PROJECT DOCUMENTATION

Deep Learning Fundus Image Analysis for Early Detection of Diabetic Retinopathy

Team Id:- PNT2022TMID03873

Submitted By:-

Jeevitha N- 412519104051 - Team Lead

Karthika J – 412419104057

Keerthana R - 412519104061

Keerthana S - 412519104062

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

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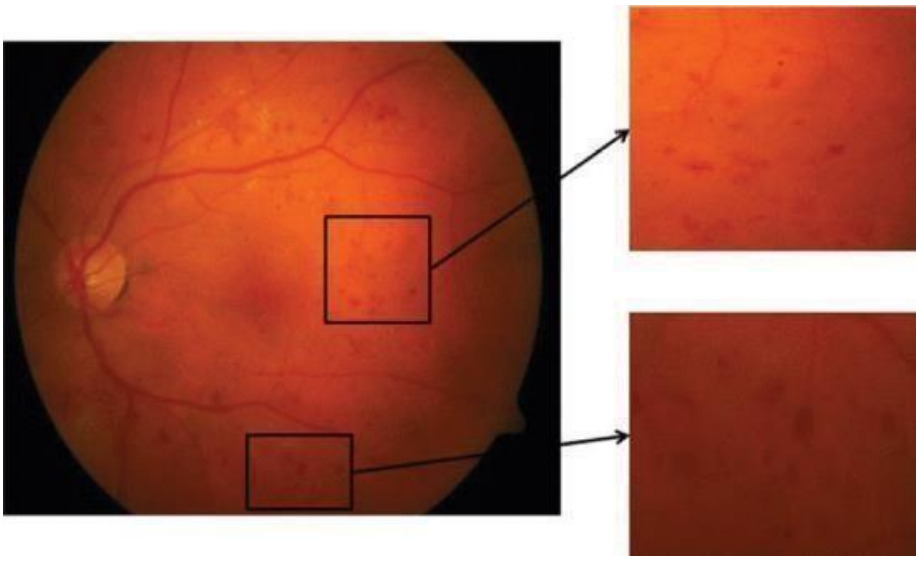
DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

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/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 (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 sudden vision can be common symptoms of diabetic retinopathy .



DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION 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

of kernel and kernel size of convolution layer are determined by using the genetic algorithm. The proposed methodology is tested on publicly available 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:-

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 current grade 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 to be more difficult, particularly in the early stages of the disease when disease features are less prominent in the images. Machine learning-based medical image analysis has 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, non referable, 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 paperalso assesses research gaps in the area of DR detection/classification and addresses various challenges that need further study and investigation.

REFERENCES:-

[1] Johari, Mohamad; Hassan, Hiron; Yassin, Ahmad; Tahir, Noorita; Azlee Zabidi; Rizman, Zairi; Baharom, R.; and Wahab, N.Utilizing a deep learning neural network for the early detection of diabetic retinopathy.United Arab Emirates International Journal of Engineering and Technology7.198 10.14419/ijet.v7i4.11.20804

[2] Convolutional Neural Networks for Diabetic Retinopathy, by Harry Pratta, Frans Coenenb, Deborah M Broadbent, Simon P Hardinga, and Yalin Zhenga (2016). https://doi.org/10.1016/j.procs.2016.07.014.

[3] M. Shaban, Z. Ogur, A. Mahmoud, A. Switala, A. Shalaby, and H. Abu Khalifeh, among others2020) A convolutional neural network for diabetic retinopathy screening and staging.

[4] PLoS ONE 15:e0233514.https://doi.org/10.1371/journal.[4] Ayala, A.; pone.0233514T. Ortiz Figueroa;B. Fernandes;Deep Learning Improved Diabetic Retinopathy Detection, Cruz, F.Appl.Sci.2021, 11, 11970.Doi: https://doi.org/10.3390/app11241197

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.

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

WHY ? Diabetes-related retinopathy is brought on by high blood sugar levels harming the eye's iris. which could result in a permanent loss of vision.

WHEN ? Early on, the DR has no symptoms, but later on, the vessels may start to leak a tiny amount of blood into your retina..

WHERE ? Blurred vision, Distorted vision will occur.

WHO? It is common among the Diabetic patients.

HOW ? The manual early detection of this DR is a challenging task

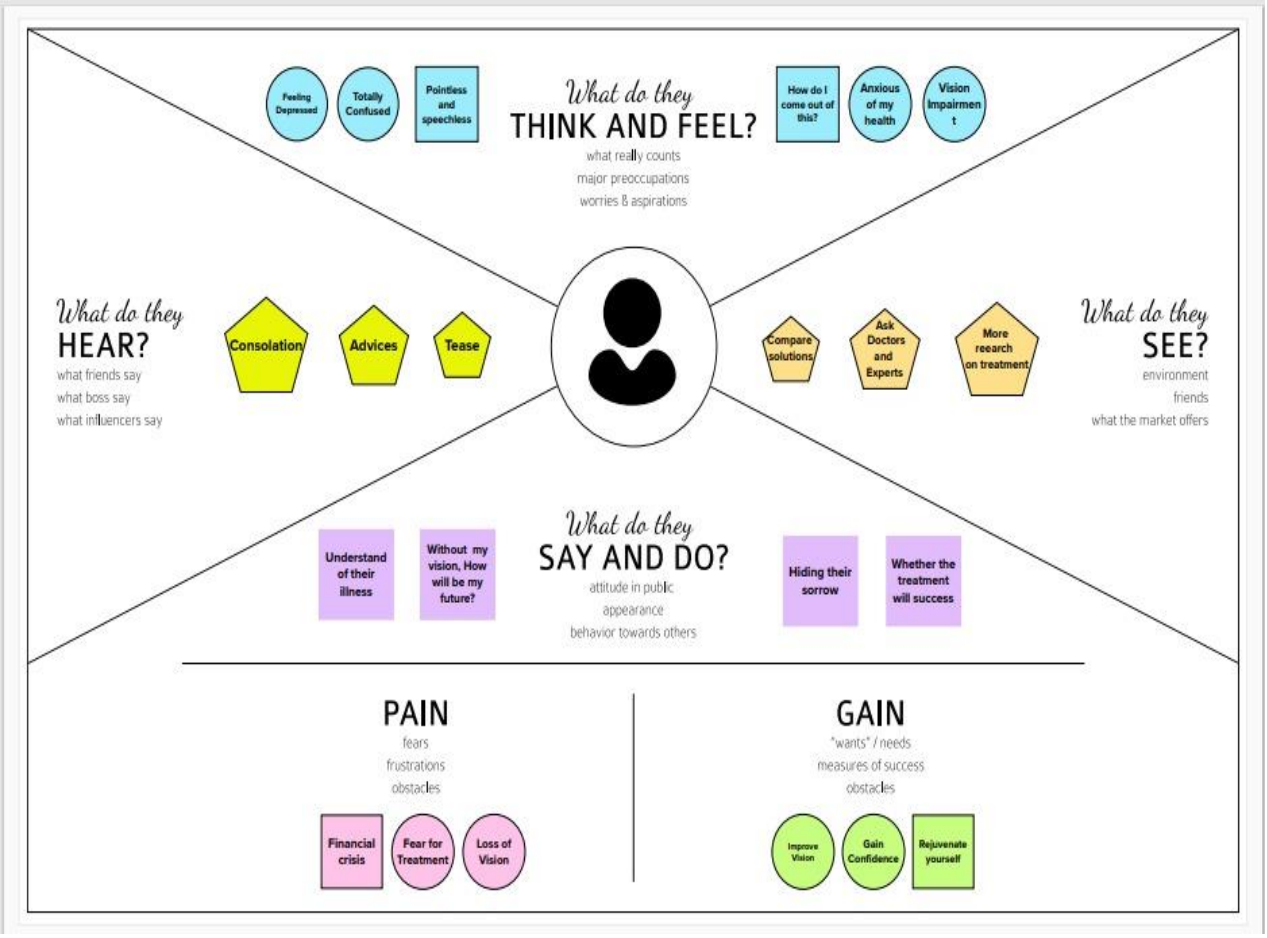
DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

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 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.

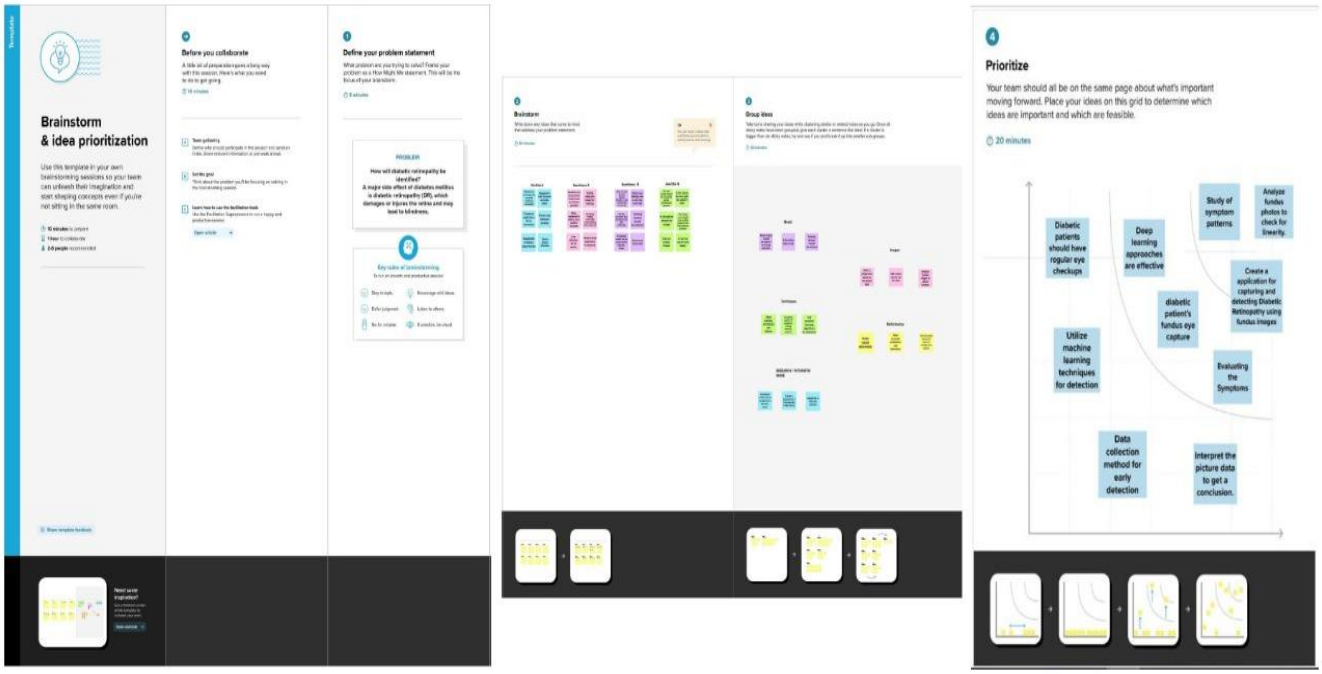
3. IDEATION PHASE & PROPOSED SOLUTION :

3.1Empathy Map Canvas :



DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

3.1 IDEATION AND BRAINSTORMING:-



3.3PROPOSED SOLUTION:-

S. No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	Analyzing a fundus image can help identify diabetic retinal disease early. ● Analyze the levelof DR ● To detect whether DR is presentor not

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

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 there is 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 very successful and lead to improved performance.

4.	Social Impact / Customer Satisfaction	People who lose their vision could actually benefit from this and live. Early analysis and detection of DR is crucial for minimizing social impact because it can help patients keep their vision.
5.	Business Model (Revenue Model)	▪ Doctors can analyze and identify DR using this model, which functions as a service model for public hospitals and a business model for private hospitals. ▪ Even exporting it to other nations who require it can work as a business strategy.
6.	Scalability of the Solution	There are increasingly more approaches to scale the solution so that the model is simple to combine with emerging technologies.

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

3.2 PROPOSED SOLUTION FIT

Project Title: Deep Learning Fundus Image Analysis For Early Detection of Diabetic retinopathy

Project Design Phase-I - Solution Fit Template

Team ID: PNT2022TMID03873

Define CS, fit into CC

1.CUSTOMER SEGMENT

People who have diabetes must have their diabetic retinopathy evaluated. The evaluation of the diabetic patient's eye will be based on the fundus or retinal pictures. For the earliest possible detection of diabetic retinopathy, this initiative will benefit diabetic patients the most.

6.CUSTOMER CONSTRAINT

Patients with diabetes do not recognise these dangerous diseases because they are unaware of the problems associated with diabetes. Since diabetic retinopathy doesn't have any distinctive symptoms other than blurred vision, many people will overlook the condition and its harmful effects.

5.AVAILABLE SOLUTIONS

The severity of the condition determines the appropriate therapies. The majority of treatments aim to halt or delay the growth of diabetic retinopathy. There are numerous treatments for diabetic retinopathy, including vitrectomy, photocoagulation, panretinal photocoagulation, and ocular injections with medicines. The best treatment for the development of new blood vessels.

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

2. JOBS-TO-BE-DONE / PROBLEMS

One of the significant side effects of diabetes is diabetic retinopathy; early diagnosis of the condition will aid in the patient's successful recovery. advising diabetic patients to avoid consuming

9.PROBLEM ROOT CAUSE

The main factor for diabetic retinopathy is excessive blood sugar levels brought on by diabetics. People's failure to recognise their sickness, which results in a negative reaction, is one of the primary causes of diabetic retinopathy. Through this project, they will be able to identify and treat .

7.BEHAVIOUR

Diabetes-related high blood sugar levels are the main cause of diabetic retinopathy. One of the main reasons of diabetic retinopathy is people's failure to recognise their illness, which generates a negative reaction. They will be able to detect diabetic retinopathy early on when it is still curable thanks to this project.

Identify strong TR & EM

3.TRIGGERS TR

Although diabetic retinopathy may only cause minor symptoms, it can result in blindness.

It may result in blurred or fluctuating vision.

The patient can also see some spots or strings floating on the vision

These triggers will trigger the patient to check their eyes.

4.EMOTIONS: BEFORE/AFTER EM

Prior: Their vision will be hazy and they will be concerned about it.
When they check the fundus image using deep learning fundus image analysis for the early identification of diabetic retinopathy, they would feel relieved that they made the proper decision.
The patient will feel optimistic that their.

10. YOUR SOLUTION SL

Our recommendation is that diabetes individuals be aware of the consequences of their condition and regularly check on it.

Additional assistance will come from the DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY.

Detecting diabetic retinopathy at an early stage when it is still easily treatable

This model will provide them with greater accuracy

8.CHANNELS OF BEHAVIOUR CH

The diabetic patient should monitor their blood pressure and blood sugar levels on a regular basis and work to keep them within normal ranges.
When someone has a vision issue, they should have an eye exam very away.

Patients with diabetes must have their eyes examined at regular intervals. Only then may diabetic retinopathy be identified earlier and treated appropriately.

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 register signing up with Gmail
FR-2	User Confirmation	Reassurance via OTP mail confirmation
FR-3	Describe what the product does	Before you notice any changes in your vision, our project can identify early retinal changes.
FR-4	Focus on user requirements	Reduce the chance of blindness and vision loss in diabetes patients who have retinal complications.
FR-5	Usually defined by the user	A patient's fundus image was obtained.
FR-6	Define product features	A cutting-edge technique for eye screening that allows for the early detection of diseases related to the eyes.

Non-functionalRequirements:

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

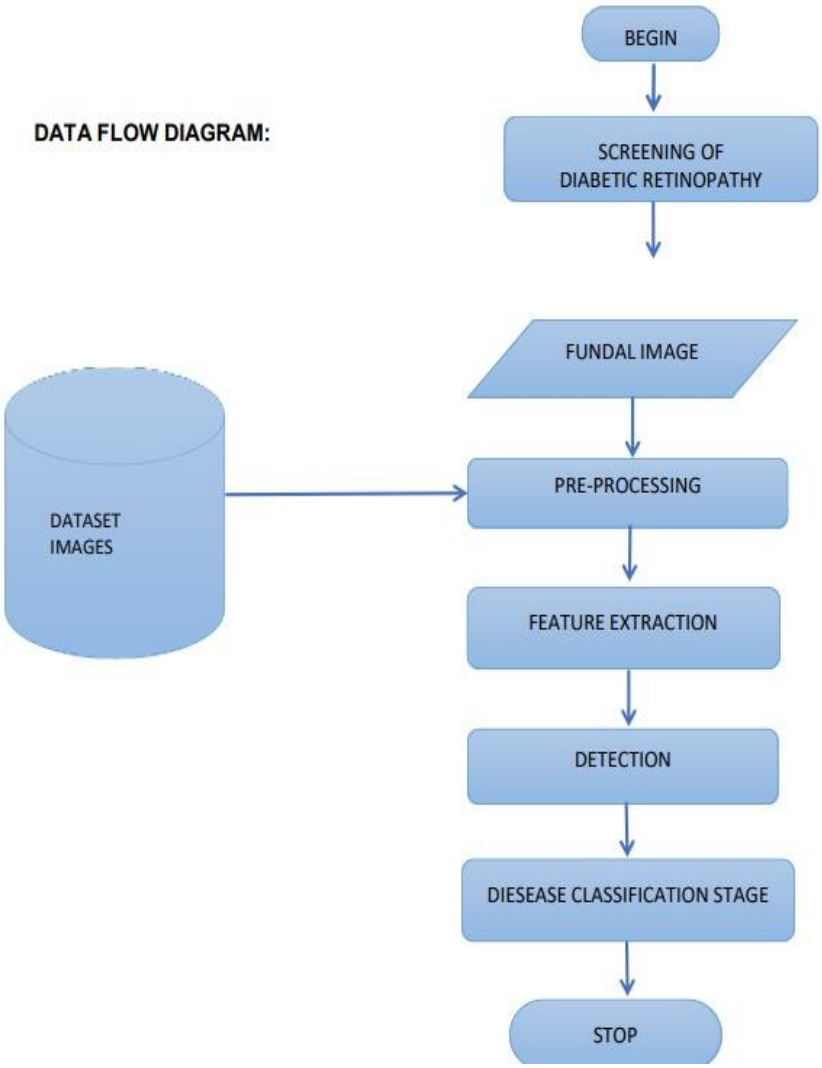
FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	Confirming that a piece of software can successfully carry out one or more specific tasks.
NFR-2	**Security**	Only the system administrator may grant permission.
NFR-3	**Reliability**	Even though the system has the ability to roll back to its original state if a system update fails or there are bugs in the code.
NFR-4	**Performance**	The loading of an image just takes twoseconds. The model's performance is intended to provide patients with quick results.

NFR-5	**Availability**	The gadget facilitates access, cost, and quality of healthcare.
NFR-6	**Scalability**	Even when several users are utilizing the product simultaneously, it must remain reliable.

5.PROJECT DESIGN:-

5.1 DATA FLOW DIAGRAM:-

Data Flow Diagrams:



DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

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, what modifies the data, and where information is kept.

- Diabetic retinopathy diseases frequently detected and examined using retinal fundus Pre-processing of raw retinal fundus images is performed using extraction of the greenchannel, histogram equalization, image enhancement and resizing techniques.
- One of the main tasks in retinal image processing is the segmentation of the retinal vasculaturefrom images of the eye fundus.
- By omitting the optic disc (OD) region of the retina, the computer-assisted automatic recognitionand segmentation of blood vessels.
- Mathematical binary morphological techniques are used to identify the retinal 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 earlydetection of eye-related disorders

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

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5.2 TECHNOLOGYARCHITECTURE:-

Project Design Phase-II
Technology Stack (Architecture & Stack)

Date	10 October 2022
Team ID	PNT2022TMID03873
Project Name	Deep Learning Fundus Image Analysis for Early Detection of Diabetic Retinopathy
Maximum Marks	4 Marks

Technical Architecture:

Project will fulfill the following information in this technology architecture.

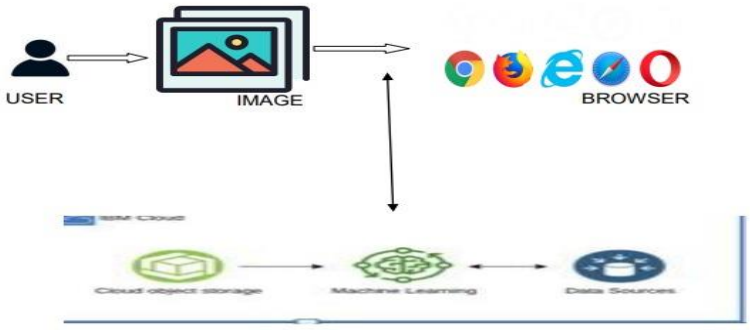


Table-1:Components& Technologies:

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 Block Storage, 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 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 Cookie Secure
3.	Scalable Architecture	Micro-Services	Micro Web Application Framework By 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 emailaddress or a phone number and password.	I can create myaccount.	High	Sprint-3
	Login	USN-2	With the provided Login credentials, I can access the website as a user.	I can log in and access my account .	High	Sprint-3
	Upload image	USN-3	I can post my data as a user in format like pdf and doc.	I can upload mydata.	Mediun	Sprint-3
Administration (Web developer)	Admin Login	USN-4	I can log in to the website as the admin and analyze the user information .	I can log in and analyze the user data.	High	Sprint-3
	Data collection	USN-5	I can gather the datasetfor the DR from the sourceas an admin.	I can collect the dataset.	Low	Sprint-1
	Create model	USN-6	I can build the modeland train it using the dataset as an administrator to make predictions.	I can create and train the model	High	Sprint-1
	Test the model	USN-7	I can evaluatethe model's predictive abilities as an admin.	I can test the model.	High	Sprint-2
Patient (Web user)	Diagnosis	USN-8	I can access the application's diagnosis results asa user and continuewith treatments..	He/shecanget 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	Registration	USN-1	As a user, I can register for the application by entering my email or phone number and password, and confirming my password.	10	High	Jeevitha N Keerthana R
Sprint -1	Dashboard	USN-2	As a user, I will Redirect to the dashboard after registration which shows the importance of DR.	10	Mediun	Jeevitha N Keerthana R
Sprint -2	Login	USN-3	As a user, I can log into the application byentering Login credentials.	5	High	Jeevitha N Keerthana R
Sprint -2	Upload Images	USN-4	As a user, I should be able to upload the image of eyeRetina.	10	High	Karthika J Keerthana S

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

Sprint-2	Dashboard	USN-5	As a user, basedon my requirement I cannavigate through the dashboard.	5	Medium	Karthika J Keerthana S
Sprint-3	Train the model	Task 1	As a developer, the dataset will be uploadedand trained by developed algorithm.	20	High	Karthika J Keerthana S
Sprint-4	Testing& Evaluation	Task 2	As a developer, we tested the trained model using the provided dataset andmodelwill be evaluated for accurate results.	10	High	Karthika J Keerthana S
Sprint-4	Display predicted result	USN-6	As a user, I can viewthe predicted resultinthe dashboard.	10	High	Jeevitha N Keerthana R

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	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

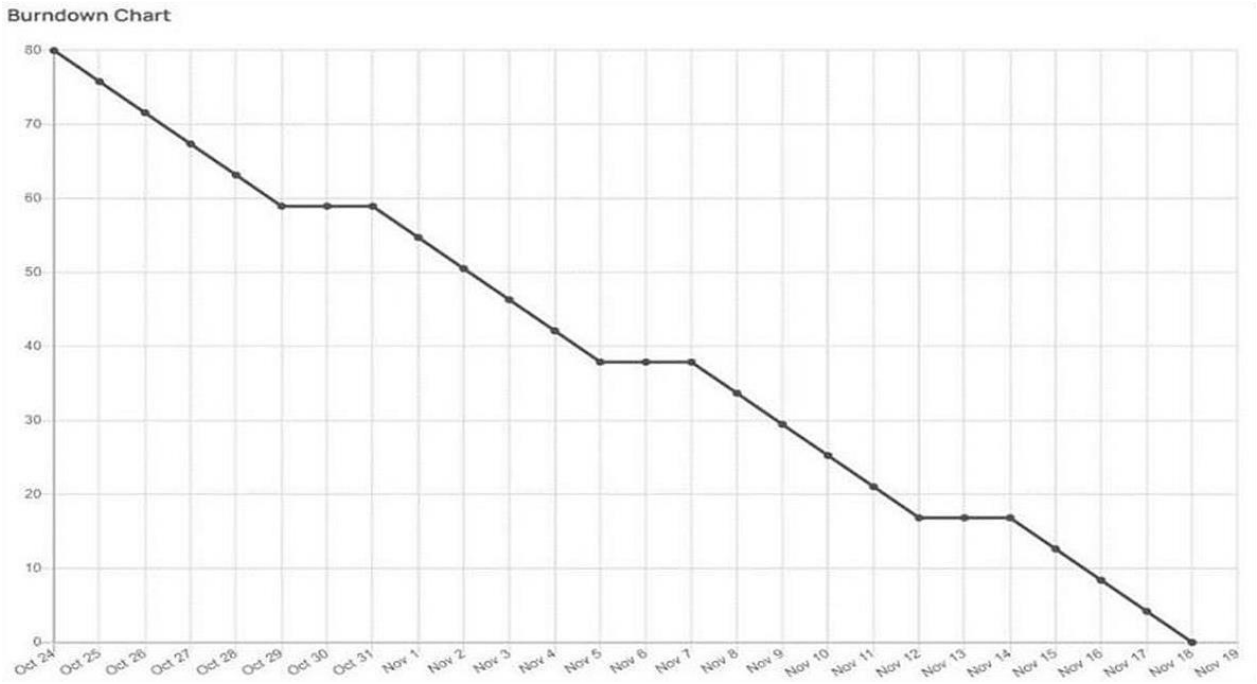
Velocity:

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 per day).

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

AV=20/6=3.33points per day.

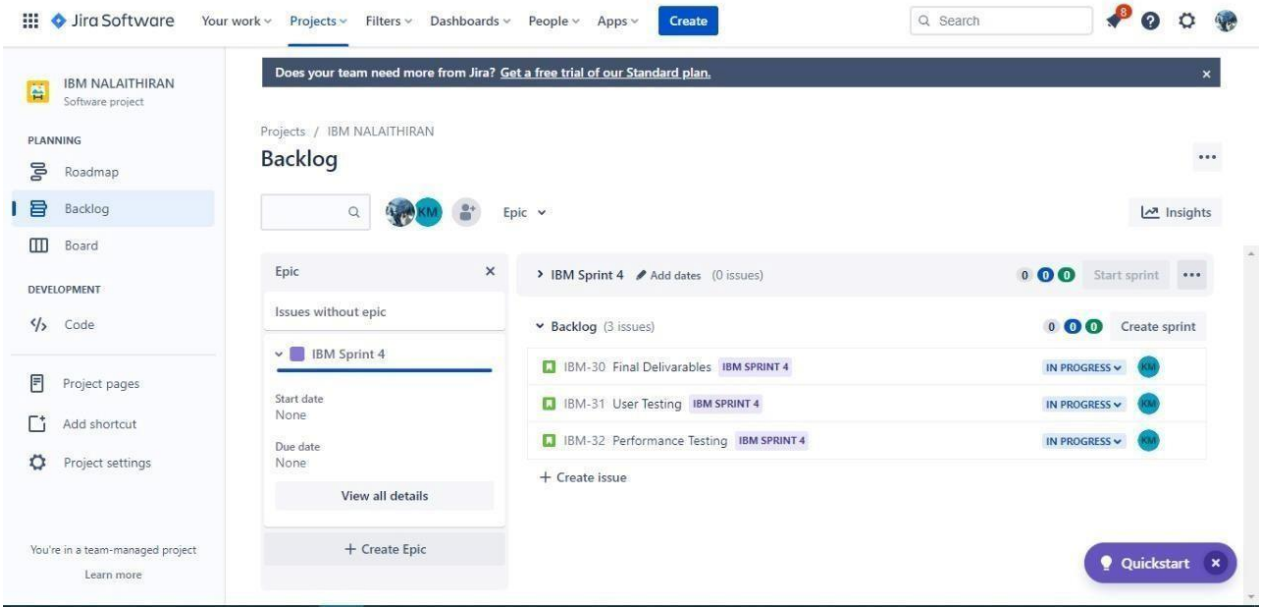
6.2 Burn Down Chart & JIRA :

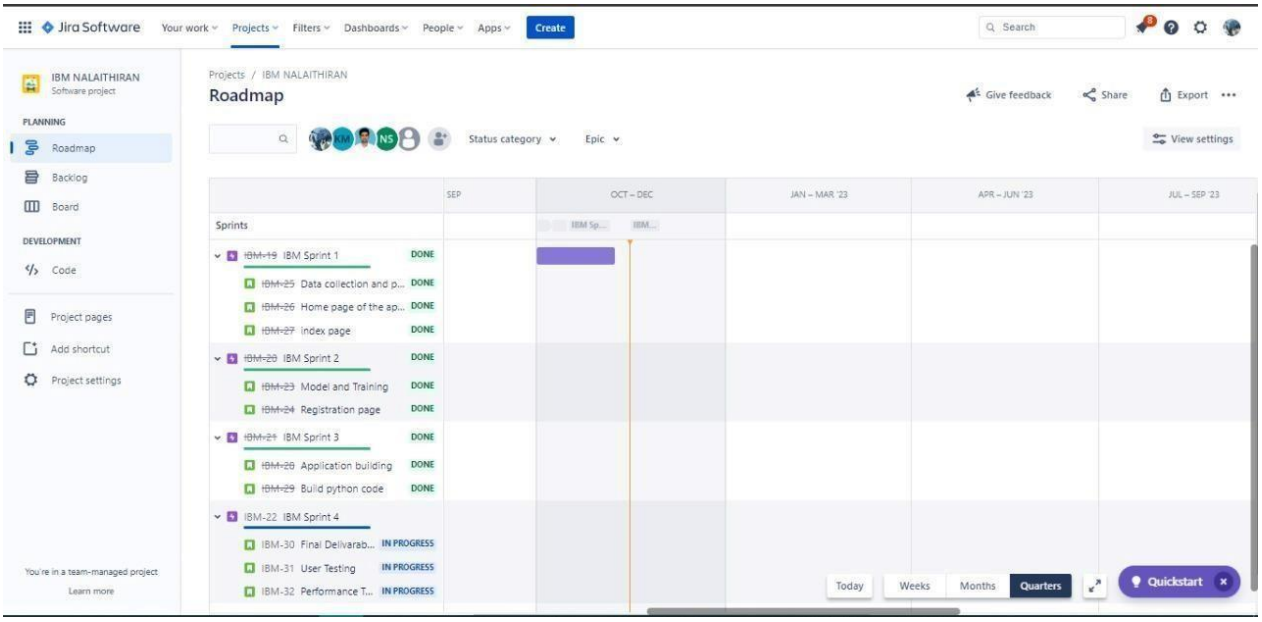


A burn down chart plots the amount of work remaining to perform against the amount of time. In agilesoftware development approaches like Scrum, it is frequently employed. Burn down charts, however,can beused for any project that makes observable progress over time.

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

JIRA SCREENSHOTS:-





JIRA Folder is created to show the Scrum methodologies and Burn Down chart progress.

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

7. CODING AND SOLUTIONING:-

Feature 1:-

We have devloped a website which authenticates users and help them upload and check the seriousness of the diabetics.

Feature 2:-

We have devloped a multilayer deep convolutional nueral network that classifies the 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 and report them on asking for prediction. We have also devloped a messaging service for recieiving message for the type of diabetics.

8. TESTING:-

8.1 TEST CASES:-

8.2 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.

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

Acceptance Testing
UAT Execution & Report Submission

Team ID	PNT2022TMID03873
Project Name	Deep Learning Fundus Image Analysis for Early Detection of Diabetic Retinopathy
Maximum Marks	4 Marks

1. Purpose of Document

The purpose of this document is to briefly explain the test coverage and open issues of the Deep Learning Fundus Image Analysis for Early Detection of Diabetic Retinopathy project at the time of the release to User Acceptance Testing (UAT).

2. DefectAnalysis

Thisreportshowsthenumberofresolvedor closed bugs at each severity level, and how they were resolved

Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Subtotal
By Design	5	4	2	2	13
Duplicate	1	0	2	0	3
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	4	2	1	7
Totals	16	14	13	21	64

3. TestCaseAnalysis

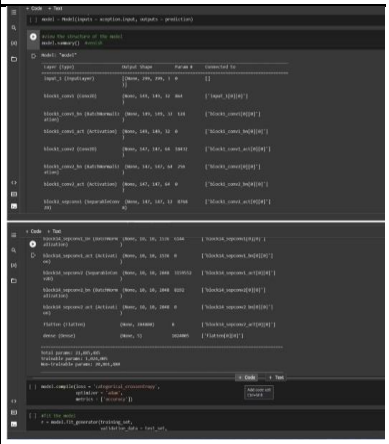
Thisreportshowsthenumberoftestcasesthathavepassed,failed,anduntested

Section	TotalCases	Not Tested	Fail	Pass
PrintEngine	10	0	0	9
ClientApplication	45	0	0	45
Security	2	0	0	2
OutsourceShipping	3	0	0	3
ExceptionReporting	9	0	0	9
FinalReportOutput	4	0	0	4
VersionControl	3	0	0	2

9.RESULTS:-

9.1 \Performance Metrics:-

ModelPerformance Testing:

S. NO	Parameter	Values	Screenshot
1.	Model Summary	**Total params: 21,885,485** **Trainable params: 1,024,005** **Non-trainable params: 20,861,480**	
2.	Accuracy	Training Accuracy – **0.7396** Validation Accuracy – **loss 2.7268**	
3.	Confidence Score(Only Yolo Projects)	Class Detected - Confidence Score -	-- -- -- --

Project team shall fill the following information in model performance testing template.

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 analysis tasks. This is because deep learning algorithms can automatically learn features 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 medical images 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 for medical 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 often there 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 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. FUTURE SCOPE:-

There is a great potential for deep learning in fundus image analysis for early detection of diabetic retinopathy. However, there are 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 learning models are not able to generalize well to real-world data.

13. APPENDIX:-

app.py:-

```
import numpy as np
import os
from tensorflow.keras.models import load_model
from tensorflow.keras.preprocessing import image
from tensorflow.keras.applications.inception_v3 import preprocess_input
from flask import Flask, request,flash, render_template, redirect,url_for
from cloudant.client import Cloudant
from twilio.rest import Client
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'))
# default home 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":
        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 already a member , please login using your details ")
    else:
        return render_template('register.html')


@ app.route('/login', methods=['GET','POST'])
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')
```

```
@ 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 present
        basepath = 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 to array
        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 Diabetic Retinopathy ', ' 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)

        ''' Change the value of 'from' with the number
        received 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()
```

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

cloud.ipynb:-

```
from cloudant.client import Cloudant
client=Cloudant.iam('655489f8-18d0-4a44-a701-5de60570a973-
bluemix','Jc4eF6CXk72w0wGCsM_KUuXKVjsCcT4a54UKBXckK5Bv',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" />
   <!-- 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/TYkiZhlZB6+fzT"
    crossorigin="anonymous"
   />
   <!-- JavaScript Bundle with 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>
   <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 collapse w-100 order-3 dual-collapse2" id="navbarNav">
        <ul class="navbar-nav mr-auto text-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 diabetes complication that affects eyes. It's caused by damage to the blood vessels of the light-sensitive tissue at the back of the eye (retina).
          At first, diabetic retinopathy might cause no symptoms or only mild vision problems. But it can lead to blindness.
          The condition can develop in anyone who has type 1 or type 2 diabetes. The longer you have diabetes and the less controlled your blood sugar is, the more likely you are to develop this eye complication.</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:-

```
<!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/TYkiZhlZB6+fzT"
      crossorigin="anonymous"
    />
    <!-- JavaScript Bundle with 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>
  <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 collapse w-100 order-3 dual-collapse2" id="navbarNav">
        <ul class="navbar-nav mr-auto text-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" 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.lordicon.com/elkhjhci.json"
              trigger="hover"
              style="width:200px;height: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="Enter
Password">
          </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

```
<!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/TYkiZhlZB6+fzT"
   crossorigin="anonymous"
  />
  <!-- JavaScript Bundle with 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>
  <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 collapse w-100 order-3 dual-collapse2" id="navbarNav">
      <ul class="navbar-nav mr-auto text-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>
    <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:-

```
<!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/TYkiZhlZB6+fzT"
crossorigin="anonymous"/>
 <!-- JavaScript Bundle with 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>
```

```
 <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 collapse w-100 order-3 dual-collapse2" id="navbarNav">
   <ul class="navbar-nav mr-auto text-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-controlform-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" >
    <img src="static/level.png" style="width: 90%">
```

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

register.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/TYkiZhlZB6+fzT"
      crossorigin="anonymous"
    />
    <!-- JavaScript Bundle with 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>
    <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>
        <a class="navbar-brand" href="#" style="color:aliceblue">Registration</a>
        </div>
        <div class="navbar-collapse collapse w-100 order-3 dual-collapse2" id="navbarNav">
          <ul class="navbar-nav mr-auto text-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-flex justify-content-center"><script src="https://cdn.lordicon.com/xdjxvujz.js"></script>
        <lord-icon
          src="https://cdn.lordicon.com/elkhjhci.json"
          trigger="hover"
          style="width:200px;height: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">
            <input type="password" class="form-control" id="exampleInputPassword1" name="pass" placeholder="Enter
Password">
          </div>
          <div class="mb-3">
          <button type="submit form-control" class="btn btn-dark btn-primary" style="width:100%;">Register</button>
        </div>
                          <div class="mb-3 d-flex justify-content-center">
                          <a href="login" class="nav-link"> Already Registered: Login Here</a>
    </div>
    {{pred}}
    </div>
   </form>
  </body>
</html> -->
```

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

Python Notebook screenshots:-

```
In [ ]: pip install -q kaggle

In [ ]: mkdir ~/.kaggle

mkdir: cannot create directory '/root/.kaggle': File exists

In [ ]: cp kaggle.json ~/.kaggle/

In [ ]: !chmod 600 ~/.kaggle/kaggle.json

In [ ]: !kaggle datasets download -d arbethi/diabetic-retinopathy-level-detection

Downloading diabetic-retinopathy-level-detection.zip to /content
100% 9.65G/9.66G [01:17<00:00, 186MB/s]
100% 9.66G/9.66G [01:17<00:00, 133MB/s]

In [ ]: !unzip diabetic-retinopathy-level-detection.zip

Archive:  diabetic-retinopathy-level-detection.zip
  inflating: inception-diabetic.h5
  inflating: preprocessed dataset/preprocessed dataset/testing/0/cfb17a7cc8d4.png
  inflating: preprocessed dataset/preprocessed dataset/testing/0/cfdbaef73a8b.png
  inflating: preprocessed dataset/preprocessed dataset/testing/0/cfed7c1172ec.png
  inflating: preprocessed dataset/preprocessed dataset/testing/0/cff262ed8f4c.png
  inflating: preprocessed dataset/preprocessed dataset/testing/0/cffc50047828.png
  inflating: preprocessed dataset/preprocessed dataset/testing/0/d02b79fc3200.png
  inflating: preprocessed dataset/preprocessed dataset/testing/0/d0926ed2c8e5.png
  inflating: preprocessed dataset/preprocessed dataset/testing/0/d160ebef4117.png
  inflating: preprocessed dataset/preprocessed dataset/testing/0/d16e39b9d6f0.png
```

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

```
inflating: preprocessed dataset/preprocessed dataset/training/4/ebe0175e530c.png
inflating: preprocessed dataset/preprocessed dataset/training/4/ed246ae1ed08.png
inflating: preprocessed dataset/preprocessed dataset/training/4/ed3a0fc5b546.png
inflating: preprocessed dataset/preprocessed dataset/training/4/ee1ec90b980f.png
inflating: preprocessed dataset/preprocessed dataset/training/4/ef26625121b3.png
inflating: preprocessed dataset/preprocessed dataset/training/4/f0098e9d4aee.png
inflating: preprocessed dataset/preprocessed dataset/training/4/f025f33b2c9b.png
inflating: preprocessed dataset/preprocessed dataset/training/4/f03d3c4ce7fb.png
inflating: preprocessed dataset/preprocessed dataset/training/4/f0f89314e860.png
inflating: preprocessed dataset/preprocessed dataset/training/4/f1dc26c4bfa3.png
inflating: preprocessed dataset/preprocessed dataset/training/4/f2d2a0c92034.png
inflating: preprocessed dataset/preprocessed dataset/training/4/f549294e12e1.png
inflating: preprocessed dataset/preprocessed dataset/training/4/f58d37d48e42.png
inflating: preprocessed dataset/preprocessed dataset/training/4/f5e6226bd2e0.png
inflating: preprocessed dataset/preprocessed dataset/training/4/f69835dc7c50.png
inflating: preprocessed dataset/preprocessed dataset/training/4/f6f3ea0d2693.png
inflating: preprocessed dataset/preprocessed dataset/training/4/f72adcac5638.png
inflating: preprocessed dataset/preprocessed dataset/training/4/f850cb51fdba.png
inflating: preprocessed dataset/preprocessed dataset/training/4/f8cf7ed8ef00.png
inflating: preprocessed dataset/preprocessed dataset/training/4/fa59221cf464.png
inflating: preprocessed dataset/preprocessed dataset/training/4/fb696a8e055a.png
inflating: preprocessed dataset/preprocessed dataset/training/4/fce93caa4758.png
inflating: preprocessed dataset/preprocessed dataset/training/4/fdd534271f3d.png
inflating: preprocessed dataset/preprocessed dataset/training/4/ff8a0b45c789.png
```

In [ ]:
```
from tensorflow.keras.layers import Dense,Flatten,Input
```

In [ ]:
```
from tensorflow.keras.models import Model
```

In [ ]:
```
from tensorflow.keras.preprocessing import image
```

In [ ]:
```
from tensorflow.keras.preprocessing.image import ImageDataGenerator,load_img
```

In [ ]:
```
from glob import glob
```

In [ ]:
```
import numpy as np
```

In [ ]:
```
import matplotlib.pyplot as plt
```

In [ ]:
```
imageSize=[299,299]
```

In [ ]:
```
trainPath=r"/content/preprocessed dataset/preprocessed dataset/training"
```

In [ ]:
```
testPath=r"/content/preprocessed dataset/preproccessed dataset/testing"
```

In [ ]:
```
train_datagen=ImageDataGenerator(rescale=1./255,shear_range=0.2,zoom_range=0.2,horizontal_flip=True)
```

In [ ]:
```
test_datagen=ImageDataGenerator(rescale=1./255)
```

In [ ]:
```
training_set=train_datagen.flow_from_directory('/content/preprocessed dataset/preprocessed dataset/training',target_size=(299,299),batch_size=
```

```
Found 3662 images belonging to 5 classes.
```

In [ ]:
```
test_set=test_datagen.flow_from_directory('/content/preprocessed dataset/preprocessed dataset/testing',target_size=(299,299),batch_size=32,cla
```

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

```
Found 3662 images belonging to 5 classes.
```

In [ ]:
```
test_set=test_datagen.flow_from_directory('/content/preprocessed dataset/preprocessed dataset/testing',target_size=(299,299),batch_size=32,cla
```

```
Found 734 images belonging to 5 classes.
```

In [ ]:
```
xception=Xception(input_shape=imageSize+[3],weights='imagenet',include_top=False)
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/xception/xception_weights_tf_dim_ordering_tf_kernels_notop.h
5
83683744/83683744 [==============================] - 0s 0us/step
```

In [ ]:
```
for layer in xception.layers:
  layer.trainable=False
```

In [ ]:
```
x=Flatten()(xception.output)
```

In [ ]:
```
prediction=Dense(5,activation='softmax')(x)
```

In [ ]:
```
model=Model(inputs=xception.input,outputs=prediction)
```

In [ ]:
```
model.summary()
```

```
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_1 (InputLayer)        [(None, 299, 299, 3)]     0
```

```
Model: "model"
__________________________________________________________________________________________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================================
 input_1 (InputLayer)           [(None, 299, 299, 3  0           []
                                )]

 block1_conv1 (Conv2D)          (None, 149, 149, 32  864         ['input_1[0][0]']
                                )

 block1_conv1_bn (BatchNormaliz  (None, 149, 149, 32  128        ['block1_conv1[0][0]']
 ation)                         )

 block1_conv1_act (Activation)  (None, 149, 149, 32  0           ['block1_conv1_bn[0][0]']
                                )

 block1_conv2 (Conv2D)          (None, 147, 147, 64  18432       ['block1_conv1_act[0][0]']
                                )

 block1_conv2_bn (BatchNormaliz  (None, 147, 147, 64  256        ['block1_conv2[0][0]']
 ation)                         )

 block1_conv2_act (Activation)  (None, 147, 147, 64  0           ['block1_conv2_bn[0][0]']
                                )

 block2_sepconv1 (SeparableConv  (None, 147, 147, 12  8768       ['block1_conv2_act[0][0]']
 2D)                            8)

 block2_sepconv1_bn (BatchNorma  (None, 147, 147, 12  512        ['block2_sepconv1[0][0]']
 lization)                      8)

 block2_sepconv2_act (Activatio  (None, 147, 147, 12  0           ['block2_sepconv1_bn[0][0]']
 n)                             8)

 block2_sepconv2 (SeparableConv  (None, 147, 147, 12  17536       ['block2_sepconv2_act[0][0]']
 2D)                            8)
```

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

```
Epoch 21/30
3/3 [==============================] - 43s 13s/step - loss: 3.4297 - accuracy: 0.6771
Epoch 22/30
3/3 [==============================] - 43s 13s/step - loss: 5.0327 - accuracy: 0.6979
Epoch 23/30
3/3 [==============================] - 37s 14s/step - loss: 5.6452 - accuracy: 0.6026
Epoch 24/30
3/3 [==============================] - 44s 14s/step - loss: 5.8190 - accuracy: 0.6562
Epoch 25/30
3/3 [==============================] - 43s 13s/step - loss: 3.5427 - accuracy: 0.6979
Epoch 26/30
3/3 [==============================] - 43s 13s/step - loss: 3.7831 - accuracy: 0.7083
Epoch 27/30
3/3 [==============================] - 50s 16s/step - loss: 3.7079 - accuracy: 0.6250
Epoch 28/30
3/3 [==============================] - 42s 13s/step - loss: 2.3158 - accuracy: 0.7292
Epoch 29/30
3/3 [==============================] - 46s 13s/step - loss: 5.2872 - accuracy: 0.6979
Epoch 30/30
3/3 [==============================] - 43s 13s/step - loss: 3.2610 - accuracy: 0.7917
```

In [ ]:
```
model.save('Updated-Xception-diabetic-retinopathy.h5')
```

```
 alization)                  )

 block14_sepconv2_act (Activati  (None, 10, 10, 2048  0          ['block14_sepconv2_bn[0][0]']
 on)                         )

 flatten (Flatten)           (None, 204800)       0           ['block14_sepconv2_act[0][0]']

 dense (Dense)               (None, 5)            1024005     ['flatten[0][0]']

==================================================================================================
Total params: 21,885,485
Trainable params: 1,024,005
Non-trainable params: 20,861,480
__________________________________________________________________________________________________
```

In [ ]:
```
model.compile(loss='categorical_crossentropy',optimizer='adam',metrics=['accuracy'])
```

In [ ]:
```
r=model.fit_generator(training_set,validation_data=test_set,epochs=30,steps_per_epoch=len(training_set)//32,validation_steps=len(test_set)//32
```

```
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:1: UserWarning: `Model.fit_generator` is deprecated and will be removed in a futur
e version. Please use `Model.fit`, which supports generators.
  """Entry point for launching an IPython kernel.
Epoch 1/30
3/3 [==============================] - 52s 15s/step - loss: 10.3196 - accuracy: 0.2396
Epoch 2/30
3/3 [==============================] - 44s 13s/step - loss: 16.3913 - accuracy: 0.4896
Epoch 3/30
3/3 [==============================] - 43s 13s/step - loss: 5.7194 - accuracy: 0.5521
Epoch 4/30
3/3 [==============================] - 45s 13s/step - loss: 6.0489 - accuracy: 0.5104
Epoch 5/30
3/3 [==============================] - 35s 9s/step - loss: 2.6817 - accuracy: 0.5897
Epoch 6/30
3/3 [==============================] - 45s 14s/step - loss: 5.3608 - accuracy: 0.5833
Epoch 7/30
```

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

GITHUB LINK:- IBM-EPBL/IBM-Project-25488-1659965904: Deep Learning Fundus Image Analysis for Early Detection of Diabetic Retinopathy (github.com)

DEMO LINK:-

https://github.com/IBM-EPBL/IBM-Project-25488-1659965904/tree/main/Project/Final%20Deliverables/Demonstration%20Video

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY