PROJECT DOCUMENTATION

Deep Learning Fundus Image Analysis for Early Detection of Diabetic Retinopathy

Team Id:-PNT2022TMID41310

Submitted By:

Kalai selvi –(team lead)

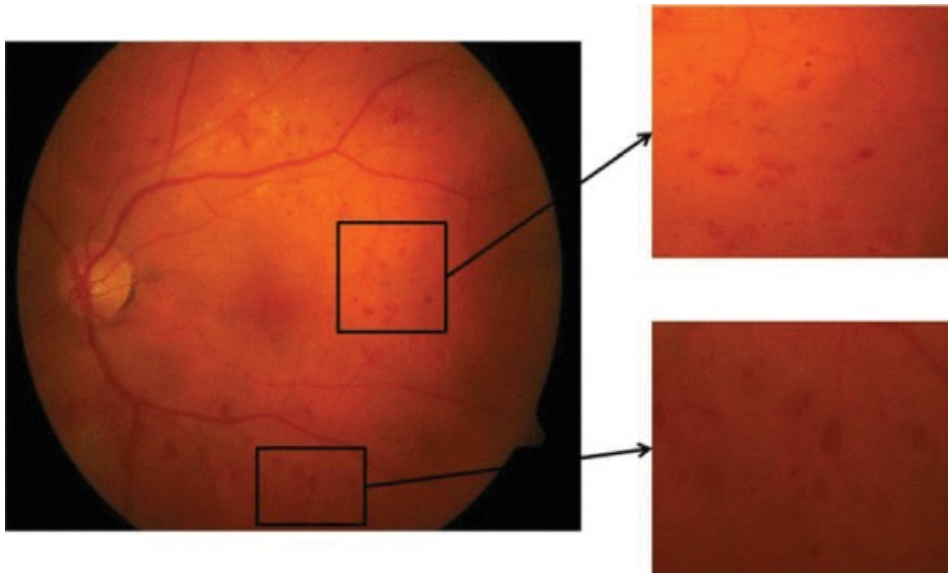
DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

Table of Contents:-

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 .



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 Messidor 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

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

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, nonreferable, and proliferative classifications of Diabetic Retinopathy are reviewed and summarized. Moreover, the paper discusses the available retinal fundus datasets for Diabetic Retinopathy that are used for tasks such as detection, classification, and segmentation. The paper also assesses research gaps in the area of DR detection/classification and addresses various challenges that need further study and investigation.

REFERENCES:-

Survey 1 :
AUTHORS: Mohammad Z. Atwany ,Abdulwahab H. Sahyoun , And Mohammad Yaqub (March 22).
TITLE: 'Deep Learning Techniques for Diabetic Retinopathy Classification: A Survey.' **METHODS:** This paper reviews and analyzes state-of- theart deep learning methods in supervised, self-supervised, and Vision Transformer setups, proposing retinal fundus image classification and detection. For instance, referable, nonreferable, and proliferative classifications of Diabetic Retinopathy are reviewed and summarized. Moreover, the paper discusses the available retinal fundus datasets for Diabetic Retinopathy that are used for tasks such as detection, classification, and segmentation

Survey 2 :
AUTHORS: Mohamad HazimJohari ,Hasliza Abu Hassan , Ahmad Ihsan Mohd Yassin (July 2018).

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

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

Survey 3 :
AUTHOR: Recep Emre Hacisoftaoglu (Dec 2019).
TITLE: 'Deep Learning Frameworks For Diabetic Retinopathy Detection Using Smartphone-Based Retinal Imaging Systems.'
METHODS: In this thesis, we first investigate the smartphone-based portable ophthalmoscope systems available on the market and compare their Field of View and image quality to determine if they are suitable for Diabetic Retinopathy detection during a general health screening. Then, we propose automatic Diabetic Retinopathy detection algorithms for smartphone-based retinal images using deep learning frameworks, AlexNet and GoogLeNet. To test our proposed methods, we generate smartphone-based synthetic retina images by simulating the different Field of View with masking the original image around the optic disk and cropping it.

Survey 4 :
AUTHORS: Lei Lu , Ying Jiang , Ravindran Jaganathan , and Yanli Hao. (Jan 2019). **TITLE:** 'Current Advances in Pharmacotherapy and Technology for Diabetic Retinopathy: A Systematic Review.'
METHODS: Direct injections or intra virtual antiinflammatory and anti angiogenesis agents are widely used pharmacotherapy to effectively treat DR and diabetic macular edema (DME). However, their effectiveness is short term, and the delivery system is often associated with adverse effects, such as cataract and increased intraocular pressure. Further, systemic agents and plants-based drugs have also provided promising treatment in the progression of DR. Recently, advancements in pluripotent stem cells

technology enable restoration of retinal functionalities after transplantation of these cells into animals with retinal degeneration. This review paper summarizes the developments in the current and potential pharmacotherapy and therapeutic technology of DR. Literature search was done on online databases, PubMed, Google Scholar, clinitrials.gov, and browsing through individual ophthalmology journals and leading pharmaceutical company websites.

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.

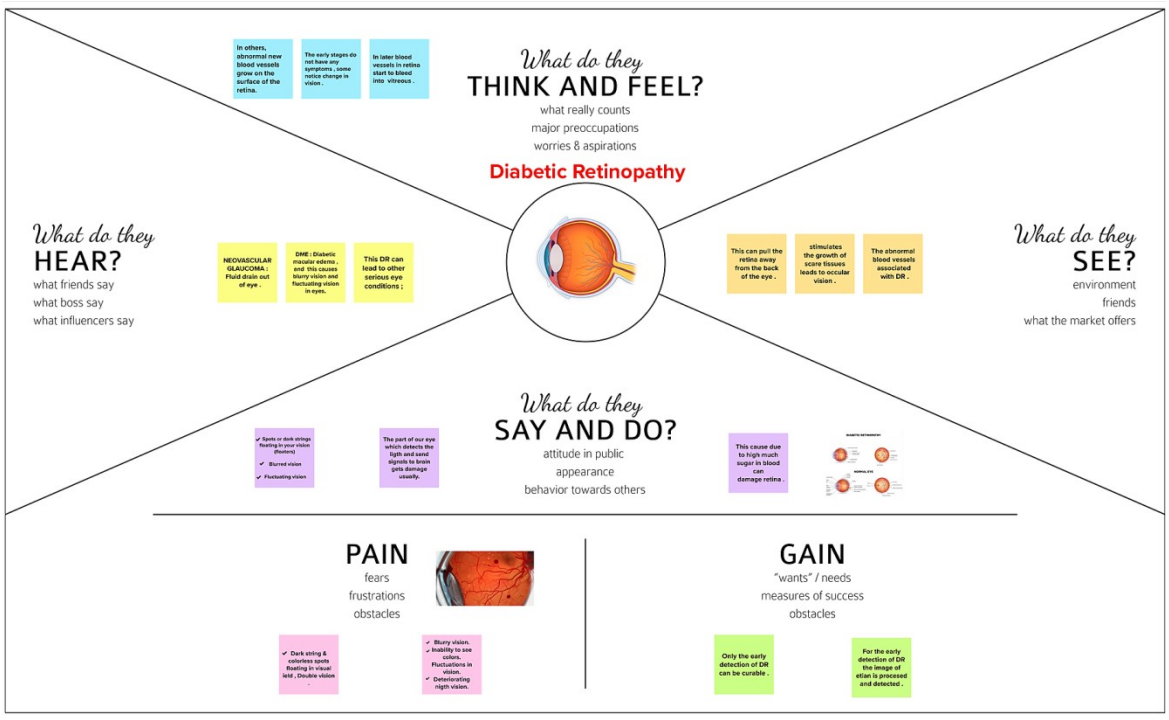
OBJECTIVES :

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.

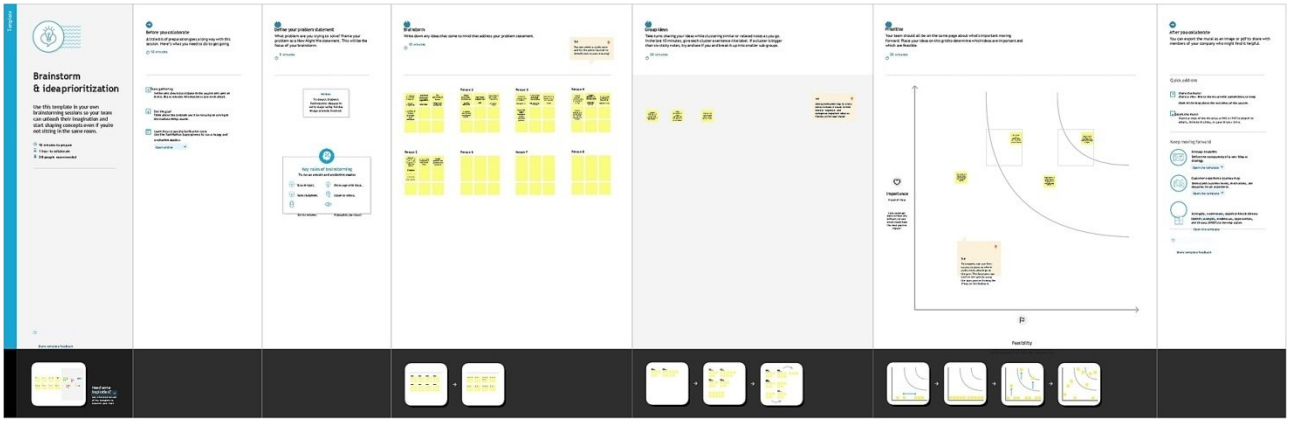
3.IDEATION PHASE & PROPOSED SOLUTION :

3.1 Empathy Map Canvas :



3.2 IDEATION AND BRAINSTORMING:-

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY



3.3 PROPOSED SOLUTION:-

S.No.	Parameter	Description
1.	ProblemStatement (Problemtobesolved)	Analyzing a fundus image can help identifydiabeticretinal diseaseearly. ● AnalyzethelevelofDR ● TodetectwhetherDRispresentornot
2.	Idea/Solutiondescription	1. The goal is to identify diabetic retinopathyfrom the fundus image dataset as soon aspossible,allowingindividualstoproceedwiththenecessarytreatments andavoidtemporaryor permanentvisionloss. 2. We will create a deep learning model (CNN)with high accuracy to detect DR and protectpeople at risk of losing their vision

		becausethereisnocompletecurefo rthisformof DR.
3.	Novelty/Uniqueness	On the basis of the level of DR performed duringanalysis, a class-based classifier will be provided.As part of the work, we'll also test out a transferlearningstrategythathasthepotentialtobevery successfulandleadtoimprovedperformance.

4.	SocialImpact/ CustomerSatisfaction	Peoplewholosetheirvisioncouldactually benefitfromthisandlive.Earlyanalysisanddetection of DR is crucial for minimizing socialimpact because it can help patients keep theirvision.
5.	BusinessModel(RevenueModel)	■ Doctors can analyze and identify DR usingthismodel,whichfunctionsas aservicemodel for public hospitals and a businessmodelfor private hospitals. ■ Evenexportingittoothernationswho requireitcanworkas a businessstrategy.
6.	ScalabilityoftheSolution	Thereareincreasinglymoreapproachesto scalethe solution so that the model is

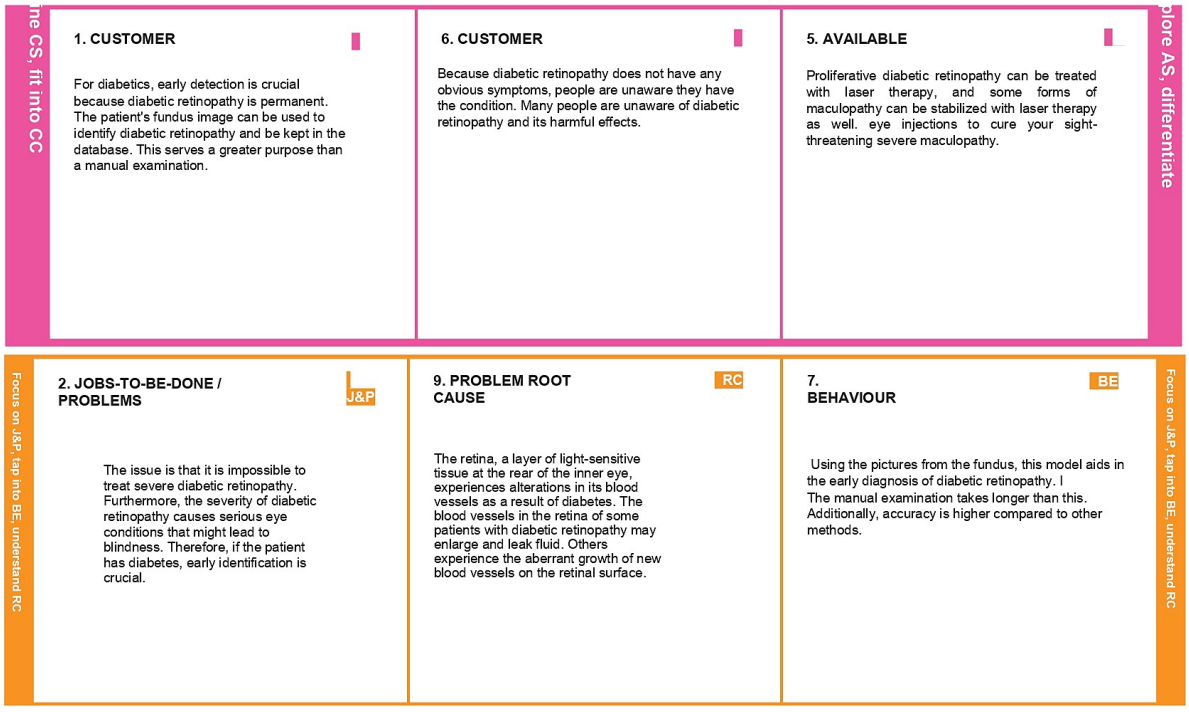
		simple tocombinewithemergingtechnologies.

3.4 PROPOSED SOLUTION FIT

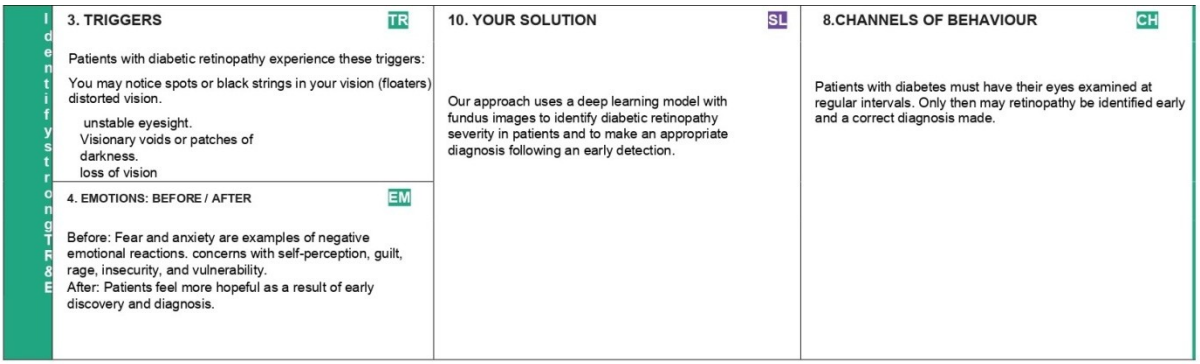
Project Title: Deep Learning Fundus Image Analysis For early detection of Diabetic Retinopathy.

Project Design Phase-I = Problem-Solution Fit Template

Project ID : IBM-Project-18407-1659684768



DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY



4.REQUIREMENT ANALYSIS:-

FunctionalRequirements:

Followingarethefunctional requirementsoftheproposedsolution.

FR No.	FunctionalRequirement(Epic)	SubRequirement(Story/Sub-Task)
FR-1	UserRegistration	Using a phone number to registersigningupwithGmail
FR-2	UserConfirmation	Reassurance via OTP mailconfirmation
FR-3	Describe whattheproductdoes	Before you notice any changes in your vision, our projectcanidentifyearlyretinalchanges.
FR-4	Focusonuserrequirements	Reduce the chance of blindness and vision loss indiabetes patientswhohave retinalcomplications.
FR-5	Usuallydefinedbytheuser	Apatient'sfundusimagewasobtained.
FR-6	Defineproductfeatures	A cutting-edge technique for eye screening that allowsfortheearlydetectionofdiseasesrelatedtothe eyes.

Non-functionalRequirements:

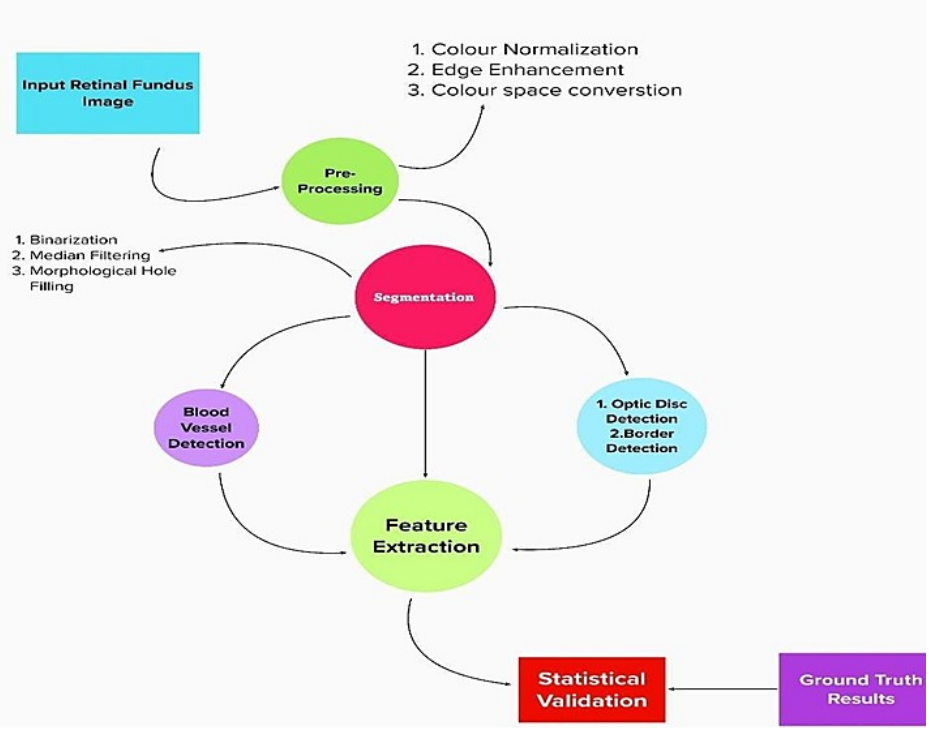
Followingarethe non-functionalrequirementsoftheproposed solution.

FR No.	Non-FunctionalRequirement	Description
NFR-1	**Usability**	Confirming that a piece of software can successfullycarryoutoneormorespecific tasks.
NFR-2	**Security**	Only the system administrator may grantpermission.
NFR-3	**Reliability**	Eventhoughthesystem hasthe abilityto rollback to its original state if a system update fails or thereare bugs in thecode.
NFR-4	**Performance**	Theloadingofanimagejusttakestwoseconds.Themodel'sperformanceisintended toprovidepatientswithquickresults.
NFR-5	**Availability**	The gadget facilitates access, cost, and quality ofhealthcare.
NFR-6	**Scalability**	Even when several users are utilising the productsimultaneously,itmustremainreliable.

5.PROJECT DESIGN:-
5.1 DATA FLOW DIAGRAM:-

DataFlowDiagrams:

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 systemneeds can be graphically represented by a tidy and understandable DFD. It demonstrates how information enters and exits the system, whatmodifiesthe data,and where information iskept.

- Diabeticretinopathydiseaseisfrequently detectedandexaminedusingretinalfundus Pre-processing of raw retinal fundus images isperformedusing extraction of thegreenchannel,histogramequalization,imageenhancement,andresizi ngtechniques.
- Oneofthemaintasksinretinalimageprocessingis thesegmentationofthe retinalvasculaturefrom images oftheeyefundus.
- Byomittingtheopticdisc(OD)regionoftheretina,thecomputer-assistedautomaticrecognitionandsegmentationofbloodvessels.
- Mathematicalbinarymorphologicaltechniquesareusedtoidentifytheretinalblood vessels.
- The term "feature extraction from the fundus images for the diagnosis of Diabetic Retinopathy" refers to a sophisticated eye screeningtechniquethatallowsforthe earlydetection ofeye-relateddisorders.

5.2 TECHNOLOGY ARCHITECTURE:-

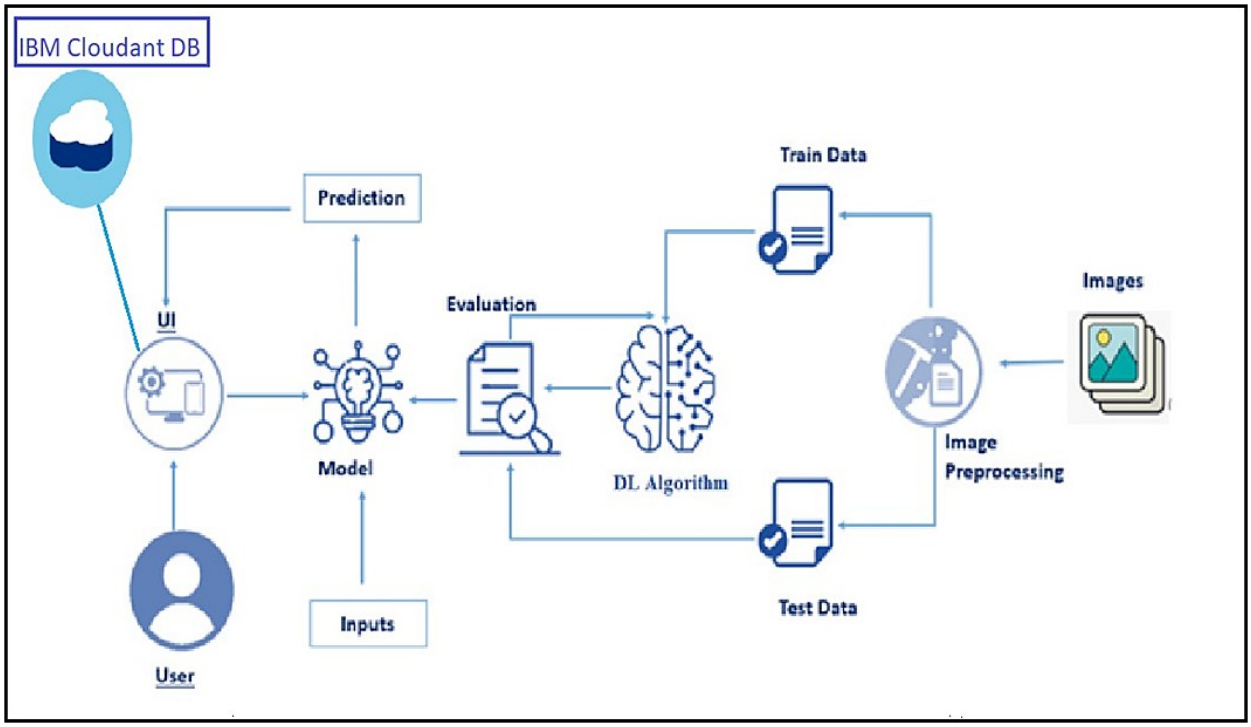


Table-1:Components&Technologies:

1.	UserInterface	WebUI	HTML,CSS,JavaScript,Python
2.	Applicationlogic-1	ImagePreprocessing	Keras,Tensorflow,Numpy
3.	Applicationlogic-2	CNNModel	Keras,Tensorflow,Numpy
4.	Applicationlogic-3	WebUIApplication	Flask
5.	Database	DRImages(Jpeg,Png,Jpg,Etc.,)	UploadsFolder
6.	File storage	File Storage Requirements(OnlyIfNecessary)	IBMBlockStorage,GoogleDrive
7.	ExternalApi	Keras	ImageProcessingAPI

8.	Deep LearningModel	InceptionV3Architecture	Pre-Trained Convolution NeuralNetwork Model
9.	Infrastructure (Server)	ApplicationDeploymenton Webserver	Flask-APythonWSGIHTTPServer.

Table-2:Applicationcharacteristics:

S.No	Characteristics	Description	Technology
1.	Open-SourceFrameworks	Flask	FlaskFrameworks
2.	SecurityImplementations	CSRFProtection,SecureFlagForCookies	Flask-WTF, Session CookieSecure
3.	ScalableArchitecture	Micro-Services	Micro Web Application FrameworkByFlask

5.3 USER STORIES:-

UserType	Functional Requirement (Epic)	User Story Number	UserStory/Task	Acceptance criteria	Priority	Release
Patient(Webuser)	Registration	USN-1	I can register as a user on the websitewitheitheranemailaddre	Icancreatemyaccount.	High	Sprint-3

			ssoraphone numberandpassword.			
	Login	USN-2	WiththeprovidedLogincredentials,Icanaccessthewebsiteasauser.	Icanloginandaccessmyaccount.	High	Sprint-3
	Uploadimage	USN-3	Icanpostmydataasauserinformatslikepdfanddoc.	Icanuploadmy data.	Medium	Sprint-3
Administration (Webdeveloper)	AdminLogin	USN-4	Icanlog intothewebsite asthead min and analyze the userinformation.	I can log in andanalyzetheuserdata.	High	Sprint-3
	Datacollection	USN-5	IcangatherthedatasetfortheDRfromthesourceas anadmin.	Icancollectthedataset.	Low	Sprint-1
	Createmodel	USN-6	Icanbuildthemodeland train itusing thedatasetasan administratorto makeprediction s.	Icancreate andtrainthemodel.	High	Sprint-1
	Test themodel	USN-7	Icanevaluate themodel'spredictiveabilitiesasanadmin.	Icantestthemodel.	High	Sprint-2
Patient(Webuser)	Diagnosis	USN-8	Icanaccessthe application'sdiagnosisresultsasauserandcontinuewith treatments..	He/ shecangettheresultsand continue thetreatment.	High	Sprint-2

6.PROJECT PLANNING AND SCHEDULING:-

6.1 SPRINT PLANNING AND ESTIMATION:-

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

Sprint	Functional Requirement(Epic)	UserStoryNumber	UserStory/ Task	Story Points	Priority	TeamMembers
Sprint-1	Registration	USN-1	Asauser,I canregisterforthe application by entering my email or phone numberand password ,and confirming my password.	10	High	NaveenS
Sprint-1	Dashboard	USN-2	Asauser,I willRedirecttothe dashboardafter registration which shows theimportanceofDR.	10	Medium	Sundarakalathi K& SyedAbuthairA
Sprint-2	Login	USN-3	Asauser,I canlogintotheapplication byenteringLogin credentials.	5	High	NaveenS
Sprint-2	UploadImages	USN-4	As a user, I should be able to upload the imageofeyeRetina.	10	High	KarthickM
Sprint-2	Dashboard	USN-5	Asauser,basedonmyrequirementIcannavigatethrough thedashboard.	5	Medium	SyedAbuthairA

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

Sprint-3	Trainthemodel	Task 1	Asadeveloper,thedatasetwillbeuploadedandtrainedbydevelopedalgorithm.	20	High	SundarakalathiK
Sprint-4	Testing&Evaluation	Task 2	As a developer, we tested the trained modelusing the provided dataset andmodel will beevaluatedfor accurateresults.	10	High	NaveenS
Sprint-4	Display predicted result	USN-6	Asauser,Icanviewthepredicteddresultintheadashboard.	10	High	KarthickM

Sprint	**Total story point**	**Duration**	**SprintStartDate**	**SprintEnd Date(Planned)**	**Story Points Completed (as on PlannedEndDate)**	**Sprint ReleaseDate(Actual)**
Sprint-1	20	6 Days	24Oct 2022	29Oct 2022	20	29Oct 2022
Sprint-2	20	6 Days	31Oct 2022	05Nov2022	20	05Nov2022
Sprint-3	20	6 Days	07Nov2022	12Nov2022	20	12Nov2022
Sprint-4	20	6 Days	14Nov2022	19Nov2022	20	19Nov2022

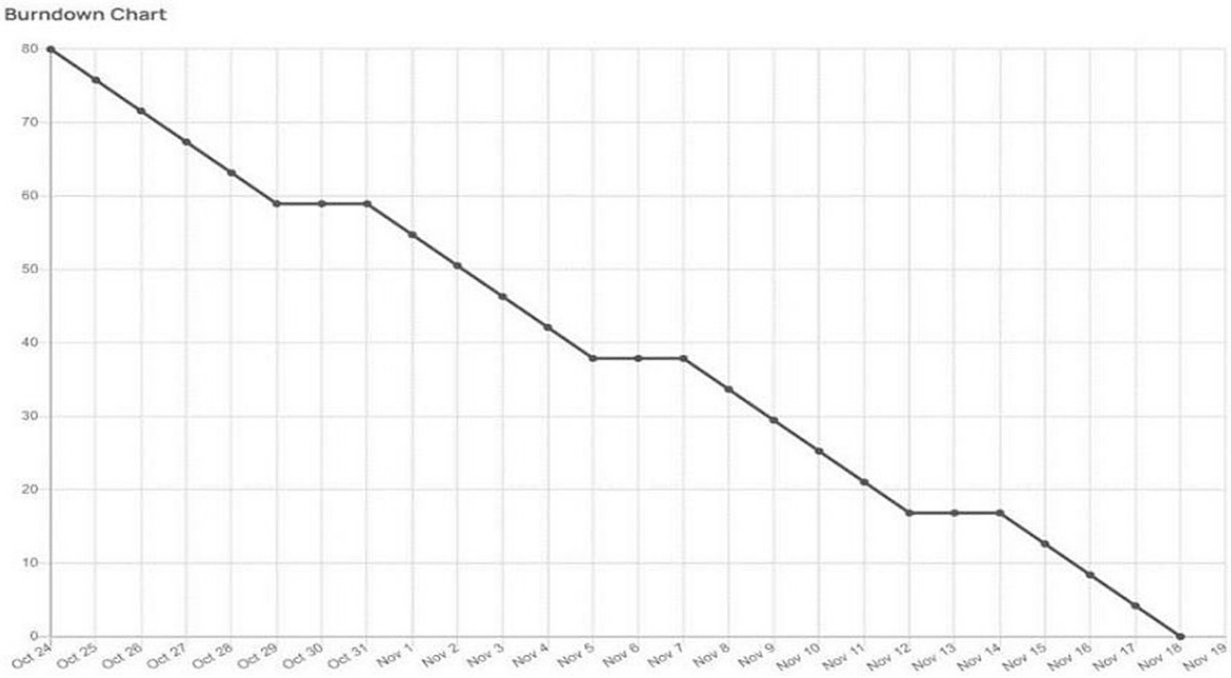
Velocity:

Imaginewehavea 10-daysprintduration,andthevelocityoftheteamis20(points persprint).Let's calculatetheteam'saveragevelocity(AV)periterationunit (storypointsperday).

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

AV=20/6=3.33pointsperday.

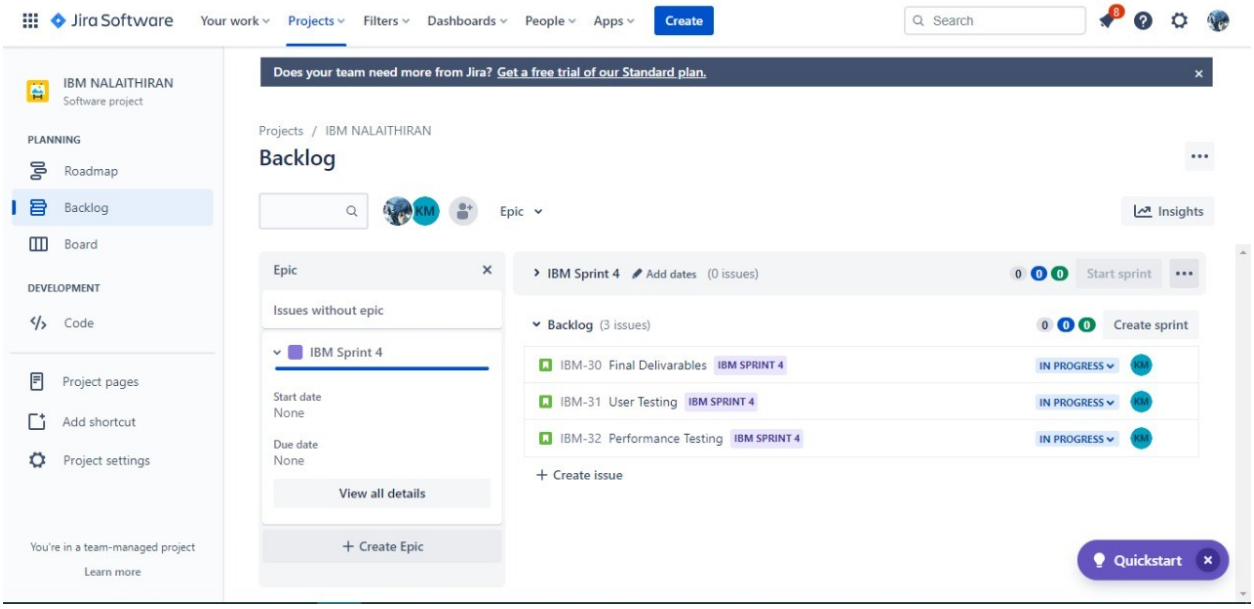
6.2 BurnDownChart &JIRA:

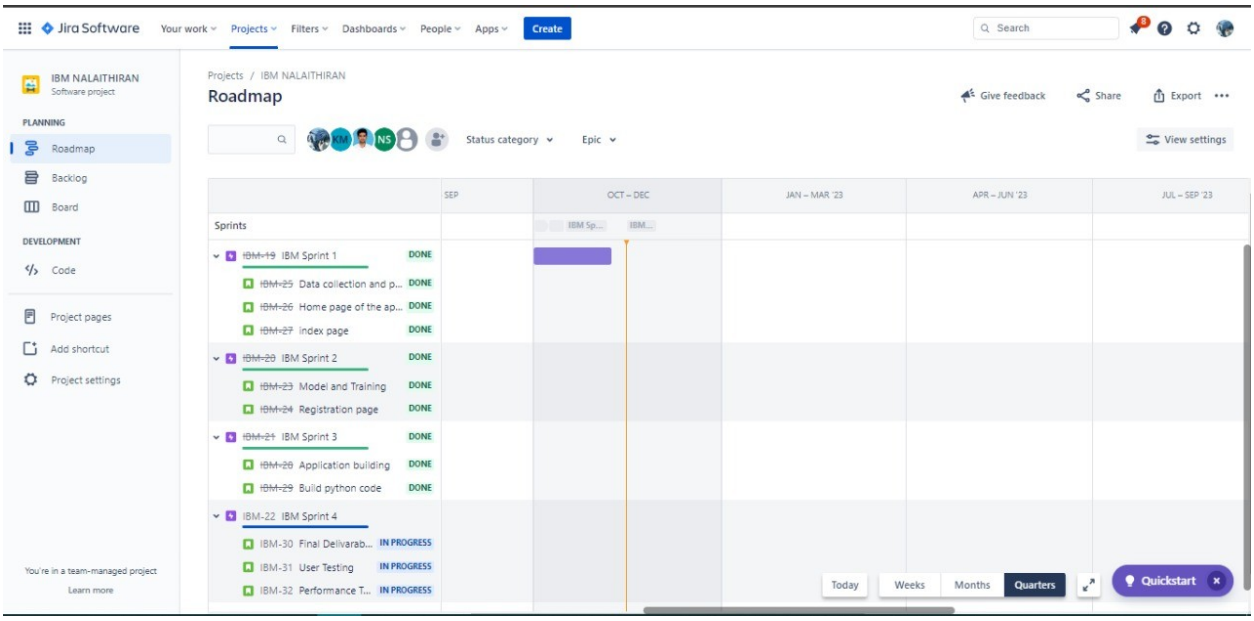


A burn down chart plots the amount of work remaining to perform against the amount of time. In agilesoftwaredevelopmentapproacheslikeScrum,itisfrequentlyemployed.Burndowncharts,however,canbeused forany projectthatmakesobservableprogressovertime.

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

JIRA SCREENSHOTS:-





JIRAFolderis createdtoshowtheScrummethodologiesandBurnDownchartprogress.

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.

Resolution	Severity 1	Severity 2	Severity 3	Severity4	Subtotal

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

3.Test-CaseAnalysis

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

Section	TotalCases	Not Tested	Fail	Pass
PrintEngine	9	0	0	9
ClientApplication	45	0	0	45
Security	2	0	0	2
Out-sourceShipping	3	0	0	3
ExceptionReporting	9	0	0	9
FinalReportOutput	4	0	0	4
VersionControl	2	0	0	2

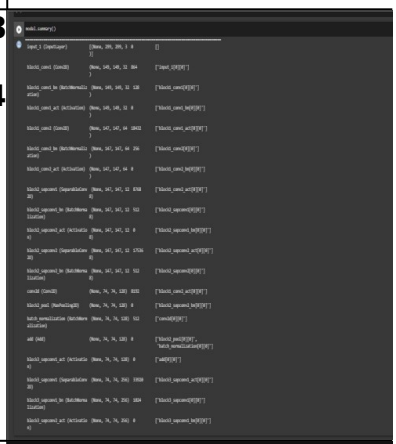
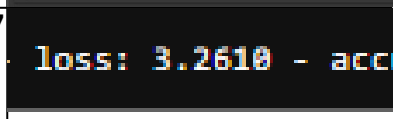
9.RESULTS:-

9.1 PerformanceMetrics:-

ModelPerformanceTesting:

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

PerformanceParameter

S.NO	Pe Parameter	Values	Screenshot
1.	ModelSummary	**Totalparams:21,885,485 Trainableparams:1,024,005 Non-trainableparams:20,861,480**	
2.	Accuracy	TrainingAccuracy–**0.7917** ValidationAccuracy–**loss3.2610**	
3.	Confidence Score(Only YoloProjects)	ClassDetected- Confidence Score -	-- -- -- --

Projectteamshallfillthefollowinginformationinmodelperformancetestingtemplate.

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()
```

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 -->
```

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

```
<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="btnbtn-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="btnbtn-lgbtn-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-control form-control-lg" name ="file" type="file" />
<br>
<button class="btnbtn-lgbtn-dark" type = "submit">Predict</button>
</form>
<br>
<h1>{{prediction}}</h1>
</div>
<br><br><br>
```

```
<div class="d-flex justify-content-center" >
<imgsrc="static/level.png" style="width: 90%">
</div>
</body>
</html>
```

register.html:-

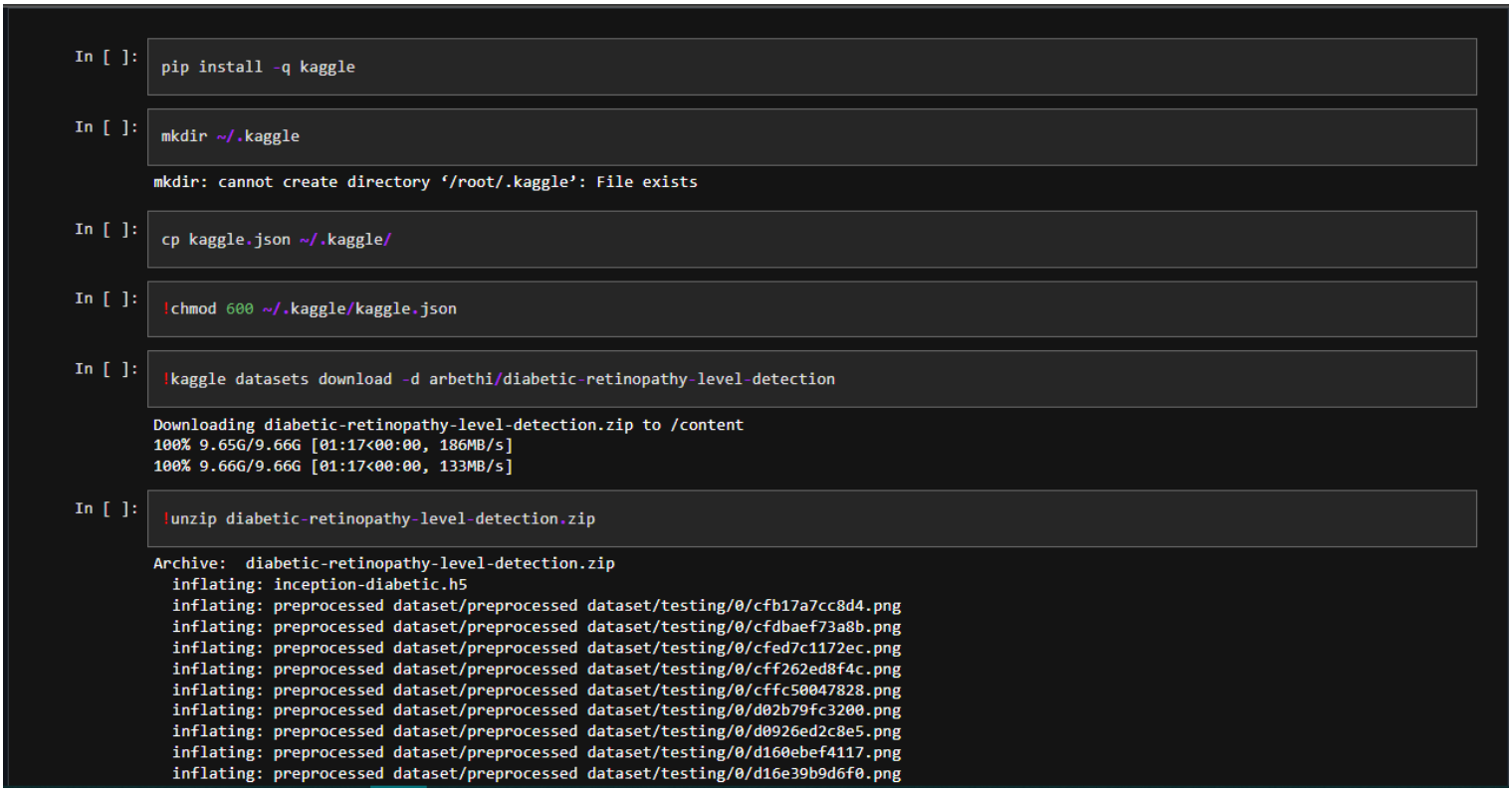
```
<!--<!DOCTYPE html>
<html lang="en">
<head>
<meta charset="UTF-8" />
<meta http-equiv="X-UA-Compatible" content="IE=edge" />
<meta name="viewport" content="width=device-width, initial-scale=1.0" />
<!-- CSS only -->
<link
    href="https://cdn.jsdelivr.net/npm/bootstrap@5.2.1/dist/css/bootstrap.min.css"
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="btnbtn-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> -->

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
```

GITHUB LINK:-[IBM-EPBL/IBM-Project-18407-1659684768: Deep Learning Fundus Image Analysis for Early Detection of Diabetic Retinopathy (github.com)]

DEMO LINK:-[IBM-Project-18407-1659684768/Demo Video.mp4 at main · IBM-EPBL/IBM-Project-18407-1659684768 (github.com)]

DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY