains 1200 pieces of fundus images. The images were filtered based on the project needed. There were 580 pieces of images types has been used after filtered and those pictures were divided into 2, which is Exudates images and Normal images. On the training and testing session, the 580 mixed of exudates and normal fundus images were divided into 2 sets which is training set and testing set. The result of the training and testing set were merged into a confusion matrix. The result for this project shows that the accuracy of the CNN for training and testing set was 99.3% and 88.3% respectively.

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Survey 3 :

AUTHOR: Recep Emre Hacisoftaoglu (Dec 2019).

TITLE: 'Deep Learning Frameworks For Diabetic Retinopathy Detection Using Smartphone-BasedRetinal Imaging Systems.'

METHODS: In this thesis, we first investigate the smartphone-based portable ophthalmoscope systems available on the market and compare their Field of View and image quality to determine if they are suitable for Diabetic Retinopathy detection during a general health screening. Then, we propose automatic Diabetic Retinopathy detection algorithms for smartphone-based retinal images using deep learning frameworks, AlexNet and GoogLeNet. To test our proposed methods, we generate smartphone-based synthetic retina images by simulating the different Fieldof View with masking the original image aroundthe optic disk and cropping it.

Survey 4 :

AUTHORS: Lei Lu , Ying Jiang , Ravindran Jaganathan , and Yanli Hao. (Jan 2019).

TITLE: 'Current Advancesin Pharmacotherapy and Technology for Diabetic Retinopathy: A SystematicReview.'

METHODS: Direct injections or intra virtualantiinflammatory and anti angiogenesis agentsare widely used pharmacotherapy to effectively treat DR and diabetic macularedema (DME). However, their effectiveness is short term, and the delivery system is often associated with adverseeffects, such as cataractand increased intraocular pressure. Further, systemic agents and plants-based drugs have also provided promising treatment in the progression of DR. Recently, advancements in pluripotent stem cells technology enable restoration of retinal functionalities after transplantation of these cells into animals with retinal degeneration. This review paper summarizes the developments in the current and potential pharmacotherapy and therapeutic technology of DR. Literature search was done on online databases, PubMed, Google Scholar, clinitrials.gov, and browsing through individual ophthalmology journals and leadingpharmaceutical company websites.

2.3.PROBLEM STATEMENTDEFINITION:-

Diabetic Retinopathy (DR) is common complication of diabetes mellitus, which will cause lesions on the retina that affects vision. If it is not detected early, it can lead to blindness. Unfortunately, DR is not a reversible proves,and the given treatment will only give us a sustainvision.DR early detection and treatment can significantly reduce the risk of vision loss.

WHAT ? In contrastto computer-aided diagnosis systems, the manual/ human- based diagnosisprocess of DR retina fundus images by doctors (ophthalmologists) is time-consuming, labor-intensive, expensive, and prone to error.

WHY ? Diabetes-related retinopathy is broughton by high blood sugarlevels harming theeye's iris. which could result in a permanent loss of vision.

WHEN ? Early on, theDR has no symptoms, but later on, the vessels may start to leak atinyamount of blood into your retina..

WHERE ? Blurred vision,Distorted vision will occur.

WHO? It is common among the Diabeticpatients.

HOW ? The manualearly detection of this DR is a challenging task.
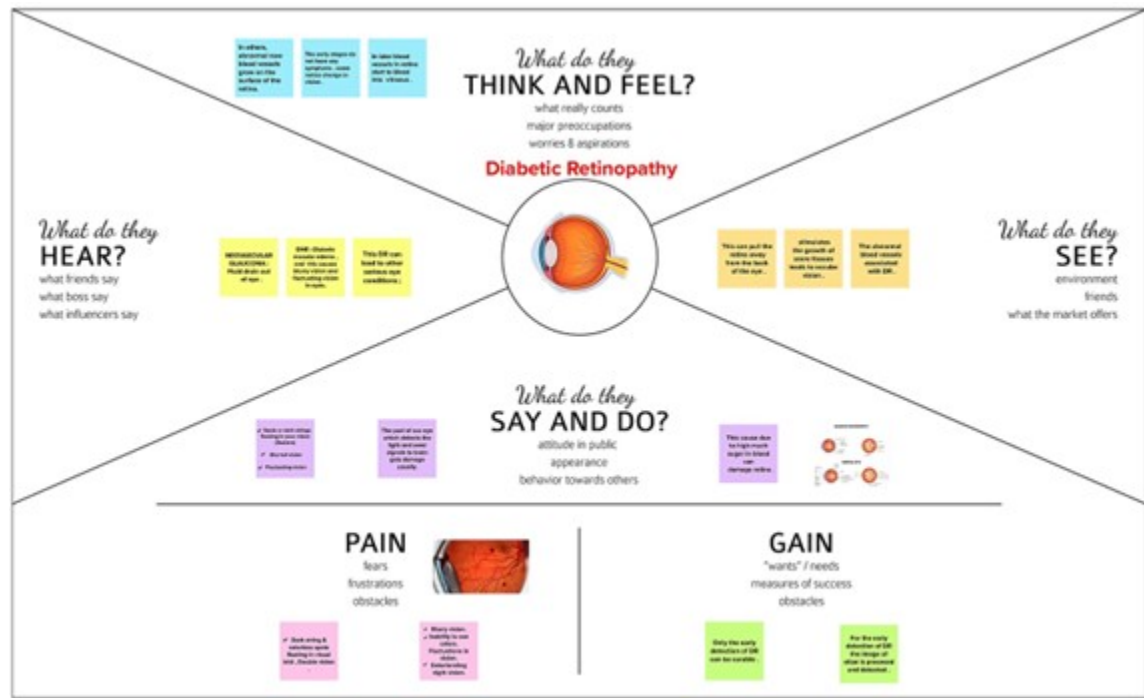
OBJECTIVES :
        The primary goal is to identify diabetic retinopathy by processing retinal images. Transfer learning has arose as one of the most popular techniques that has enhanced performance inmany areas, notably in the analysis and classification of medical images. We used transfer learning techniques that are more frequently used in medicalimage analysis and have beenextremely effective, including such Inception V3, Resnet50, and Xception V3.

3.IDEATION PHASE & PROPOSED SOLUTION :

3.1 Empathy Map Canvas :

3.2 IDEATION AND BRAINSTORMING:-

3.3 PROPOSED SOLUTION:-

S. No.	Parameter	Description
1.	Problem Statement (Problem to besolved)	Analyzing a fundusimage can helpidentify diabetic retinal disease early. 1. Analyze the levelof DR 2. To detectwhether DR is present or not
2.	Idea / Solution description	1. The goal is to identify diabetic retinopathy from the fundus image dataset as soon as possible, allowing individuals to proceed with the necessary treatments and avoidtemporary or permanent visionloss. 2. We will create a deep learning model (CNN)with high accuracy to detect DR and protectpeople at risk of losing their vision because thereis no complete cure for thisform of DR.
3.	Novelty / Uniqueness	On the basis of the level of DR performed during analysis, a class-based classifier will be provided. As part of the work, we'll also test out a transfer learning strategy that has the potential to be verysuccessful and lead to improved performance.

4.	Social Impact/ Customer Satisfaction	People who lose their visioncould actually benefitfrom this and live.Earlyanalysis and detection of DR is crucial for minimizing social impact because it can help patients keep their vision.
5.	Business Model(Revenue Model)	1. Doctors can analyze and identify DR using thismodel, whichfunctions as a servicemodel for public hospitals and a business model for private hospitals. 2. Even exporting it to othernations who requireit canworkas a business strategy.
6.	Scalability of the Solution	There are increasingly more approaches to scalethe solution so that the model is simple to combine withemerging technologies.

3.4 PROPOSED SOLUTION FIT

Project Title: Deep Learning Fundus Image Analysis
For early detection of Diabetic Retinopathy.

Project Design Phase-I = Problem-Solution Fit Template
Project ID : IBM-Project-51964-1660987442

Define CS, fit into CC

Explore AS, differentiate

1. CUSTOMER

For diabetics, early detection is crucial because diabetic retinopathy is permanent. The patient's fundus image can be used to identify diabetic retinopathy and be kept in the database. This serves a greater purpose than a manual examination.

6. CUSTOMER

Because diabetic retinopathy does not have any obvious symptoms, people are unaware they have the condition. Many people are unaware of diabetic retinopathy and its harmful effects.

5. AVAILABLE

Proliferative diabetic retinopathy can be treated with laser therapy, and some forms of maculopathy can be stabilized with laser therapy as well. eye injections to cure your sight-threatening severe maculopathy.

Focus on J&P, tap into BE, understand RC

2. JOBS-TO-BE-DONE / PROBLEMS — J&P

The issue is that it is impossible to treat severe diabetic retinopathy. Furthermore, the severity of diabetic retinopathy causes serious eye conditions that might lead to blindness. Therefore, if the patient has diabetes, early identification is crucial.

9. PROBLEM ROOT CAUSE — RC

The retina, a layer of light-sensitive tissue at the rear of the inner eye, experiences alterations in its blood vessels as a result of diabetes. The blood vessels in the retina of some patients with diabetic retinopathy may enlarge and leak fluid. Others experience the aberrant growth of new blood vessels on the retinal surface.

7. BEHAVIOUR — BE

Using the pictures from the fundus, this model aids in the early diagnosis of diabetic retinopathy. I The manual examination takes longer than this. Additionally, accuracy is higher compared to other methods.

Focus on J&P, tap into BE, understand RC

Identify strong TR & E

3. TRIGGERS — TR

Patients with diabetic retinopathy experience these triggers:
You may notice spots or black strings in your vision (floaters) distorted vision.

unstable eyesight.
Visionary voids or patches of darkness.
loss of vision

4. EMOTIONS: BEFORE / AFTER — EM

Before: Fear and anxiety are examples of negative emotional reactions. concerns with self-perception, guilt, rage, insecurity, and vulnerability.
After: Patients feel more hopeful as a result of early discovery and diagnosis.

10. YOUR SOLUTION — SL

Our approach uses a deep learning model with fundus images to identify diabetic retinopathy severity in patients and to make an appropriate diagnosis following an early detection.

8. CHANNELS OF BEHAVIOUR — CH

Patients with diabetes must have their eyes examined at regular intervals. Only then may retinopathy be identified early and a correct diagnosis made.

4. REQUIREMENT ANALYSIS:-

Functional Requirements:

Following are the functional requirements of the proposed solution.

FR No.	Functional Requirement (Epic)	Sub Requirement (Story/ Sub-Task)
FR-1	User Registration	Using a phone number to registersigning up with Gmail
FR-2	User Confirmation	Reassurance via OTP mailconfirmation
FR-3	Describe whatthe productdoes	Before you notice any changes in your vision, ourprojectcan identify earlyretinal changes.
FR-4	Focus on user requirements	Reduce the chance of blindness and vision lossindiabetes patients who have retinal complications.
FR-5	Usually definedby the user	A patient's fundusimage was obtained.
FR-6	Define productfeatures	A cutting-edge technique for eye screening that allowsfor the earlydetection of diseases relatedto the eyes.

Non-functional Requirements:

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

FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	Confirming that a piece of software can successfullycarry out one or more specific tasks.

NFR-2	**Security**	Only the system administrator maygrantpermission.
NFR-3	**Reliability**	Even thoughthe system has the ability to roll backto its original state if a system update fails or thereare bugs in the code.
NFR-4	**Performance**	The loadingof an image just takes twoseconds. The model's performance is intended to provide patients with quickresults.
NFR-5	**Availability**	The gadget facilitates access, cost, and qualityofhealthcare.
NFR-6	**Scalability**	Even when several users are utilising the productsimultaneously, it mustremain reliable.

# 5.PROJECT DESIGN:-

DATA FLOW DIAGRAM:-
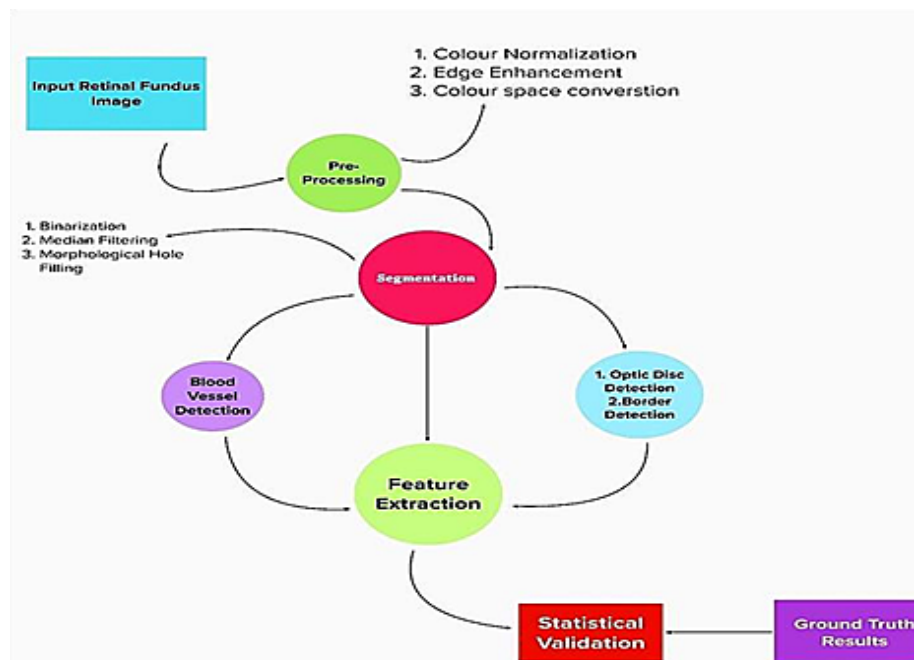
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The classic visual representation of how information moves through a system is a data flow diagram (DFD). The ideal amount of the system needs can be graphically represented by a tidy and understandable DFD. It demonstrates how information enters and exits the system, whatmodifies the data, and where information is kept.

- Diabetic retinopathy diseaseis frequently detected and examined using retinal fundus Pre-processing of raw retinal fundusimages isperformed using extraction of the greenchannel, histogramequalization, image enhancement,and resizingtechniques.

- One of the main tasks in retinalimage processing is thesegmentation of the retinalvasculature from images of the eye fundus.

- By omitting the optic disc (OD) regionof the retina, the computer-assisted automatic recognition and segmentation of blood vessels.

- Mathematicalbinary morphological techniques are used to identifythe retinal bloodvessels.

- The term "feature extraction from the fundus images for the diagnosis of Diabetic Retinopathy" refers to a sophisticated eye screeningtechnique that allows for the earlydetection of eye-related disorders.

5.2 TECHNOLOGY ARCHITECTURE:-
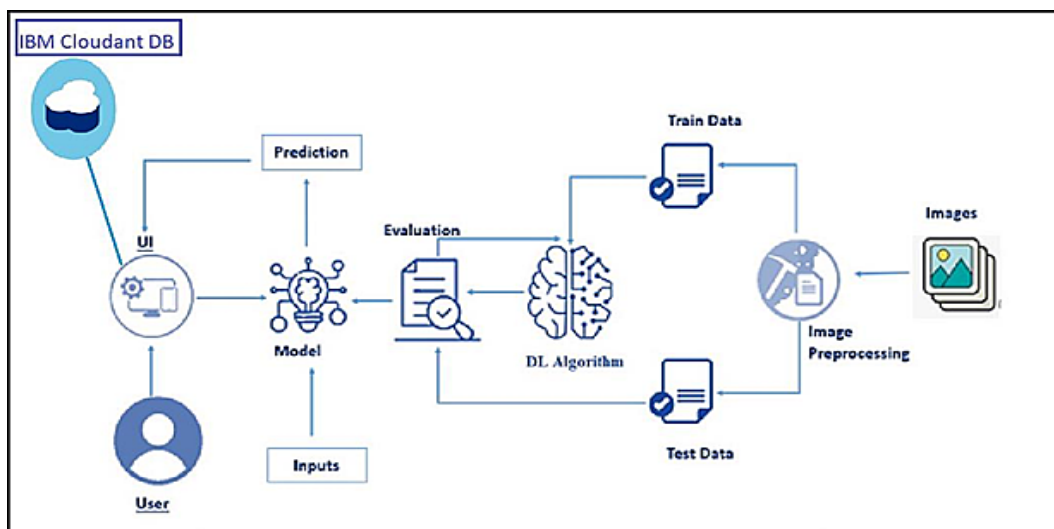
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Table-1:Components& Technologies:

1.	User Interface	Web UI	HTML, CSS, JavaScript, Python
2.	Application logic-1	Image Preprocessing	Keras,Tensorflow,Numpy
3.	Application logic-2	CNN Model	Keras,Tensorflow,Numpy
4.	Application logic-3	Web UI Application	Flask
5.	Database	DR Images(Jpeg,Png,Jpg,Etc.,)	Uploads Folder
6.	File storage	File Storage Requirements(Only If Necessary)	IBM BlockStorage, GoogleDrive
7.	External Api	Keras	Image Processing API
8.	Deep Learning Model	Inception V3 Architecture	Pre-Trained Convolution NeuralNetwork Model
9.	Infrastructure (Server)	Application Deployment on Webserver	Flask-A PythonWSGI HTTPServer.

Table-2:Application characteristics:

S.No	Characteristics	Description	Technology
1.	Open-Source Frameworks	Flask	Flask Frameworks
2.	Security Implementations	CSRF Protection,Secure FlagFor Cookies	Flask-WTF, Session CookieSecure
3.	Scalable Architecture	Micro-Services	Micro Web Application FrameworkBy Flask

5.3 USER STORIES:-

User Type	Functional Requirement (Epic)	User Story Number	User Story/ Task	Acceptance criteria	Priority	Release
Patient (Webuser)	Registration	USN-1	I can register as a user on the website witheitheran email address or a phone number and password.	I can createmy account.	High	Sprint-3
	Login	USN-2	With theprovided Login credentials, I canaccessthe website as a user.	I can log in andaccess myaccount.	High	Sprint-3
	Uplo ad image	USN-3	I can post my data as a userin formats likepdfanddoc.	I can uploadmydata.	Medi um	Sprint-3
Administrat ion (Web developer)	Admin Login	USN-4	I can log into the website as theadmin and analyze the user information .	I can login and analyze the user data.	High	Sprint-3
	Data collecti on	USN-5	I can gatherthe datasetforthe DR fromthe source as anadmin.	I can collect thedataset.	Low	Sprint-1
	Create model	USN-6	I can buildthe modelandtrain it using the dataset as an administrator to makepredictions.	I can create andtrain themodel.	High	Sprint-1
	Test the model	USN-7	I canevaluatethe model's predictive abilities as anadmin.	I can testthe model.	High	Sprint-2
Patient (Webuser)	Diagnosis	USN-8	I can access the application's diagnosisresults asa userand continuewith treatments..	He/she can getthe resultsand continue the treatment.	High	Sprint-2

6.PROJECT PLANNING AND SCHEDULING:-

6.1 SPRINT PLANNING AND ESTIMATION:-

Sprint	Functional Requirement (Epic)	User StoryNumber	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Registration	USN-1	As a user, Ican register for the application by entering my email, and password, and confirming my password.	10	High	MADURAIVEERAN K SAKTHISHWARAN A VEERAMANIKANDAN R SURIYA V ARUNPANDI V
Sprint-1	E-mail confirmation	USN-2	As a user, I will receive a confirmation email once I have registered forthe application	10	Medium	MADURAIVEERAN K SAKTHISHWARAN A VEERAMANIKANDAN R SURIYA V ARUNPANDI V
Sprint-2	Login	USN-3	As a user, I can loginto the application by entering my email & password	5	High	MADURAIVEERAN K SAKTHISHWARAN A
Sprint-2	Upload Images	USN-4	As a user,Ishould be able to upload theimageof ECG.	10	High	MADURAIVEERAN K SAKTHISHWARAN A
Sprint-2	Dashboard	USN-5	As a user, basedon my requirement I cannavigate through the dashboard.	5	Medium	MADURAIVEERAN K SAKTHISHWARAN A VEERAMANIKANDAN R SURIYA V ARUNPANDI V

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Sprint-3	Train themodel	Task 1	As a developer, thedataset will be uploadedand trained by developed algorithm.	20	High	SURIYA V ARUNPANDI V
Sprint-4	Testing & Evaluation	Task 2	As a developer, we tested the trained model using the provided dataset and modelwill be evaluated for accurate results.	10	High	MADURAIVEERAN K SAKTHISHWARAN A VEERAMANIKANDAN R SURIYA V ARUNPANDI V
Sprint-4	Display predicted result	USN-6	As a user, I can view the predicted result inthe dashboard.	10	High	MADURAIVEERAN K SAKTHISHWARAN A VEERAMANIKANDAN R SURIYA V ARUNPANDI V

| Sprint	Total story point	Duration	SprintStart Date	Sprint End Date(Planned)	Story Points Completed (as on Planned EndDate)	Sprint Release Date(Actual)
Sprint-1	20	6 Days	24 Oct 2022	29 Oct 2022	20	29 Oct 2022
Sprint-2	20	6 Days	31 Oct 2022	05 Nov 2022	20	05 Nov 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	20	12 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	20	19 Nov 2022

Velocity:

Imagine we have a 10-daysprint duration,and the velocityof the team is 20 (points per sprint). Let's calculate the team'saverage velocity (AV)periteration unit (story points perday).

$$AV = \frac{sprint\ duration}{velocity} = \frac{20}{10} = 2$$

AV=20/6=3.33points per day.

6.2 Burn Down Chart& JIRA :
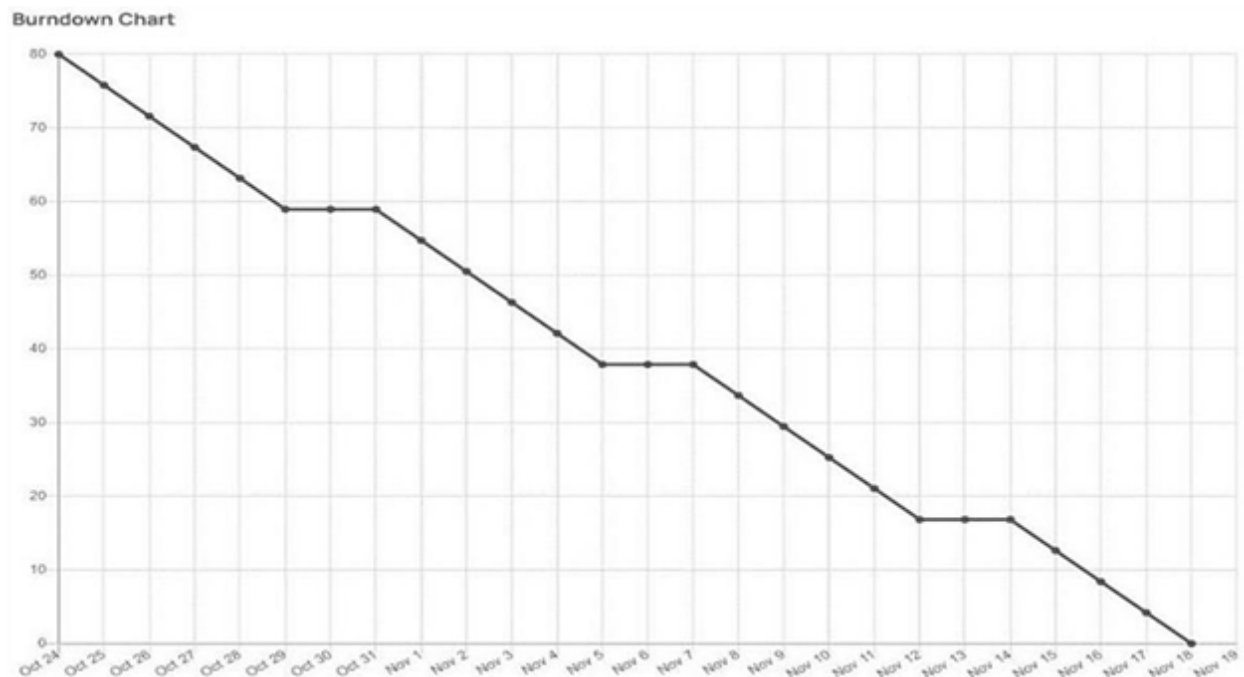
Burndown Chart

A burn down chart plots the amount of work remainingto perform against the amount of time. In agilesoftware developmentapproaches like Scrum, it is frequently employed. Burn down charts, however,can beused for any project that makes observable progress over time.

7. CODING AND SOLUTIONING:-

Feature 1:-

We have devlopeda website which authenticates users and help them uploadand check the seriousness of the diabetics.

Feature 2:-

We have devloped a multilayer deep convolutional nueral network that classifiesthe user image of a eye to which extense has the disease diabetics has been affected.The model will classify the images into 5 categories of diabetics andreport them on asking for prediction. We have also devloped a messaging servicefor recieiving message for the type of diabetics.

8.TESTING:-
8.1TEST CASES:-
8.2 USER ACCEPTANCE TESTING:-

1. **Purpose of Document:-**

This document serves as a quick reference for the Deep Learning Fundus Image Analysisfor Early Detection of Diabetic Retinopathy project's test coverage and open issues as of the project's release for user acceptance testing.

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2. Defect Analysis:-

Thisshows how many bugs were fixed orclosed at each severity level and how they werefixed.

Resolution	Severity 1	Severity 2	Severity 3	Severity4	Subtotal
By Design	5	4	2	3	14
Duplicate	1	0	3	0	4
External	2	3	0	1	6
Fixed	9	2	4	15	30
Not Reproduced	0	0	1	0	1
Skipped	0	0	1	1	2
Won'tFix	0	5	2	1	8
Totals	17	14	13	21	65

3. Test-CaseAnalysis

This report shows the number of test cases that have passed, failed,and untested.
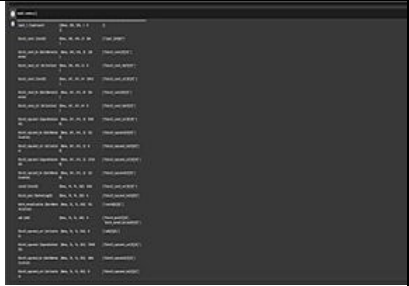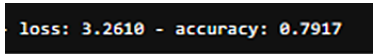
Section	TotalCases	Not Tested	Fail	Pass
PrintEngine	9	0	0	9
ClientApplication	45	0	0	45
Security	2	0	0	2
Out-sourceShipping	3	0	0	3
ExceptionReporting	9	0	0	9
FinalReportOutput	4	0	0	4
VersionControl	2	0	0	2

9. RESULTS:-

9.1 Performance Metrics:-

Model Performance Testing:

S.NO	Parameter	Values	Screenshot
1.	Model Summary	Total params:21,885,485 Trainable params:1,024,005Non-trainable params: 20,861,480	
2.	Accuracy	Training Accuracy – 0.7917 Validation Accuracy – loss3.2610	loss: 3.2610 - accuracy: 0.7917
3.	Confidence Score(Only YoloProjects)	Class Detected- Confidence Score -	- -

Project team shall fill the followinginformation in model performance testingtemplate.

10. ADVANTAGES AND DISADVANTAGES:-
10.1 ADVANTAGES:-

There are several advantages of using deep learning for fundus image analysis for early detection of diabetic retinopathy.

First, deep learning is well-suited for image analysistasks. This is because deep learning algorithms can automatically learnfeatures from images, which is essential for accurate image analysis.

Second, deep learning is efficient at handling large amounts of data. This is important for medical image analysis, as medicalimages are often very large.

Third, deep learning is scalable. This means that it can be used to train models on very large datasets, which is important formedical image analysis tasks where data is often limited.

Fourth, deep learning is able to learn from data with little supervision. This is important for medical image analysis, as oftenthere is limited labeled data available.

Finally, deep learning is robust. This means that it is less likely to overfit to the data, which is important for medical imageanalysis where data is often limited.

10.2 DISADVANTAGES:-

There are several disadvantages of deep learning for early detection of diabetic retinopathy. One disadvantage is thatdeep learning requires a large amount of data to train the models. This can be a challenge for researchers who do nothave access to a large dataset. Another challenge is that deep learning models can be very complex, which can makethem difficult to interpret. Finally, deep learning models can be computationally intensive, which can make them difficultto deploy in resource-limited settings.

11. CONCLUSION:-

Diabetic retinopathy (DR) is a leadingcause of blindness in the UnitedStates. Early detection and treatment of DR iscritical to preventing visionloss. However, DR is often asymptomatic in its earlystages, making it difficult to detect.

Deep learning (DL) is a type of artificial intelligence that can be used to automatically detect patterns in data. DL hasbeenshown to be effective for detecting DR in images of the retina.

In this study, a DL algorithm was used to automatically detect DR in fundus images. The algorithm was able to accurately detect DR in early stages,before it is symptomatic. This could potentially lead to earlier diagnosis andtreatment of DR, which could help to prevent vision loss.

12. FUTURE SCOPE:-

There is a great potential for deep learning in fundus image analysis for early detection of diabetic retinopathy. However, thereare a few challenges that need to be addressed. First,the current data sets are small and lack diversity. Second, the images are often low quality and need to be pre-processed before they can be used for deep learning.
Third, the ground truth labels for the images are often not available. Finally,the current deep learningmodels are notable to generalize well to real-world data.

13. APPENDIX:-

app.py:-

```python
import numpy as npimport os
from tensorflow.keras.models import load_model from tensorflow.keras.preprocessing importimage
from tensorflow.keras.applications.inception_v3 importpreprocess_inputfrom flask import Flask,
request,flash, render_template, redirect,url_for
from cloudant.client import Cloudant
from twilio.rest importClient
model = load_model(r"Updated-xception-diabetic-retinopathy.h5")
app = Flask(_name_)
app.secret_key="abc" app.config['UPLOAD_FOLDER'] = "User_Images"
# Authenticate using an IAM API key

client = Cloudant.iam('08bcbaf0-260b-48e0-abdb-08db348afcf2-bluemix',
                'yhZfUubpS3vS1vEKZSS37teD6IAUi8oLynOCQLIwnQsa', connect=True)
# Create a database using an initialized client my_database = client.create_database('my_database')
if my_database.exists():
    print("Database '{0}' successfully created.".format('my_db'))
# defaulthome page or route

user = ""

@app.route('/')
def index():
    return render_template('index.html', pred="Login", vis ="visible")

@ app.route('/index')
def home():
    return render_template("index.html", pred="Login", vis ="visible")


# registration page
@ app.route('/register',methods=["GET","POST"])


def register():
    if request.method == "POST":
```

```python
    name = request.form.get("name")
    mail = request.form.get("emailid")
    mobile = request.form.get("num")
    pswd = request.form.get("pass") data = {
        'name': name,
        'mail': mail, 'mobile': mobile,'psw': pswd
    }
    print(data)
    query = {'mail':{'$eq': data['mail']}}
    docs = my_database.get_query_result(query)print(docs)
    print(len(docs.all()))
    if (len(docs.all()) == 0):
        url = my_database.create_document(data)
        return render_template("register.html", pred=" Registration Successful , please
    login using your details ")else:
        return render_template('register.html', pred=" You are alreadya member , please login using your
        details ")
    else:
        return render_template('register.html')


@
app.route('/login',
methods=['GET','P
OST'])def login():
    if request.method  == "GET": user = request.args.get('mail') passw = request.args.get('pass')print(user,
    passw)
    query = {'mail': {'$eq': user}}
    docs = my_database.get_query_result(query)print(docs)
    print(len(docs.all()))
    if (len(docs.all()) == 0):
        return render_template('login.html', pred="")else:
        if ((user == docs[0][0]['mail'] and passw ==
            docs[0][0]['psw'])):flash("Logged in as " +
            str(user))
            return render_template('index.html', pred="Logged in as "+str(user), vis
        ="hidden", vis2="visible")else:
            return render_template('login.html', pred="The password is wrong.")
    else:
        return render_template('login.html')
```

DEEP LEARNING FUNDUSIMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

```python
@ app.route('/logout')def logout():
    return render_template('logout.html')

@app.route("/predict",methods=["GET", "POST"])def predict():
    if request.method == "POST":f = request.files['file']
        # getting the current path 1.e where app.py is presentbasepath = os.path.dirname(_file_)
        #print ( "current path " ,basepath )
        # from anywhere in the system we can give image but we want that filepath=
        os.path.join(str(basepath), 'User_Images', str(f.filename))#print ( " upload folder is " , filepath )
        f.save(filepath)
        img = image.load_img(filepath, target_size=(299, 299))x = image.img_to_array(img)  # ing toarray
        x = np.expand_dims(x, axis=0)# used for adding one more dimension#print ( x )
        img_data = preprocess_input(x)
        prediction = np.argmax(model.predict(img_data), axis=1)index = [' No DiabeticRetinopathy ', '
        Mild NPDR ',
            ' Moderate NPDR ', ' Severe NPDR ', ' Proliferative DR ']result = str(index[prediction[0]])
        print(result)
        account_sid = 'AC8e0f2f5263d71c8f630a6486779cf08b'auth_token =
        '30b489873afb3c47340070eabd6bfb15'

        client = Client(account_sid, auth_token)

        ''' Changethe value of 'from' with the numberreceived from Twilio and the value of 'to'
        with the number in which you want to send message.'''message = client.messages.create(
                    from_='+16075363206',
                    body ='Results: '+ result,to ='+919445979800'
                )
        return render_template('prediction.html',
    prediction=result, fname = filepath)else:
        return render_template("prediction.html")

if__name_== "_main_":app.debug = True app.run()
```

cloud.ipynb:-

```python
from cloudant.client import Cloudant
client=Cloudant.iam('655489f8-18d0-
4a44-a701-5de60570a973-
bluemix','Jc4eF6CXk72w0wGCsM_KUuXKVjsCcT4a54UK
```

DEEP LEARNING FUNDUSIMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

BXckK5Bv',connect=True)
my_database=client.create_database('my-database')

index.html:-

```html
<!DOCTYPE html>
<html lang="en">
  <head>
    <meta charset="UTF-8" />
    <meta http-equiv="X-UA-Compatible" content="IE=edge" />
    <meta name="viewport" content="width=device-width, initial-scale=1.0" />
    <!-- CSS only -->
    <link
      href="https://cdn.jsdelivr.net/npm/bootstrap@5.2.1/
      dist/css/bootstrap.min.css" rel="stylesheet"
      integrity="sha384-
      iYQeCzEYFbKjA/T2uDLTpkwGzCiq6soy8tYaI1GyVh/UjpbCx/TYkiZhlZB
      6+fzT" crossorigin="anonymous"
    />
    <!-- JavaScript Bundle with Popper -->
    <script
      src="https://cdn.jsdelivr.net/npm/bootstrap@5.2.1/dist/js/b
      ootstrap.bundle.min.js"
      integrity="sha384-
      u1OknCvxWvY5kfmNBILK2hRnQC3Pr17a+RTT6rIHI7NnikvbZlHgTPOOmMi466C8"
      crossorigin="anonymous"
    ></script>
    <style>
      #navbarRight { margin-left: auto; padding-right:10px;
      }
      .navbar-brand{ padding-left:15px;
      }
    </style>
    <title>DR Predcition</title>
  </head>
  <body>
    <nav class="navbar navbar-expand-lg navbar-light bg-dark">
      <div>
      <a class="navbar-brand" href="#" style="color:aliceblue">Diabetic Retinopathy Classification</a>
      </div>
      {{msg}}
      <div class="navbar-collapse collapsew-100 order-3 dual-collapse2" id="navbarNav">
```

DEEP LEARNING FUNDUSIMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

```html
      <ul class="navbar-nav mr-autotext-center" id="navbarRight">
      <li class="nav-item active">
        <a class="nav-link" href="index" style="color: aliceblue;">Home </a>
       </li>
       <li class="nav-item" style="visibility:{{ vis2 }}">
        <a class="nav-link" href="predict" style="color: aliceblue;">Prediction</a>
       </li>
       <li class="nav-item">
        <a class="nav-link" href="login" style="color: aliceblue;">{{pred}}</a>
       </li>
       <li class="nav-item" style="visibility:{{ vis }}">
        <a class="nav-link" href="register" style="color: aliceblue;">Register</a>
       </li>
      </ul>
     </div>
    </nav>
    <br><br>
     <div class="jumbotron container">
      <h1 class="display-4">Diabetic Retinopathy</h1>
      <p class="lead">Diabetic retinopathy is a diabetescomplication that affectseyes. It's
causedby damage to the bloodvessels of the light-sensitive tissue at the back of the eye (retina).
      At first, diabeticretinopathy might cause no symptoms or only mild vision problems.But it can
      lead to blindness.
      The condition can develop in anyone who has type 1 or type 2diabetes. The longeryou
have diabetesand the lesscontrolled your blood sugar is, the more likely you are to develop this
eye complication.</p>
      <hr class="my-4">
      <div class="d-flex justify-content-center">
       <img style="width:70vw;" src="static/diabetic-retinopathy-home.jpg">
       </div>
     </div>
   </body>
</html>
```

login.html:-
```html
<!DOCTYPE html>
<html lang="en">
 <head>
  <meta charset="UTF-8" />
  <meta http-equiv="X-UA-Compatible" content="IE=edge" />
  <meta name="viewport" content="width=device-width, initial-scale=1.0" />
```

DEEP LEARNING FUNDUSIMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

```html
<!-- CSS only -->
<link
  href="https://cdn.jsdelivr.net/npm/bootstrap@5.2.1/
  dist/css/bootstrap.min.css" rel="stylesheet"
  integrity="sha384-
  iYQeCzEYFbKjA/T2uDLTpkwGzCiq6soy8tYaI1GyVh/UjpbCx/TYkiZhlZB
  6+fzT" crossorigin="anonymous"
/>
<!-- JavaScript Bundle with Popper -->



<script
  src="https://cdn.jsdelivr.net/npm/bootstrap@5.2.1/dist/js/b
  ootstrap.bundle.min.js"
  integrity="sha384-
  u1OknCvxWvY5kfmNBILK2hRnQC3Pr17a+RTT6rIHI7NnikvbZlHgTPOOmMi466C8"
  crossorigin="anonymous"
></script>
<style>
    #navbarRight { margin-left: auto; padding-right:10px;

    }
    .navbar-brand{ padding-left:15px;
    }
</style>
<title>DR Predcition</title>
</head>
<form action="",method='POST'>
  <nav class="navbar navbar-expand-lg navbar-light bg-dark">
    <div>
    <a class="navbar-brand" href="#" style="color:aliceblue">User Login</a>
    </div>
    <div class="navbar-collapse collapsew-100 order-3 dual-collapse2" id="navbarNav">
     <ul class="navbar-nav mr-autotext-center" id="navbarRight">
      <li class="nav-item active">
        <a class="nav-link" href="index" style="color: aliceblue;">Home </a>
      </li>
      <li class="nav-item">
        <a class="nav-link" href="login" style="color: aliceblue;">Login</a>
      </li>
      <li class="nav-item">
```

DEEP LEARNING FUNDUSIMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

```html
      <a class="nav-link" href="register"style="color: aliceblue;">Register</a>
    </li>
  </ul>
 </div>
</nav>
<br><br>
<form class="form-inline" action="/login" method="GET">
<div class="container" style="width: 600px; height: 600px;">
 <div class="mb-3 d-flex justify-content-center"><script
  src="https://cdn.lordicon.com/xdjxvujz.js"></script>
    <lord-icon
      src="https://cdn.lordico
      n.com/elkhjhci.json"
      trigger="hover"
      style="width:200px;hei
      ght:200px">
    </lord-icon></div>
    <div class="mb-3">



      <input type="email" class="form-control" id="exampleInputEmail1" name="mail" aria-
describedby="emailHelp"placeholder="Enter Registered Mail ID">
      </div>
      <div class="mb-3">
       <input type="password" class="form-control" id="exampleInputPassword1"
name="pass" placeholder="EnterPassword">
      </div>
      <div class="mb-3">
      <button type="submit form-control" class="btn btn-dark btn-primary"
style="width:100%;"type="submit">Login</button>
      </div>
      {{pred}}
    </div>
  </form>
 </body>
</html>
```

logout.html
```html
<!DOCTYPE html>
<html lang="en">
```

DEEP LEARNING FUNDUSIMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

```html
<head>
  <meta charset="UTF-8" />
  <meta http-equiv="X-UA-Compatible" content="IE=edge" />
  <meta name="viewport" content="width=device-width, initial-scale=1.0" />
  <!-- CSS only -->
  <link
    href="https://cdn.jsdelivr.net/npm/bootstrap@5.2.1/
    dist/css/bootstrap.min.css" rel="stylesheet"
    integrity="sha384-
    iYQeCzEYFbKjA/T2uDLTpkwGzCiq6soy8tYaI1GyVh/UjpbCx/TYkiZhlZB
    6+fzT" crossorigin="anonymous"
  />
  <!-- JavaScript Bundle with Popper -->
  <script
    src="https://cdn.jsdelivr.net/npm/bootstrap@5.2.1/dist/js/b
    ootstrap.bundle.min.js"
    integrity="sha384-
    u1OknCvxWvY5kfmNBILK2hRnQC3Pr17a+RTT6rIHI7NnikvbZlHgTPOOmMi466C8"
    crossorigin="anonymous"
  ></script>
  <style>
    #navbarRight { margin-left: auto; padding-right:10px;
    }
    .navbar-brand{ padding-left:15px;
    }
  </style>
  <title>DR Predcition</title>

</head>
<body>
  <nav class="navbar navbar-expand-lg navbar-light bg-dark">
    <div>
    <a class="navbar-brand" href="#" style="color:aliceblue">Diabetic Retinopathy</a>
    </div>
    <div class="navbar-collapse collapsew-100 order-3 dual-collapse2" id="navbarNav">
      <ul class="navbar-nav mr-autotext-center" id="navbarRight">
        <li class="nav-item active">
          <a class="nav-link" href="index" style="color: aliceblue;">Home </a>
        </li>
        <li class="nav-item">
          <a class="nav-link" href="login" style="color: aliceblue;">Login</a>
        </li>
        <li class="nav-item">
```

```html
        <a class="nav-link" href="register"style="color: aliceblue;">Register</a>
      </li>
     </ul>
    </div>
   </nav>
   <br><br>
   <div class="d-flex justify-content-center">
    <div class="row d-flex
      display-3 justify-content-
      center">Successfully
      Logged Out!
      <br><br>
      <a href="login" class="btn btn-lg btn-dark">Login for more Information</a>
       </div>
    </div>
  </body>
</html>
```

prediction.html:-

```html
<!DOCTYPE html>
<html lang="en">

<head>
  <meta charset="UTF-8" />
  <meta http-equiv="X-UA-Compatible" content="IE=edge" />
  <meta name="viewport" content="width=device-width, initial-scale=1.0" />
  <!-- CSS only -->
  <link
    href="https://cdn.jsdelivr.net/npm/bootstrap@5.2.1/dist/css/bootstrap.min.cs
    s" rel="stylesheet" integrity="sha384-
    iYQeCzEYFbKjA/T2uDLTpkwGzCiq6soy8tYaI1GyVh/UjpbCx/TYkiZhlZB
    6+fzT"
crossorigin="anonymous" />
  <!-- JavaScript Bundlewith Popper -->
  <script src="https://cdn.jsdelivr.net/npm/bootstrap@5.2.1/dist/js/bootstrap.bundle.min.js"
    integrity="sha384-
    u1OknCvxWvY5kfmNBILK2hRnQC3Pr17a+RTT6rIHI7NnikvbZlHgTPOOmMi466C8"
    crossorigin="anonymous"></script>
```

DEEP LEARNING FUNDUSIMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

```html
    <style> #navbarRight { margin-left: auto;
      padding-right: 10px;
     }

     .navbar-brand { padding-left: 15px;
     }

     .row {
      width: 90%;
     }
    </style>
    <title>DR Predcition</title>
  </head>

  <body>
    <nav class="navbar navbar-expand-lg navbar-light bg-dark">
     <div>
      <a class="navbar-brand" href="#" style="color:aliceblue">Diabetic Retinopathy Classification</a>
     </div>
     <div class="navbar-collapse collapsew-100 order-3 dual-collapse2" id="navbarNav">
      <ul class="navbar-nav mr-autotext-center" id="navbarRight">
       <li class="nav-item active">
        <a class="nav-link" href="index" style="color: aliceblue;">Home </a>
       </li>
       <li class="nav-item">
        <a class="nav-link" href="logout" style="color: aliceblue;">Logout</a>
       </li>
      </ul>
     </div>
    </nav>
    <br><br>
    <div class="container justify-content-center" style="width:700px">
     <form action = "/predict" method= "POST" enctype="multipart/form-data">
     <label for="formFileLg" class="form-label">Upload Image</label>
     <input class="form-control form-control-lg" name ="file" type="file" />
     <br>
     <button class="btn btn-lg btn-dark" type = "submit">Predict</button>
     </form>
     <br>
     <h1>{{prediction}}</h1>
    </div>
    <br><br><br>
    <div class="d-flex justify-content-center" >
```

DEEP LEARNING FUNDUSIMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

```html
    <img src="static/level.png" style="width: 90%">

  </div>
</body>
</html>
```

register.html:-

```html
<!-- <!DOCTYPE html>
<html lang="en">
  <head>
    <meta charset="UTF-8" />
    <meta http-equiv="X-UA-Compatible" content="IE=edge" />
    <meta name="viewport" content="width=device-width, initial-scale=1.0" />
    <!-- CSS only -->
    <link
      href="https://cdn.jsdelivr.net/npm/bootstrap@5.2.1/
      dist/css/bootstrap.min.css" rel="stylesheet"
      integrity="sha384-
      iYQeCzEYFbKjA/T2uDLTpkwGzCiq6soy8tYaI1GyVh/UjpbCx/TYkiZhlZB
      6+fzT" crossorigin="anonymous"
    />
    <!-- JavaScript Bundle with Popper -->
    <script
      src="https://cdn.jsdelivr.net/npm/bootstrap@5.2.1/dist/js/b
      ootstrap.bundle.min.js"
      integrity="sha384-
      u1OknCvxWvY5kfmNBILK2hRnQC3Pr17a+RTT6rIHI7NnikvbZlHgTPOOmMi466C8"
      crossorigin="anonymous"
    ></script>
    <style>
        #navbarRight { margin-left: auto; padding-right:10px;


        }
        .navbar-brand{ padding-left:15px;
        }
    </style>
    <title>DR Predcition</title>
  </head>
  <form action="{{url_for('register')}}" method="post" >
    <nav class="navbar navbar-expand-lg navbar-light bg-dark">
        <div>
```

```html
    <a class="navbar-brand" href="#" style="color:aliceblue">Registration</a>
    </div>
    <div class="navbar-collapse collapsew-100 order-3 dual-collapse2" id="navbarNav">
      <ul class="navbar-nav mr-autotext-center" id="navbarRight">
       <li class="nav-item active">
         <a class="nav-link" href="index" style="color: aliceblue;">Home </a>
       </li>

       <li class="nav-item">
         <a class="nav-link" href="login" style="color: aliceblue;">Login</a>
       </li>
       <li class="nav-item">
         <a class="nav-link" href="register"style="color: aliceblue;">Register</a>
       </li>
      </ul>
     </div>
    </nav>
    <br><br>
    <form class="form-inline" method="POST">
    <div class="container" style="width: 600px; height: 600px;">
      <div class="mb-3 d-flexjustify-content-center"><script
      src="https://cdn.lordicon.com/xdjxvujz.js"></script>
        <lord-icon
          src="https://cdn.lordico
          n.com/elkhjhci.json"
          trigger="hover"
          style="width:200px;hei
          ght:200px">
        </lord-icon></div>
                        <div class="mb-3">
          <input type="text" class="form-control" id="exampleInputName" name = "name"
aria-describedby="nameHelp"placeholder="Enter Name">
          </div>
          <div class="mb-3">
           <input type="email" class="form-control" id="exampleInputEmail1" name="emailid"
aria-describedby="emailHelp"placeholder="Enter Mail ID">
          </div>
          <div class="mb-3">
           <input type="number" class="form-control"
id="exampleInputNumber1" name="num" aria-describedby="numberHelp"
placeholder="Enter Mobile number">
          </div>
          <div class="mb-3">
```

DEEP LEARNING FUNDUSIMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

```
        <input type="password" class="form-control" id="exampleInputPassword1"
name="pass" placeholder="EnterPassword">
        </div>BH
        <div class="mb-3">
        <button type="submit form-control" class="btn btn-dark btn-primary"
        style="width:100%;">Register</button>
        </div>


    </div>
    {{pred}}
    </div>
   </form>
  </body>
</html> -->

<div class="mb-3 d-flexjustify-content-center">
<a href="login" class="nav-link"> AlreadyRegistered: Login Here</a>
```

GITHUB LINK:- https://github.com/IBM-EPBL/IBM-Project-51964-1660987442

DEMO LINK:- https://youtu.be/ukImRsHFv50