Deep Learning Fundus Image Analysis for Early Detection of Diabetic Retinopathy

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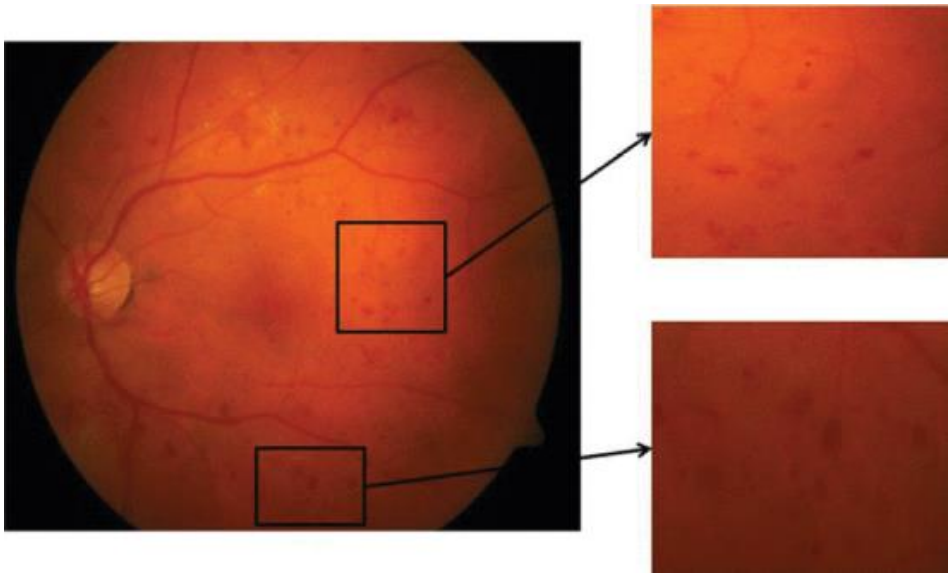
1. INTRODUCTION:

The main cause 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/or dot hemorrhages, vascular hyper permeability signs, exudates, and capillary 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 is expected as a new possibility of improving retinopathy treatment. Floating and flashes, blurred vision, and loss of sudden vision can be common symptoms of diabetic retinopathy.



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 used as a transfer learning method in medical image analysis and they are highly effective.

1.2 Purpose:

The Proposed work intends to automate the detection and classification of diabetic retinopathy from retinal fundus image which is very important in ophthalmology. Most of the existing methods use handcrafted features and 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 algorithm-based technique is proposed to automatically determine the parameters of CNN and then the network is used for classification of diabetic retinopathy. The proposed CNN model consists of a series of convolution and 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 Diabetic Retinopathy Level Detection dataset. The proposed method has achieved accuracy of 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 features and on the other hand genetic algorithm-based methodology automates the design of CNN hyper-parameters.

2. LITERATURE SURVEY:

1. The study and analysis of various machine learning techniques that have been deployed such as Fuzzy C-means Clustering ,MLP and ELM, Neural Network, meta-SVM, SVM, NB Classifier, Probabilistic Classifier, Geometric Classifier, KNN Classifier and tree-based classifier , Bayesian Classifier, Mahalanobis classifier , KNN Classifier, Gaussian Bayes Classifier , Genetic Algorithm, AlexNet DNN, Convolutional Neural Network and various other Machine Learning techniques to model systems for early DR detection and classification .

2. Automated detection of lesions in retinal images can assist in early diagnosis and screening of a common disease: Diabetic Retinopathy. A robust and computationally efficient approach for the localization of the different features and lesions in a fundus retinal image is presented in this paper. Since many features have common intensity properties, geometric features and correlations are used to distinguish between them.

3. A neural network, with CNN architecture, identifies exudates, micro-aneurysms and hemorrhages in the retina image, by training with labeled samples provided by EyePACS, a free platform for retinopathy detection. The database consists of 35126 high-resolution retinal images taken under a variety of conditions. After training, the network shows a specificity of 93.65% and an accuracy of 83.68% on validation process.

4. The loss function is calculated across all data items during an epoch and guaranteed to give the quantitative loss measure at that epoch. However, plotting the curve over iterations only shows the loss for a subset of the entire dataset as shown in fig 8. The final results show that the model outperformed with 84 percent validation accuracy.

5. The ophthalmic fundus images are used in this automatic process [7]. The preprocessing stage includes few issues such as image blurriness, non- clarity or problems related to image size. In the initial step, the image is resized and then the color space conversion and image restoration steps are performed further. The final stage includes the enhancement of image.

References:

1. Early Detection of Diabetic Retinopathy using Machine Learning Techniques: A Survey on Recent Trends and Techniques .
Dolly Das1*, Saroj Kr. Biswas2, Sivaji Bandyopadhyay3, Sunita Sarkar4 1,2,3National Institute of Technology Silchar, 4Assam University

2. Automated feature extraction for early detection of diabetic retinopathy in fundus images, Saiprasad Ravishankar; Arpit Jain; Anurag Mittal

3. Detection of diabetic retinopathy based on a convolutional neural network using retinal fundus images .
Gabriel Garc´ıa1, Jhair Gallardo1, Antoni Mauricio2,Jorge L´opez2, and Christian Del Carpio1

4. Grading of Diabetic Retinopathy in Suspected Individuals .
Neha Sewal1[0000-0002-8730-0115] and Charu Virmani2

5. Neural Network Technique for Diabetic Retinopathy Detection .
Prabhjot Kaur, Somsirsa Chatterjee, Dilbag Singh

2.3 PROBLEM STATEMENT DEFINITION:

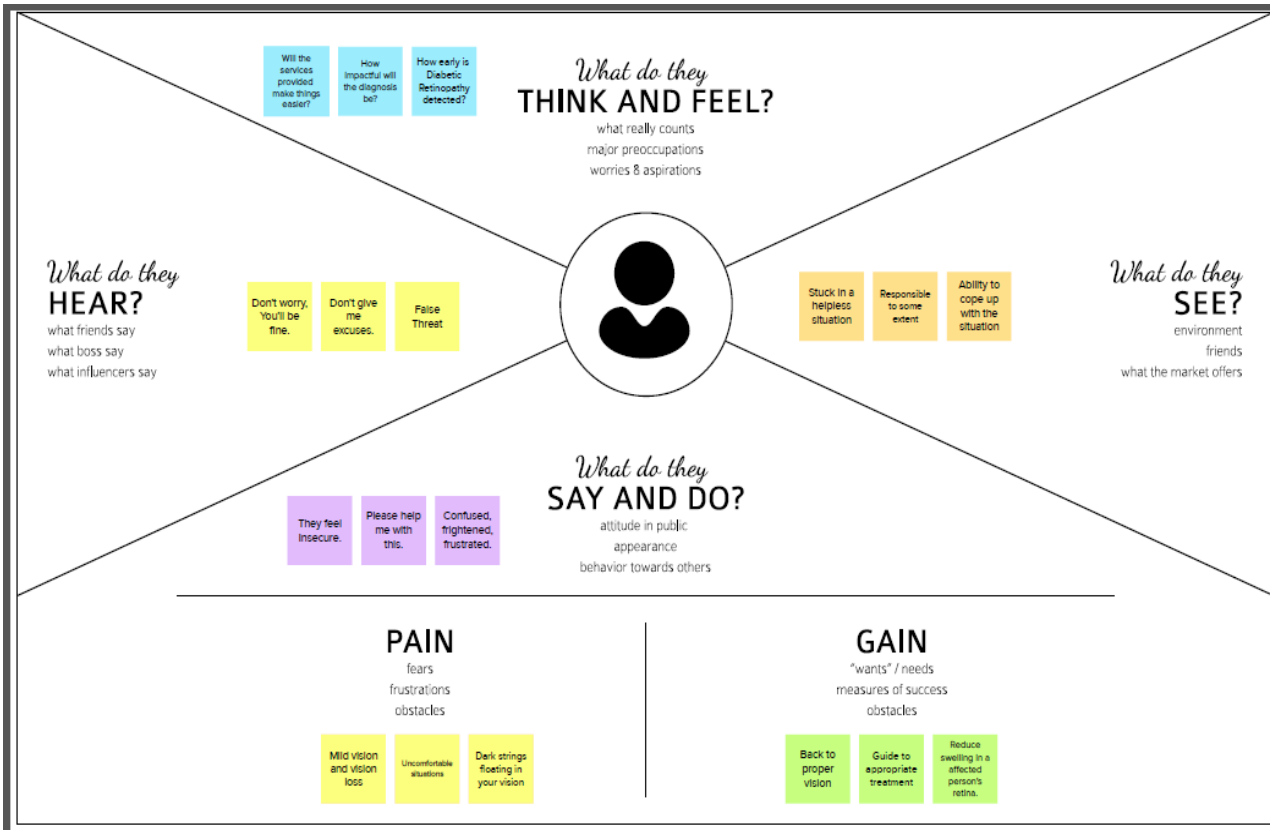
Diabetic Retinopathy (DR) is common complication of diabetes mellitus, which will cause lesions on the retina that affects vision. If it is not detected early, it can lead to blindness. Unfortunately, DR is not a reversible proves, and the given treatment will only give us a sustain vision. DR early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

OBJECTIVES:

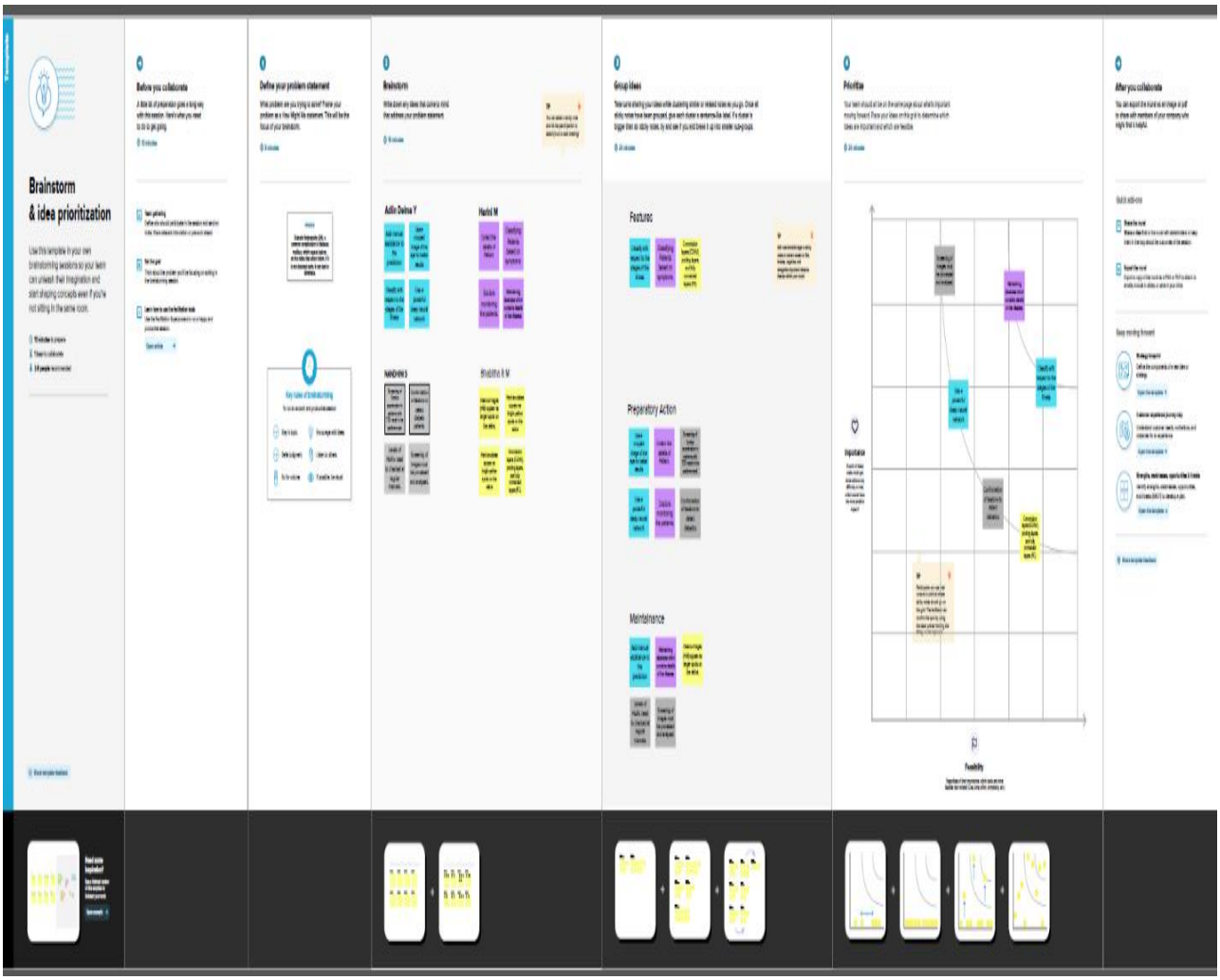
The primary goal is to identify diabetic retinopathy by processing retinal images. Transfer learning has rose as one of the most popular techniques that has enhanced performance in many areas, notably in the analysis and classification of medical images. We used transfer learning techniques that are more frequently used in medical image analysis and have been extremely effective, including such Inception V3, Resnet50, and Xception V3.

3.IDEATION PHASE & PROPOSED SOLUTION:

3.1 Empathy Map Canvas:



3.2 IDEATION AND BRAIN STROMING:



3.3 PROPOSED SOLUTION:

S. No	Parameter	Description
1	Problem statement	1)To find the presence of lesions in the eye. 2) To find HbA1c level 3) Early detection of illness
2	Idea / Solution description	1)Prediction is done at a faster rate. 2)Accuracy of prediction. 3)laser treatment can stop or slow the leakage of blood and fluid in the eye.
3	Novelty / Uniqueness	1) Use of powerful deep neural network. 2) It provides robust and trusted support. 3)Maintaining database which contains details of the disease.
4	Social Impact	1) Reduction of Diabetic Retinopathy risk. 2) Provides Digital Assistance. 3) Very helpful in making decisions faster. 4) Can be used 24x7.
5	Business Model	1) This can be implemented as an essential diagnosis method in every hospital. 2) Accurate detection and analysis can encourage the increase in financial benefit.
6	Scalability of Solution	1) Accurate predictions and extensive use. 2) Based on the times of the correct diagnosis. 3) Availability.

3.4 PROPOSED SOLUTION FIT:

1.PATIENTS SEGMENT - The abnormality or the presence of lesions can be detected using the fundus image of the patient's eye. - The early detection important for the diabetic patients as diabetic retinopathy is irreversible. - Hence early detection and diagnosis is a concerned solution.	**6.CUSTOMER CONSTRAINTS** - Lack of awareness of such severity. - Utilizes a strong healthcare infrastructure, advanced technology, and adequate funding. - Not Cost effective for the annual screening.	**5. AVAILABLE SOLUTIONS** - Laser treatment to treat the growth of new blood vessels at the back of the eye (retina) in cases of proliferative diabetic retinopathy. - Eye injections - to treat severe maculopathy that's threatening your sight.
2. PROBLEMS - Severity of the eye illness due to diabetic retinopathy - High chances of losing vision. - Keen diagnosis to be done on diabetic patients.	**9. PROBLEM ROOT CAUSE** - Diabetic retinopathy is caused by changes in the blood vessels of the retina, the light-sensitive layer of tissue at the back of the inner eye. - Blockage of the tiny blood vessels that nourish the retina, cutting off its blood supply.	**7. BEHAVIOUR** - Early detection of diabetic retinopathy using the fundus images. - Consumes less time on detection than in the manual examination. - High accuracy in detection of lesions.
3. TRIGGER The triggers in diabetic retinopathy patients are: - Spots or dark strings floating in your vision (floaters)	**10. SOLUTION** - Our solution is to make use of a deep learning model that detects the severity of the diabetic retinopathy among	**8.CHANNELS OF BEHAVIOUR** - Regular checkups and examinations are to be done in the regular interval time.

- Blurred vision. - Fluctuating vision. - Dark or empty areas in vision. - Vision loss.	diabetic patients with fundus image screened. - The apt diagnosis to be done after the early detection.	- Proper diagnosis should be done.
4. EMOTIONS: BEFORE / AFTER - Before: Adverse emotional responses include fear, anxiety.		

4.REQUIREMENT ANALYSIS:

Functional Requirements:

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	Upload image	A mixed approach of retinal cameras and slit lamps are used for screening and then the screened images are used for diagnosis.
FR-2	Get diagnosis	Diagnosis of the screened eye is done and the symptoms are noted.
FR-3	Collect data	Various studies are done and data from different

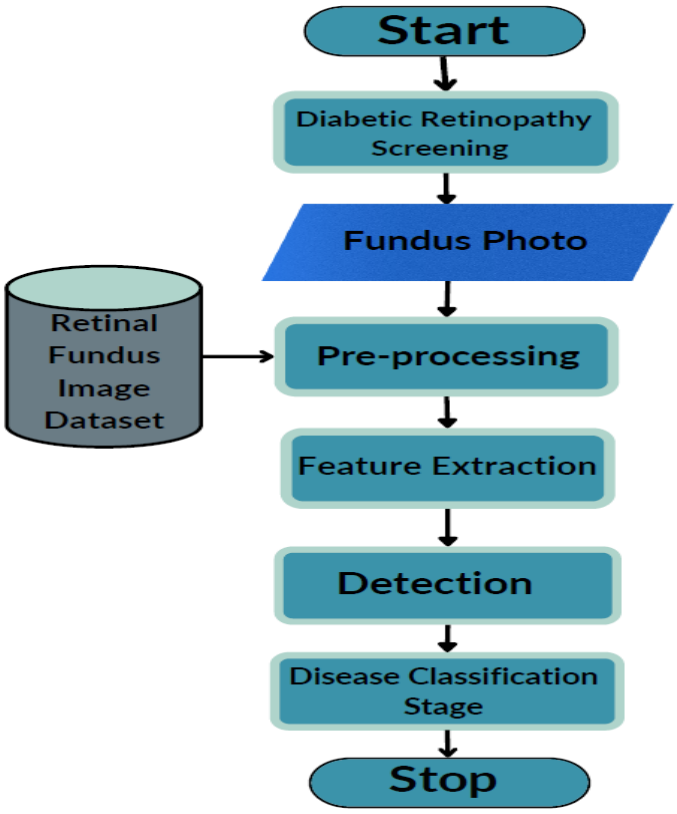
		technologies are collected for training the model.
FR-4	Create model	A model is created and trained using the data collected and screened eye and the trained model is sent for prediction

Non-functional Requirements:

FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	The project developed must be easy to understand and must be usable by everyone.
NFR-2	**Security**	The project must store and secure all the user data details and their diagnosis results.
NFR-3	**Reliability**	The project must diagnose with decent amount of accuracy and approximate result.
NFR-4	**Performance**	The project must be able to give the diagnosis result in a short span of time.
NFR-5	**Availability**	The project must be available at any platform and ready to use.
NFR-6	**Scalability**	The project must hold stability when multiple users are using it at the same times or multiple data records are given for diagnosis without impacting the result.

5.PROJECT DESIGN:

5.1 DATA FLOW DIAGRAM:



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 disease is frequently detected and examined using retinal fundus. Pre-processing of raw retinal fundus images isperformed using extraction of the green channel, histogram equalization, image enhancement and resizing techniques.
- One of the main tasks in retinal image processing is the segmentation of the retinal vasculature from images of the eye fundus.

- By omitting the optic disc (OD) region of the retina, the computer-assisted automatic recognition and segmentation of blood vessels.
- The term "feature extraction from the fundus images for the diagnosis of Diabetic Retinopathy" refers to a sophisticated eye screening-technique that allows for the early detection of eye-related disorders.

5.2 TECHNOLOGY ARCHITECTURE:

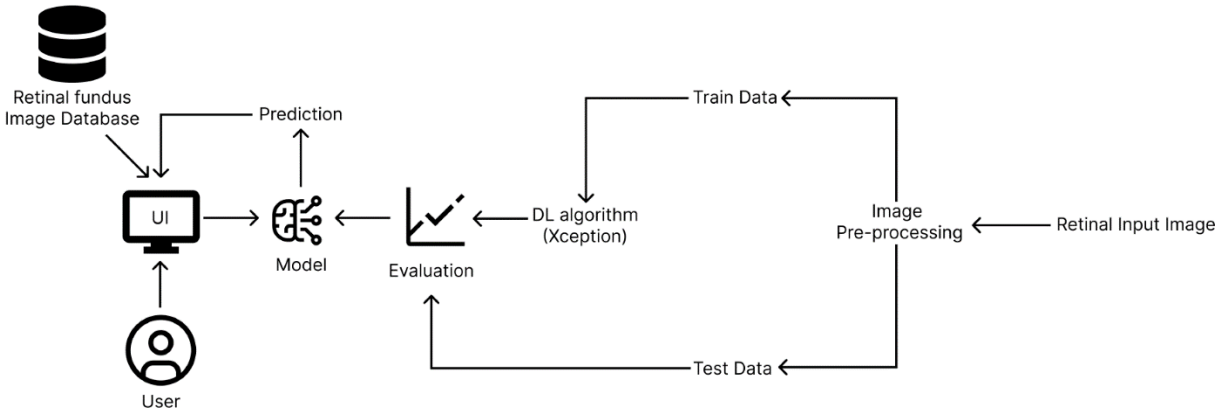


Table-1: Components& Technologies:

1.	User Interface	Web UI	HTML, CSS, JavaScript, Python
2.	Application logic-1	Image Pre-processing	Keras,Tensor flow,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	IBM Block Storage, Google Drive
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 Python WSGI HTTP Server.

Table-2: Application characteristics:

S. No	**Characteristics**	**Description**	**Technology**
1.	Open-Source Frameworks	Flask	Flask Frameworks
2.	Security Implementations	CSRF Protection, Secure Flag for 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 (Web user)	Registration	USN-1	I can register as a user on the website with either an email address or a phone number and password.	I can create my account.	High	Sprint-3
	Login	USN-2	With the provided Login credentials, I can access the website as a user.	I can log in and accessmy account.	High	Sprint-3
	Upload image	USN-3	I can post my data as a user in formats like pdf and doc.	I can upload my data.	Mediu m	Sprint-3
Administrati on (Web developer)	Admin Login	USN-4	I can log in to the website as the admin and analyse the user informatio n.	I can log in and analyze the user data.	High	Sprint-3
	Data collection	USN-5	I can gatherthe dataset forthe DR fromthe source as anadmin.	I can collect the dataset.	Low	Sprint-1
	Create model	USN-6	I can buildthe model andtrain it using the dataset as an administrator to makepredictions.	I can create andtrain the model.	High	Sprint-1

	Test the model	USN-7	I canevaluate the model's predictive abilities as an admin.	I can testthe model.	High	Sprint-2
Patient (Web user)	Diagnosis	USN-8	I can access the application's diagnosisresults as a user and continue with treatments.	He/she can get the results and continue the treatment.	High	Sprint-2

6.PROJECT PLANNING AND SCHEDULING:

6.1 SPRINT PLANNING AND ESTIMATION:

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Pre-requisites for the model	USN-1	Only if this module is done, I can rely on the accuracy of the detection of diabetic retinopathy.	5	Medium	Adlin, Harini
Sprint-1	Research	USN-2	The dataset and the path setup to be	13	High	Harini, Nandhini, Bhabhitha

			done for the right input and output			
Sprint-1	Finalizing Model	USN-3	Apt model should be selected, so that I can get an accurate result.	2	High	Adlin, Harini, Nandhini, Bhabhitha
Sprint-2	IBM cloud access	USN-4	This is the pre requisites for me to access the tools for the model building.	10	Medium	Adlin, Harini, Nandhini, Bhabhitha
Sprint-2	Model Building	USN-5	Only once the model is completed, I can process the input from the website	10	High	Adlin, Harini, Nandhini, Bhabhitha
Sprint-3	Application Building	USN-6	As a user, I can upload the fundus image so that it becomes the input to the model.	20	High	Adlin, Harini, Nandhini, Bhabhitha
Sprint-4	Training	USN-7	I can know the efficiency of the	10	High	Adlin, Harini,

			current model and the accuracy. I can also make room for improvement			Nandhini, Bhabhitha
Sprint-4	Testing	USN-8	As a user, I can know the accurate result of the severity of the illness from the fundus image uploaded.	10	Medium	Adlin, Harini, Nandhini, Bhabhitha

Sprint	**Total story point**	**Duration**	**Sprint Start Date**	**Sprint End Date (Planned)**	**Story Points Completed (as on Planned End Date)**	**Sprint Release Date(Actual)**
Sprint-1	20	6 Days	24 Oct 2022	29 Oct 2022	20	01 Nov 2022
Sprint-2	20	6 Days	31 Oct 2022	05 Nov 2022	20	07 Nov 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	20	13 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	20	20 Nov 2022

Velocity:

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

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

AV=20/6=3.33points per day.

Sprint 1: 20/6 = 3.33

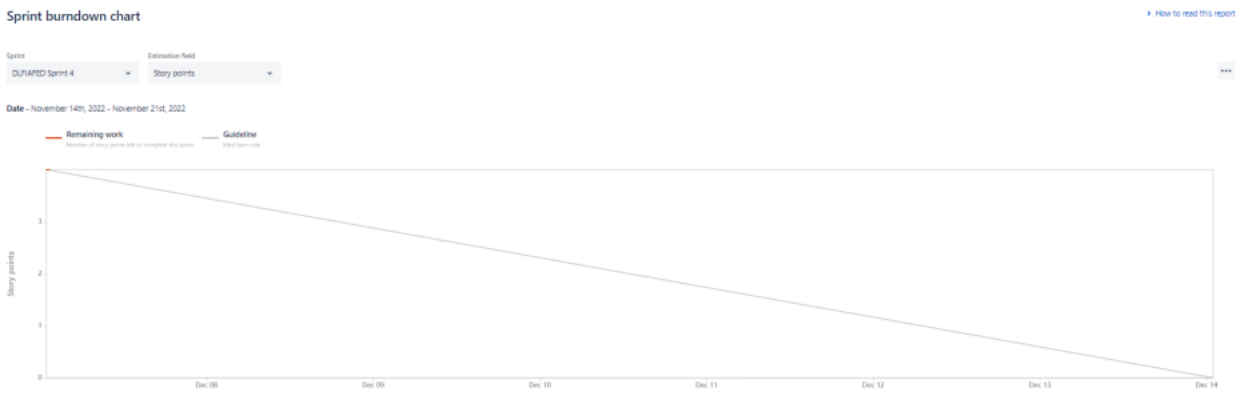
Sprint 2: 20/7 = 2.85

Sprint 3: 20/6 = 3.33

Sprint 4: 20/6 = 3.33

Burndown Chart:

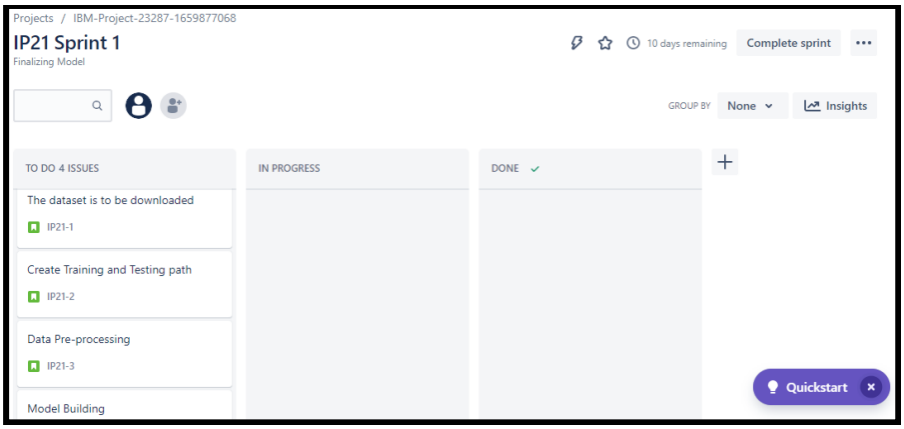
A burn down chart is a graphical representation of work left to do versus time. It is often used in agile software development methodologies such as Scrum. However, burn down charts can be applied to any project containing measurable progress over time



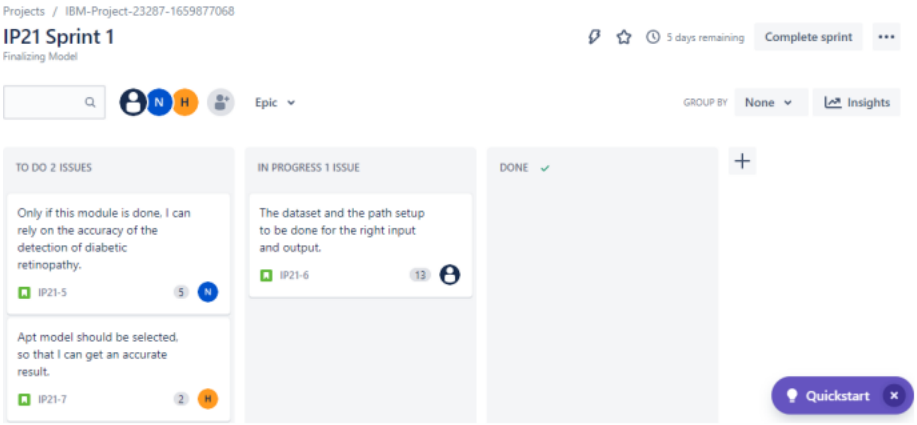
JIRA SCREENSHOTS:

JIRA Folder - Display Scrum methodologies and Burn Down chart progress.

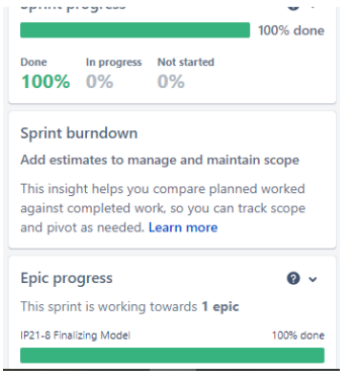
Sprint 1 Creation:



Board Details:



Insights:



7.CODING AND SOLUTION:

Severity Detection

The patient/user can login into the website and upload a fundus image to detect the condition of Diabetic Retinopathy. There are also additional benefits of knowing how severe the condition is. With this feature they can further understand their situation and act accordingly. And diagnosing the severity of the case is classified under five different groups: not affected, mild, moderate, severe and proliferative.

Efficiency (Time taken to provide results)

The patient/user can login into the website and upload a fundus image to detect the condition of Diabetic Retinopathy. It is important for the design of the system to provide results for the user instantaneously. Therefore, the model is designed to be efficient and fast in fetching back the necessary information for the user/patient. The results are displayed on the user/patient's screen within seconds, and it only depends on the internet speed.

8.TESTING:

8.1 USER ACCEPTANCE TESTING:

1. Purpose of Document:

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

2. Defect Analysis:

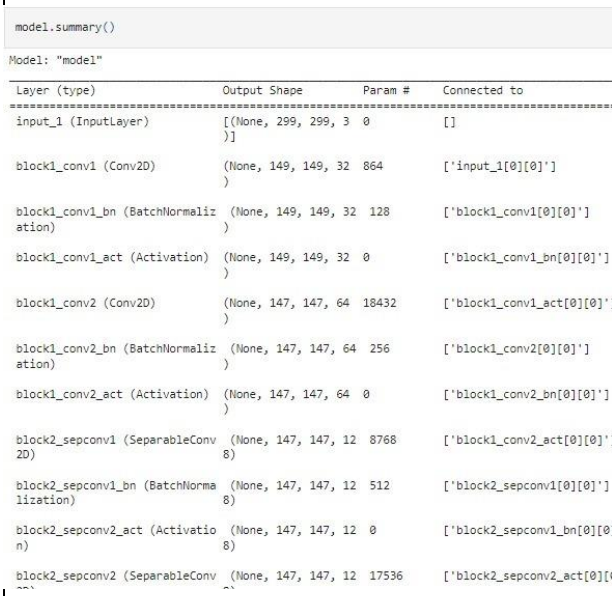
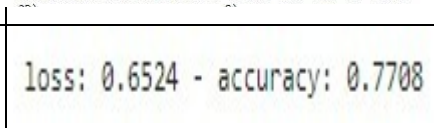
This shows how many bugs were fixed or closed at each severity level and how they were fixed.

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

S. NO	Parameter	Values	Screenshot
1.	Model Summary	Total params: 33,970,989 Trainable params: 13,109,509 Non-trainable params: 20,861,480	
2.	Accuracy	Training Accuracy – **0.7708** Validation Accuracy – **loss 0.6524**	
3.	Confidence Score (Only Yolo Projects)	Class Detected - Confidenc e Score	--- --- --

```
model.summary()
Model: "model"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_1 (InputLayer)         [(None, 299, 299, 3)]     0
_________________________________________________________________
block1_conv1 (Conv2D)        (None, 149, 149, 32)      864
_________________________________________________________________
block1_conv1_bn (BatchNormal (None, 149, 149, 32)      128
_________________________________________________________________
block1_conv1_act (Activation (None, 149, 149, 32)      0
_________________________________________________________________
block1_conv2 (Conv2D)        (None, 147, 147, 64)      18432
_________________________________________________________________
block1_conv2_bn (BatchNormal (None, 147, 147, 64)      256
_________________________________________________________________
block1_conv2_act (Activation (None, 147, 147, 64)      0
_________________________________________________________________
block2_sepconv1 (SeparableCo (None, 147, 147, 128)     8768
_________________________________________________________________
block2_sepconv1_bn (BatchNor (None, 147, 147, 128)     512
_________________________________________________________________
block2_sepconv2_act (Activat (None, 147, 147, 128)     0
_________________________________________________________________
block2_sepconv2 (SeparableCo (None, 147, 147, 128)     17536
```

```
loss: 0.6524 - accuracy: 0.7708
```

9.RESULTS:

9.1 Performance Metrics:

Model Performance Testing

USER ACCEPTANCE TESTING:

Purpose of Document:-

This is a reference for the “Deep Learning Fundus Image Analysis for Early Detection of Diabetic Retinopathy” project's test coverage and open issues as of the project's release for user acceptance testing.

Defect Analysis:-

This shows how many bugs were fixed or closed at each severity level and how they were fixed.

Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Severity 5
By Design	4	3	2	4	13
Duplicate	1	0	2	1	4
External	3	2	0	1	6
Fixed	6	1	2	13	21
Not Reproduced	0	0	1	0	1
Skipped	0	0	1	1	2
Won't Fix	0	4	2	1	7
Totals	14	10	10	21	54

Test-Case Analysis:

This report shows the number of test cases that have passed, failed, and untested.

Section	Total Cases	Not Tested	Fail	Pass
Print Engine	9	0	0	9
Client Application	45	0	0	45
Security	2	0	0	2
Out-source Shipping	3	0	0	3

Exception Reporting	9	0	0	9
Final Report Output	4	0	0	4
Version Control	2	0	0	2

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.

- Deep learning is well-suited for image analysis tasks. This is because deep learning algorithms can automatically learn features from images, which is essential for accurate image analysis.
- Deep learning is efficient at handling large amounts of data. This is important for medical image analysis, as medical images are often very large.
- Deep learning is scalable. This means that it can be used to train models on very large datasets, which is important for medical image analysis tasks where data is often limited.
- Deep learning is able to learn from data with little supervision. This is important for medical image analysis, as often there is limited labeled data available.
- Deep learning is robust. This means that it is less likely to overfit to the data, which is important for medical image analysis where data is often limited.

10.2 DISADVANTAGES:-

There are several disadvantages of deep learning for early detection of diabetic retinopathy. One disadvantage is that deep learning requires a large amount of data to train the models. This can be a challenge for researchers who do not have access to a large dataset. Another challenge is that deep learning models can be very complex, which can make them difficult to interpret. Finally, deep learning models can be computationally intensive, which can make them difficult to deploy in resource-limited settings.

11.CONCLUSION:-

Diabetic retinopathy (DR) is a leading cause of blindness in the United States. Early detection and treatment of DR is critical to preventing vision loss. However, DR is often asymptomatic in its early stages, 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 has been shown 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 and treatment of DR, which could help to prevent vision loss.

12. APPENDIX:-

app.py:-

```
import os
import numpy as np
import requests
from cloudant.client import Cloudant
from flask import Flask, redirect, render_template, request, url_for
from tensorflow.keras.applications.inception_v3 import preprocess_input
from tensorflow.keras.models import load_model
from tensorflow.keras.preprocessing import image
client = Cloudant.iam('3baf147f-3fb3-4aa4-ac12-62200863d3c4-
bluemix','aTgtrUrqUdiw2rxNYMrFMa7qFqf34tDif5hpAE7JPjxs', connect=True)
my_database = client.create_database('my_database')
model = load_model(r"Updated-Xception-diabetic-retinopathy.h5")
app = Flask(__name__)
@app.route('/')
```

```
def index():
    return render_template('index.html')
@app.route('/index')
def home():
    return render_template("index.html")
@app.route('/register')
def register():
    return render_template('register.html')
@app.route('/afterreg', methods=['POST'])
def afterreg():
    x = [x for x in request.form.values()]
    print(x)
    data = {
    '_id': x[1],
    'name': x[0],
    'psw':x[2]
    }
    print(data)

    query = {'_id': {'$eq': data['_id']}}
    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 already a member, please login using your
details")

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

```
@app.route('/afterlogin',methods=['POST'])
def afterlogin():
    user = request.form['_id']
    passw = request.form['psw']
    print(user,passw)

    query = {'_id': {'$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="The username is not found.")
    else:
        if((user==docs[0][0]['_id'] and passw==docs[0][0]['psw'])):
            return redirect(url_for('prediction'))
        else:
            print('Invalid User')
    @app.route('/logout')
def logout():
    return render_template('logout.html')

@app.route('/prediction')
def prediction():
    return render_template('prediction.html')
@app.route('/result',methods=["GET","POST"])
def result():
    if request.method=="POST":
        f=request.files['image']
        basepath=os.path.dirname(__file__)
        filepath=os.path.join(basepath,'uploads',f.filename)
        f.save(filepath)
```

```
    img=image.load_img(filepath,target_size=(299,299))
      x=image.img_to_array(img)
      x=np.expand_dims(x,axis=0)
      img_data=preprocess_input(x)
      prediction=np.argmax(model.predict(img_data), axis=1)
     index=['No Diabetic Retinopathy', 'Mild DR', 'Moderate DR', 'Severe DR', 'Proliferative DR']
      result=str(index[ prediction[0]])
      print(result)
      return render_template('prediction.html',result)
""" Running our application """
if __name__ == "__main__":
   app.run()
```

Cloudant.py:

```
from cloudant.client import Cloudant
client=Cloudant.iam('3baf147f-3fb3-4aa4-ac12-62200863d3c4-
bluemix','aTgtrUrqUdiw2rxNYMrFMa7qFqf34tDif5hpAE7JPjxs',connect=True)
my_database=client.create_database('my-database')
```

index.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">

   <link rel="stylesheet"
href="https://maxcdn.bootstrapcdn.com/bootstrap/4.0.0/css/bootstrap.min.css"
integrity="sha384-
Gn5384xqQ1aoWXA+058RXPxPg6fy4IWvTNh0E263XmFcJlSAwiGgFAW/dAiS6JXm"
crossorigin="anonymous">
```

```
    <script src="https://code.jquery.com/jquery-3.2.1.slim.min.js" integrity="sha384-
KJ3o2DKtIkvYIK3UENzmM7KCkRr/rE9/Qpg6aAZGJwFDMVNA/GpGFF93hXpG5Kk
N" crossorigin="anonymous"></script>
    <script src="https://cdnjs.cloudflare.com/ajax/libs/popper.js/1.12.9/umd/popper.min.js"
integrity="sha384-
ApNbgh9B+Y1QKtv3Rn7W3mgPxhU9K/ScQsAP7hUibX39j7fakFPskvXusvfa0b4Q"
crossorigin="anonymous"></script>
    <script src="https://maxcdn.bootstrapcdn.com/bootstrap/4.0.0/js/bootstrap.min.js"
integrity="sha384-
JZR6Spejh4U02d8jOt6vLEHfe/JQGiRRSQQxSfFWpi1MquVdAyjUar5+76PVCmYl"
crossorigin="anonymous"></script>


    <script src="https://kit.fontawesome.com/8b9cdc2059.js"
crossorigin="anonymous"></script>
    <link
href="https://fonts.googleapis.com/css2?family=Akronim&family=Roboto&display=swap"
rel="stylesheet">
    <link rel="stylesheet" href="../static/style.css">
    <title>Diabetic Retinopathy Classification</title>
</head>
<body>
    <header id="head" class="header">
   <section  id="navbar">
         <h1 class="nav-heading"></i>Diabetic Retinopathy Classification</h1>
       <div class="nav--items">
         <ul>
                                    <li><a  href="index.html">Home</a></li>
                                    <li><a href="login.html">Login</a></li>
                                    <li><a href="register.html">Register</a></li>
            <li><a href="prediction.html">Prediction</a></li>
```

```
        </ul>
      </div>
  </section>
  <section id="slider">
   <div id="carouselExampleIndicators" class="carousel" data-ride="carousel">
      <ol class="carousel-indicators ">
         <li data-target="#carouselExampleIndicators" data-slide-to="0" class="active "></li>
         <li data-target="#carouselExampleIndicators" data-slide-to="1"></li>
         <li data-target="#carouselExampleIndicators" data-slide-to="2"></li>
         <li data-target="#carouselExampleIndicators" data-slide-to="3"></li>
         <li data-target="#carouselExampleIndicators" data-slide-to="4"></li>
      </ol>
      <div class="carousel-inner">

         <div class="carousel-item active">
            <img class="d-block w-100" src="../static/img/first.png" alt="First slide">
         </div>
         <div class="carousel-item">
            <img class="d-block w-100" src="../static/img/second.png" alt="Second slide">
         </div>
         <div class="carousel-item">
            <img class="d-block w-100" src="../static/img/third.png" alt="Third slide">
         </div>
      </div>
      <a class="carousel-control-prev" href="#carouselExampleIndicators" role="button" data-slide="prev">
         <span class="carousel-control-prev-icon" aria-hidden="true"></span>
         <span class="sr-only">Previous</span>
      </a>
      <a class="carousel-control-next" href="#carouselExampleIndicators" role="button" data-slide="next">
```

```
        <span class="carousel-control-next-icon" aria-hidden="true"></span>
        <span class="sr-only">Next</span>
      </a>
    </div>

  </section>
</header>
<section id="about">
   <div class="top">
      <h3 class="title text-muted">
         ABOUT PROJECT
      </h3>
      <div class="line"></div>
   </div>
<div class="body">
<div class="left">
   <h2>Problem:</h2>
   <p>
      Diabetic Retinopathy (DR) is a common complication of diabetes mellitus, which causes lesions on the retina that effect
         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.

                  </p>
</div>
<div class="right">
```

<h2>Solution:</h2>

In this project, we will be building a Transfer learning model that can detect and classify types of Diabetic Retinopathy. A web application is integrated with the model, from where the user can upload a Diabetic Retinopathy (DR) image like Mild DR, Severe DR, etc., and see the analyzed results on UserInterface.

</section>
<section id="services">
<h3 class="title text-muted">WE CLASSIFY</h3>

<img src="../static/img/testimonials/NoDR.png" class="card-img-top" alt="cardboard">

<h5 class="card-title text-muted">No DR</h5>

<img src="../static/img/testimonials/MildDR.png" class="card-img-top" alt="bottle">

<h5 class="card-title text-muted">Mild DR</h5>

<img src="../static/img/testimonials/ModerateDR.png" class="card-img-top" alt="metal">

```
      <div class="card-body text-muted">
            <h5 class="card-title text-muted">Moderate DR</h5>

      </div>
    </div>
  <div class="card" style="width: 25rem;">
      <img src="../static/img/testimonials/SevereDR.png" class="card-img-top" alt="page">
      <div class="card-body text-muted">
                  <h5 class="card-title text-muted">Severe DR</h5>  </div>
    </div>
  <div class="card" style="width: 25rem;">
      <img src="../static/img/testimonials/ProliferativeDR.png" class="card-img-top"
alt="plastic">
      <div class="card-body text-muted">
                  <h5 class="card-title text-muted">Proliferative DR</h5>

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

login.html:-

```
<!DOCTYPE html>
<html >

<head>
  <meta charset="UTF-8">
  <meta name="viewport" content="width=device-width, initial-scale=1">
  <title> Login Page</title>
  <link href='https://fonts.googleapis.com/css?family=Pacifico' rel='stylesheet' type='text/css'>
```

```
<link href='https://fonts.googleapis.com/css?family=Arimo' rel='stylesheet' type='text/css'>
<link href='https://fonts.googleapis.com/css?family=Hind:300' rel='stylesheet' type='text/css'>
<link href='https://fonts.googleapis.com/css?family=Open+Sans+Condensed:300' rel='stylesheet'
type='text/css'>
<link rel="stylesheet" href="{{ url_for('static', filename='css/style.css') }}">
<link href='https://fonts.googleapis.com/css?family=Merriweather' rel='stylesheet'>
<link href='https://fonts.googleapis.com/css?family=Josefin Sans' rel='stylesheet'>
<link href='https://fonts.googleapis.com/css?family=Montserrat' rel='stylesheet'>


<style>
.header {
                        top:0;
                        margin:0px;
                        left: 0px;
                        right: 0px;
                        position: fixed;
                        background-color: #28272c;
                        color: white;
                        box-shadow: 0px 8px 4px grey;
                        overflow: hidden;
                        padding-left:20px;
                        font-family: 'Josefin Sans';
                        font-size: 2vw;
                        width: 100%;
                        height:8%;
                        text-align: center;
                }
.topnav {
  overflow: hidden;
  background-color: #333;
}

.topnav-right a {
```

```
  float: left;
  color: #f2f2f2;
  text-align: center;
  padding: 14px 16px;
  text-decoration: none;
  font-size: 18px;
}

.topnav-right a:hover {
  background-color: #ddd;
  color: black;
}

.topnav-right a.active {
  background-color: #565961;
  color: white;
}

.topnav-right {
  float: right;
  padding-right:100px;
}

.login{
margin-top:-70px;
}
body {

  background-color:#ffffff;
  background-repeat: no-repeat;
  background-size:cover;
  background-position: 0px 0px;
  }
.login{
```

```
        margin-top:100px;
}
form {border: 3px solid #f1f1f1; margin-left:400px;margin-right:400px;}

input[type=text], input[type=email],input[type=number],input[type=password] {
  width: 100%;
  padding: 12px 20px;
  display: inline-block;
  margin-bottom:18px;
  border: 1px solid #ccc;
  box-sizing: border-box;
}

button {
  background-color: #28272c;
  color: white;
  padding: 14px 20px;
  margin-bottom:8px;
  border: none;
  cursor: pointer;
  width: 100%;
  font-weight:bold;
}

button:hover {
  opacity: 0.8;
}

.cancelbtn {
  width: auto;
  padding: 10px 18px;
  background-color: #f44336;
}
```

```
.imgcontainer {
  text-align: center;
  margin: 24px 0 12px 0;
}

img.avatar {
  width: 30%;
  border-radius: 50%;
}

.container {
  padding: 16px;
}

span.psw {
  float: right;
  padding-top: 16px;

}

@media screen and (max-width: 300px) {
  span.psw {
     display: block;
     float: none;
  }
  .cancelbtn {
     width: 100%;
  }
}

</style>
</head>

<body style="font-family:Montserrat;">
```

```
<div class="header">
 <div style="width:50%;float:left;font-size:2vw;text-align:left;color:white; padding-top:1%">DR Login Page</div>
  <div class="topnav-right" style="padding-top:0.5%;">

    <a  href="index.html">Home</a>
    <a class="active" href="login.html">Login</a>
    <a  href="register.html">Register</a>

  </div>
</div>
<div id="login" class="login">


        <form action="prediction.html" method="post">
                <div class="imgcontainer">
                        <img style="" src="https://pngimage.net/wp-content/uploads/2018/05/agriculteur-png.png" alt="Avatar" class="avatar">
                </div>

                <div class="container">
                        <input type="email" placeholder="Enter registered email ID" name="_id" required><br>

                        <input type="password" placeholder="Enter Password" name="psw" required>


                        <button type="submit">Login</button><br>
                </div>
        </form>

</div>
</body>
```

```
</html>
```

logout.html

```
<!DOCTYPE html>
<html >
<head>
  <meta charset="UTF-8">
  <meta name="viewport" content="width=device-width, initial-scale=1">
 <title>Plant Disease Prediction</title>
  <link href='https://fonts.googleapis.com/css?family=Pacifico' rel='stylesheet' type='text/css'>
<link href='https://fonts.googleapis.com/css?family=Arimo' rel='stylesheet' type='text/css'>
<link href='https://fonts.googleapis.com/css?family=Hind:300' rel='stylesheet' type='text/css'>
<link href='https://fonts.googleapis.com/css?family=Open+Sans+Condensed:300' rel='stylesheet'
type='text/css'>
<link href='https://fonts.googleapis.com/css?family=Merriweather' rel='stylesheet'>
<link href='https://fonts.googleapis.com/css?family=Josefin Sans' rel='stylesheet'>
<link href='https://fonts.googleapis.com/css?family=Montserrat' rel='stylesheet'>

<style>
.header {
                                top:0;
                                margin:0px;
                                left: 0px;
                                right: 0px;
                                position: fixed;
                                background-color: #28272c;
                                color: white;
                                box-shadow: 0px 8px 4px grey;
                                overflow: hidden;
                                padding-left:20px;
                                font-family: 'Josefin Sans';
                                font-size: 2vw;
                                width: 100%;
                                height:8%;
```

```
                        text-align: center;
                    }
                    .topnav {
  overflow: hidden;
  background-color: #333;
}

.topnav-right a {
  float: left;
  color: #f2f2f2;
  text-align: center;
  padding: 14px 16px;
  text-decoration: none;
  font-size: 18px;
}

.topnav-right a:hover {
  background-color: #ddd;
  color: black;
}

.topnav-right a.active {
  background-color: #565961;
  color: white;
}

.topnav-right {
  float: right;
  padding-right:100px;
}

.login{
margin-top:-70px;
}
```

```
body {

  background-color:#ffffff;
  background-repeat: no-repeat;
  background-size:cover;
  background-position: 0px 0px;
  }
.main{
        margin-top:100px;
        text-align:center;
}
form { margin-left:400px;margin-right:400px;}

input[type=text], input[type=email],input[type=number],input[type=password] {
  width: 100%;
  padding: 12px 20px;
  display: inline-block;
  margin-bottom:18px;
  border: 1px solid #ccc;
  box-sizing: border-box;
}

button {
  background-color: #28272c;
  color: white;
  padding: 14px 20px;
  margin-bottom:8px;
  border: none;
  cursor: pointer;
  width: 20%;
}

button:hover {
  opacity: 0.8;
```

```
}

.cancelbtn {
  width: auto;
  padding: 10px 18px;
  background-color: #f44336;
}

.imgcontainer {
  text-align: center;
  margin: 24px 0 12px 0;
}

img.avatar {
  width: 30%;
  border-radius: 50%;
}

.container {
  padding: 16px;
}

span.psw {
  float: right;
  padding-top: 16px;

}

@media screen and (max-width: 300px) {
  span.psw {
     display: block;
     float: none;
  }
  .cancelbtn {
```

```
    width: 100%;
  }
}

</style>
</head>

<body style="font-family:Montserrat;">

<div class="header">
 <div style="width:50%;float:left;font-size:2vw;text-align:left;color:white; padding-top:1%">Plant
Disease Prediction</div>
  <div class="topnav-right" style="padding-top:0.5%;">

    <a  href="index.html">Home</a>
    <a href="login.html">Login</a>
    <a href="register.html">Register</a>
  </div>
</div>
<div class="main">
<h1>Successfully Logged Out!</h1>
<h3 style="color:#4CAF50">Login for more information<h3>

          <a href="login.html"><button type="submit">Login</button></a>
</form>
</div>

</body>
</html>
```

prediction.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">

    <link rel="stylesheet"
href="https://maxcdn.bootstrapcdn.com/bootstrap/4.0.0/css/bootstrap.min.css" integrity="sha384-
Gn5384xqQ1aoWXA+058RXPxPg6fy4IWvTNh0E263XmFcJlSAwiGgFAW/dAiS6JXm"
crossorigin="anonymous">
    <script src="https://code.jquery.com/jquery-3.2.1.slim.min.js" integrity="sha384-
KJ3o2DKtIkvYIK3UENzmM7KCkRr/rE9/Qpg6aAZGJwFDMVNA/GpGFF93hXpG5KkN"
crossorigin="anonymous"></script>
    <script src="https://cdnjs.cloudflare.com/ajax/libs/popper.js/1.12.9/umd/popper.min.js"
integrity="sha384-
ApNbgh9B+Y1QKtv3Rn7W3mgPxhU9K/ScQsAP7hUibX39j7fakFPskvXusvfa0b4Q"
crossorigin="anonymous"></script>
    <script src="https://maxcdn.bootstrapcdn.com/bootstrap/4.0.0/js/bootstrap.min.js"
integrity="sha384-
JZR6Spejh4U02d8jOt6vLEHfe/JQGiRRSQQxSfFWpi1MquVdAyjUar5+76PVCmYl"
crossorigin="anonymous"></script>


    <script src="https://kit.fontawesome.com/8b9cdc2059.js" crossorigin="anonymous"></script>
    <link href="https://fonts.googleapis.com/css2?family=Akronim&family=Roboto&display=swap"
rel="stylesheet">
    <link rel="stylesheet" href="../static/style.css">

    <script defer src="../static/js/JScript.js"></script>
    <title>Prediction</title>
</head>
<body>
    <header id="head" class="header">
        <section  id="navbar">
            <h1 class="nav-heading"></i>Diabetic Retinopathy Classification</h1>
          <div class="nav--items">
```

```
            <ul>
              <li><a  href="index.html">Home</a></li>
                                    <li><a href="logout.html">Logout</a></li>

            </ul>
          </div>
      </section>
   </header>
   <section id="prediction">
      <div class="prediction-input">
      <div class="circle">
         <img src="../static/img/dummy/dr.jpg" alt="Demo" id="demo" class="circle">
      </div>
            <form id="form" action="/result" method="post"  enctype="multipart/form-data">
               <input type="file" id="imageupload"  name="image" accept="image/*" class="input-
image">
               <input type="submit" class="submitbtn">
               <h5>
               Diabetic Retinopathy Classification is  : <b><b>
               </h5>
            </form>
      </div>
          <div class="line"></div>
                <div class="card" style="width: 78rem;">
             <img src="../static/img/testimonials/stages.png" alt="">
              </div>
    </body>
</html>
```

register.html:-

```
<!DOCTYPE html>
<html >
<head>
```

```
 <meta charset="UTF-8">
 <meta name="viewport" content="width=device-width, initial-scale=1">
 <title> Plant Disease Prediction</title>
 <link href='https://fonts.googleapis.com/css?family=Pacifico' rel='stylesheet' type='text/css'>
<link href='https://fonts.googleapis.com/css?family=Arimo' rel='stylesheet' type='text/css'>
<link href='https://fonts.googleapis.com/css?family=Hind:300' rel='stylesheet' type='text/css'>
<link href='https://fonts.googleapis.com/css?family=Open+Sans+Condensed:300' rel='stylesheet'
type='text/css'>
<link rel="stylesheet" href="{{ url_for('static', filename='css/style.css') }}">

<link href='https://fonts.googleapis.com/css?family=Merriweather' rel='stylesheet'>
<link href='https://fonts.googleapis.com/css?family=Josefin Sans' rel='stylesheet'>
<link href='https://fonts.googleapis.com/css?family=Montserrat' rel='stylesheet'>

<style>
.header {
                        top:0;
                        margin:0px;
                        left: 0px;
                        right: 0px;
                        position: fixed;
                        background-color: #28272c;
                        color: white;
                        box-shadow: 0px 8px 4px grey;
                        overflow: hidden;
                        padding-left:20px;
                        font-family: 'Josefin Sans';
                        font-size: 2vw;
                        width: 100%;
                        height:8%;
                        text-align: center;
                }
                .topnav {
  overflow: hidden;
```

```
  background-color: #333;
}

.topnav-right a {
  float: left;
  color: #f2f2f2;
  text-align: center;
  padding: 14px 16px;
  text-decoration: none;
  font-size: 18px;
}

.topnav-right a:hover {
  background-color: #ddd;
  color: black;
}

.topnav-right a.active {
  background-color: #565961;
  color: white;
}

.topnav-right {
  float: right;
  padding-right:100px;
}

.login{
margin-top:-70px;
}
body {

  background-color:#ffffff;
  background-repeat: no-repeat;
```

```
  background-size:cover;
  background-position: 0px 0px;
  }
.login{
        margin-top:100px;
}
form {border: 3px solid #f1f1f1; margin-left:400px;margin-right:400px;}

input[type=text], input[type=email],input[type=number],input[type=password] {
  width: 100%;
  padding: 12px 20px;
  display: inline-block;
  margin-bottom:18px;
  border: 1px solid #ccc;
  box-sizing: border-box;
}

button {
  background-color: #28272c;
  color: white;
  padding: 14px 20px;
  margin-bottom:8px;
  border: none;
  cursor: pointer;
  width: 100%;
}

button:hover {
  opacity: 0.8;
}

.cancelbtn {
  width: auto;
  padding: 10px 18px;
```

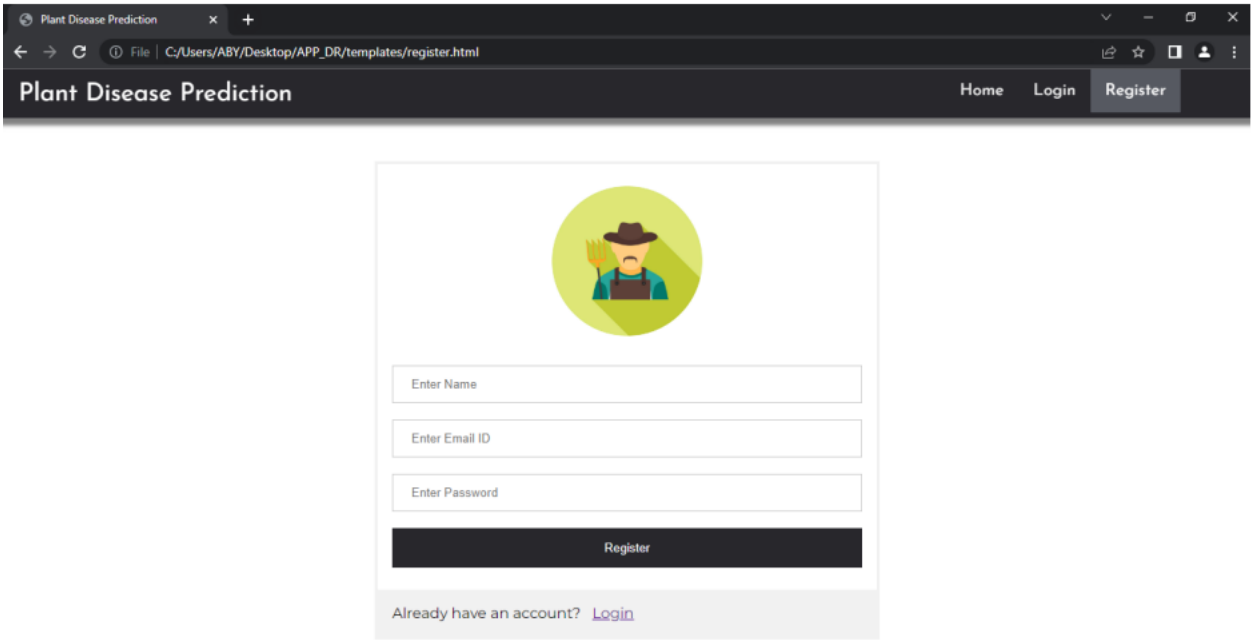
```
  background-color: #f44336;
}

.imgcontainer {
  text-align: center;
  margin: 24px 0 12px 0;
}

img.avatar {
  width: 30%;
  border-radius: 50%;
}

.container {
  padding: 16px;
}

span.psw {
  float: right;
  padding-top: 16px;

}

@media screen and (max-width: 300px) {
  span.psw {
     display: block;
     float: none;
  }
  .cancelbtn {
     width: 100%;
  }
}

</style>
```

```
</head>

<body style="font-family:Montserrat;">

<div class="header">
 <div style="width:50%;float:left;font-size:2vw;text-align:left;color:white; padding-top:1%">Plant Disease Prediction</div>
  <div class="topnav-right" >

    <a  href="index.html">Home</a>
    <a href="login.html">Login</a>
    <a class="active"  href="register.html">Register</a>

  </div>
</div>
<div id="login" class="login">


          <form action="login.html" method="post">
                    <div class="imgcontainer">
                              <img style=""
src="https://www.iconbunny.com/icons/media/catalog/product/2/1/2136.12-farmer-icon-iconbunny.jpg" alt="Avatar" class="avatar">
                    </div>

                    <div class="container">
                              <input type="text" placeholder="Enter Name" name="name" required><br>
                              <input type="email" placeholder="Enter Email ID" name="_id" required><br>
                              <input type="password" placeholder="Enter Password" name="psw" required>


                              <button type="submit">Register</button><br>
    {{pred}}
```

```
                </div>
                <div class="container" style="background-color:#f1f1f1">
  <div class="psw">Already have an account?   <a href="login.html">Login</a></div
        >
 </div>
        </form>

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

Output Screenshots:-

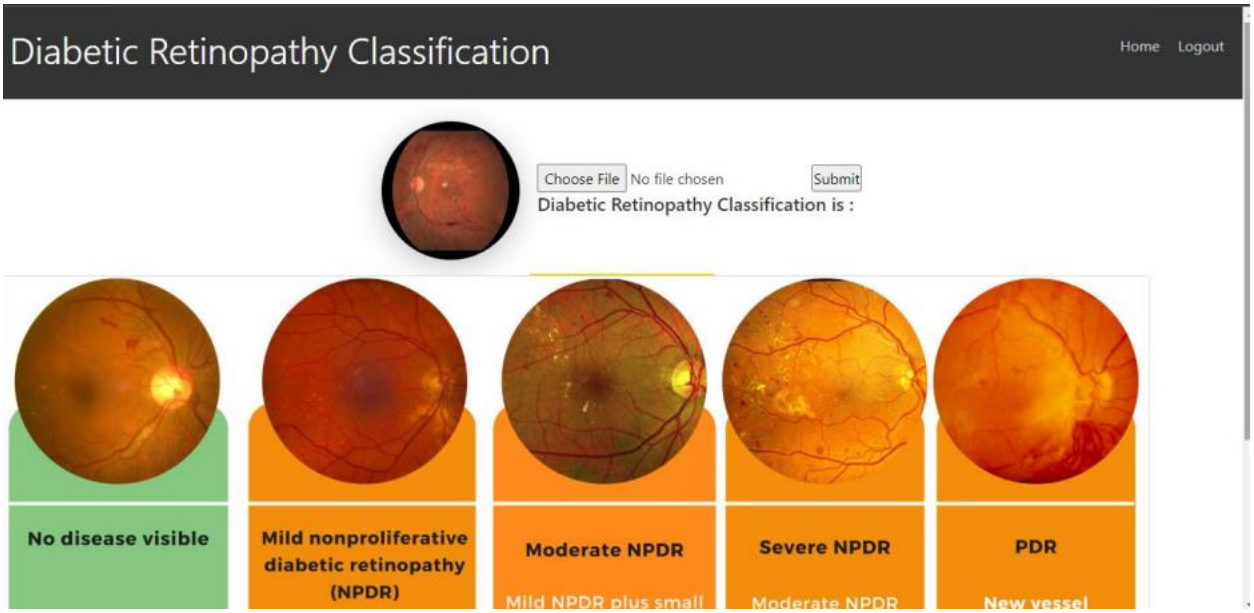
Register.html:



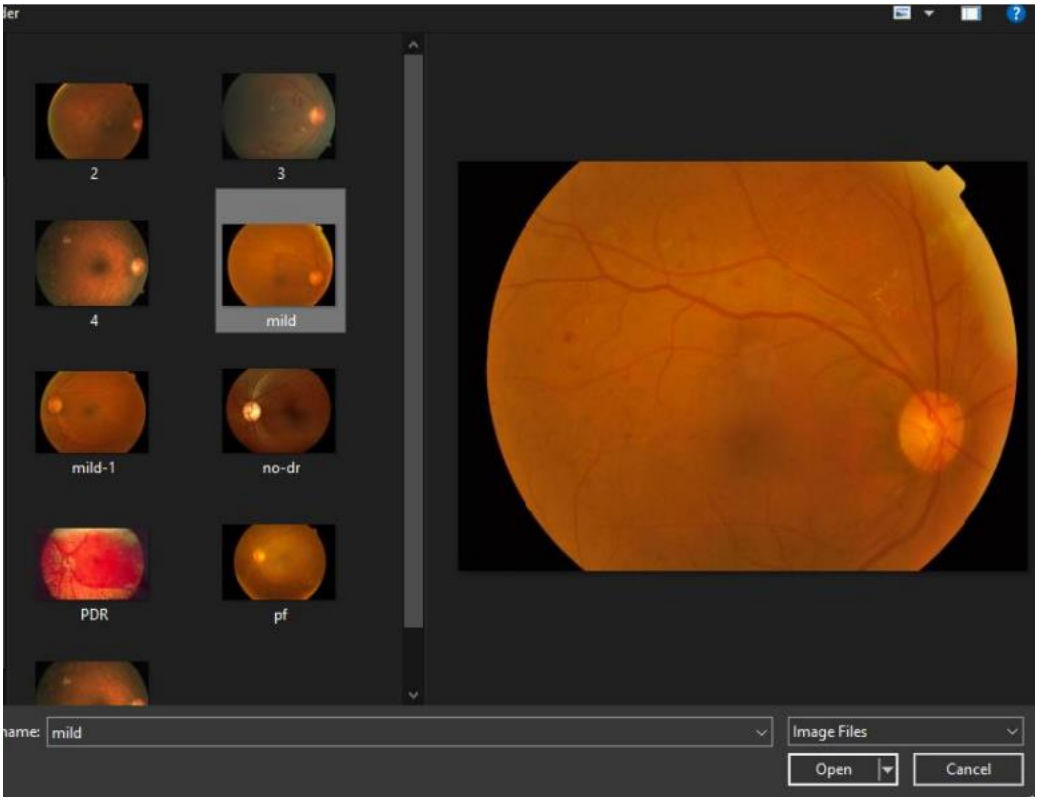
---

prediction.html

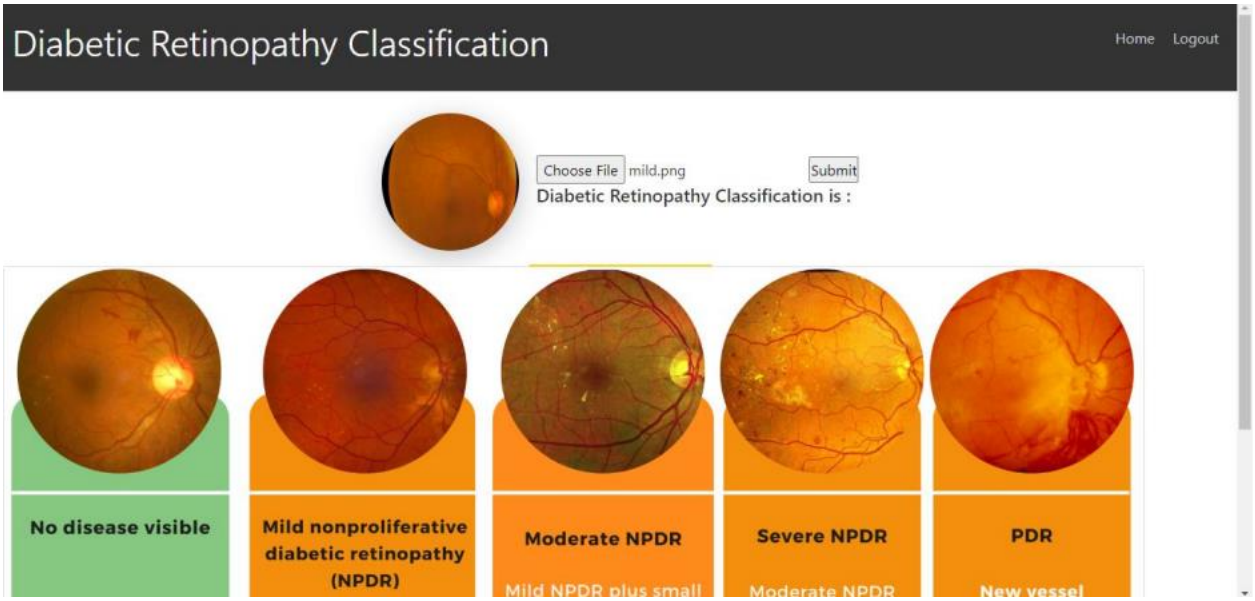
a) Initial page



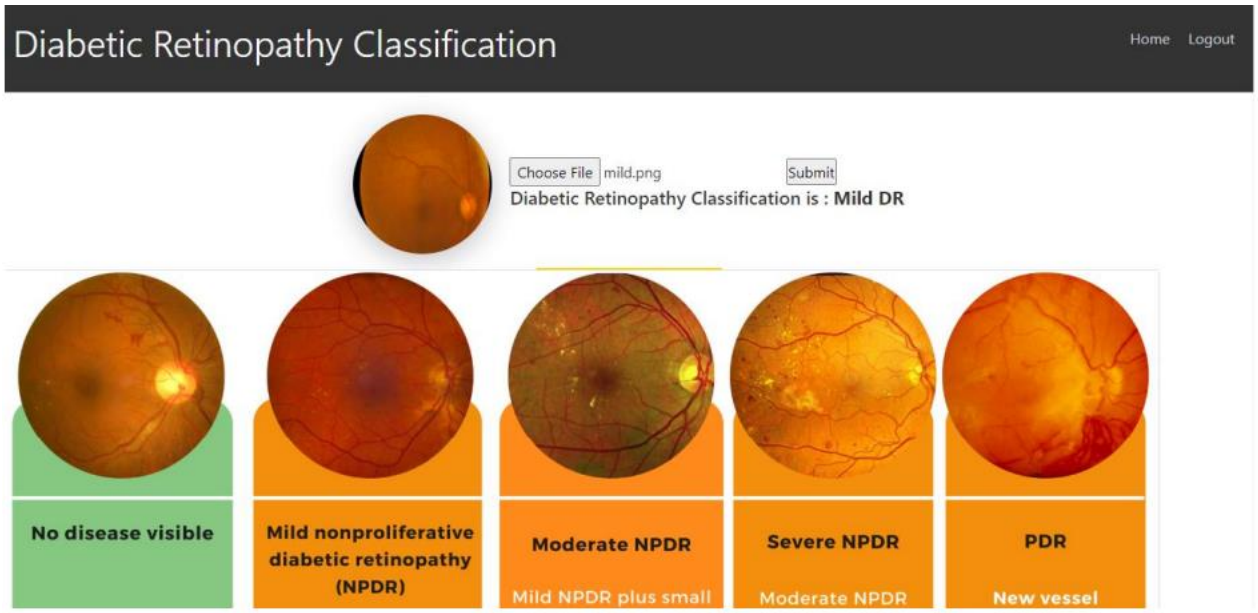
b) Choose an image:



c) Upload the image:



d) Final prediction output:



GITHUB LINK:

https://github.com/IBM-EPBL/IBM-Project-23287-1659877068/tree/main/Final%20Deliverables/Final%20Code

DEMO LINK:

https://drive.google.com/file/d/11-DbF4C6-vOdzm3qRK5MFcp4Z5vKOJBF/view?usp=sharing