DEEP LEARNING FUNDUS IMAGE ANALYSIS FOR EARLY DETECTION OF DIABETIC RETINOPATHY

TEAM LEAD

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1.INTRODUCTION

1.1 PROJECT OVERVIEW

Lesions on the retina caused by “Diabetic Retinopathy” (DR), a frequent complication of diabetes mellitus, impair vision. Blindness may result if it is not identified in its early stages. Unfortunately, DR cannot be reversed, and treatment only keeps vision intact. The risk of vision loss can be significantly decreased with early detection and treatment of DR. In contrast to computer-aided diagnosis methods, the manual diagnosis process of DR retina fundus images by ophthalmologists is time-, effort-, and cost-consuming aswell as prone to error.

One of the most popular methods for enhancing performance across a wide range of domains, particularly in the classification and image analysis of medical images, is “Transfer Learning”. We used Transfer Learning techniques that are more frequently used in medical image analysis, such as Inception V3, Resnet 50, and Xception V3, andthey are very successful.

1.2 PURPOSE

The seriousness of the condition raises the necessity of the modern solution. And the biggest problem that lies in the contemporary practices is that, to diagnose the case we need help from a clinical professional to take a fundus image of the patient and analyze manually to detect the presence of the condition. The requirement of a clinicalprofessional to be present in order to diagnose the patient can be nullified using modern technology. And that solutioncan be achieved through machinelearning or deep learning.

2. LITERATURE SURVEY

Title	Authors	Description
Real TimeAnalysisof Diabetic Retinopathy Lesionsby Employing DeepLearning and Machine Learning Algorithms using Color Fundus Data	S. Gupta, A. Panwar, A. Kapruwan, N. Chaube and M. Chauhan.	The colorfundus dataset scansafter processing are passed to multiple Deep Learning(DL) models employed to learn characteristics. These models trained on millions of different images from thousands of classes. Finally, several machine learning classifiers were usedto classify lesions using the collected characteristics. The extracted result shows very eye-catching performance. This enables experts to create architecture that fully addresses the problem of classifying unidentified scans into the rightclass or category.
Deep Learning Models for RetinalBlood Vessels Segmentation: A Review	T. A. Soomro et al.	This paper presents a comprehensive review of the Principle and application of deep learning in retinal image analysis. This paper characterizes each deep learning basedsegmentation method as described. Analyzing along with thelimitations and advantages of each method. In the end, somerecommendations for future Improvement for retinalimage analysis.

Deep Learning Techniques for Diabetic Retinopathy Classification: ASurvey	M. Z. Atwany, A. H. Sahyoun and M. Yaqub.	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. the paper discusses the available retinal fundus datasets for Diabetic Retinopathy that are used for tasks suchas 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.
Deep Learning Approach For Detection Of Retinal Abnormalities Based On Color Fundus Images	B. Bulut, V. Kalın, B. B. Güneş and R. Khazhin.	This research uses the Xception model withtransfer learning method to classify images obtained fromAkdeniz University Hospital Eye Diseases Department. During the analysis, the Xception model containing 50 differentparameter combinations wastrained by scanning the appropriate hyper- parameter spaceforthe model.
Computer assisteddiagnosis (CAD) system for Diabetic Retinopathy screening using colorfundus images usingDeep learning	N. Memari, S. Abdollahi, M. M. Ganzagh and M. Moghbel.	The proposed computer-assisted diagnosis system starts with the segmentation of theblood vessels. Then,microaneurysms and exudates are segmentation fromthe image. Statistical and regional features are then extracted utilizing first, second, and higher- order image features. A Deep Learning framework will be utilized for extracting additional statistical imagedescriptors as Deep Learning has superior contextual analysis capabilities compared to othermachine learning techniques.

A Comprehensive Review of DeepLearning Strategies inRetinal Disease Diagnosis Using Fundus Images.	B. Goutam,M. F. Hashmi, Z. W. Geem and N. D. Bokde.	This article presents a comprehensive studyof different deep learning strategies employed in recent timesfor the diagnosis of five major eye diseases, i.e., Diabetic retinopathy, Glaucoma, age- related macular degeneration, Cataract, and Retinopathy of prematurity.
Deep-learning based automated segmentation of Diabetic Retinopathy symptoms	H. Yeh, C. -J. Lin, C. -C. Hsu and C. -Y.Lee.	Deep learning is used in many typesof preprocessing for segmentation. We preprocessed fundus images and inputted them into the model fortraining. Finally, LDF image was used to obtainthe best preprocessing method for optic disc segmentation in fundus images.
Diabetic Retinopathy Diagnosis From Fundus Images Using Stacked Generalization ofDeep Models	H. Kaushik, D. Singh, M. Kaur,H. Alshazly, A. Zaguia and H. Hamam.	In this research, a methodology to eliminate these unnecessary reflectance properties of the images using a novel image processing schema and a stacked deeplearning technique for the diagnosis. For the luminosity normalization of the image, the gray worldcolor constancy algorithm is implemented whichdoes image desaturation and improves the overallimagequality.
Deep Learning-based Techniques for the Automatic Classification of Fundus Images: A Comparative Study	A Bali and V. Mansotra.	In this paper different deep learning (DL) techniques for automatic Classification offundus images have been discussed and results are compared on the basis of accuracy, f1-score and AUC.

Deep UWF: An Automated Ultra-Wide Field FundusScreening System via Deep Learning	W. Zhang,X. Zhao,Y. Chen, J. Zhong and Z. Yi.	The emerging ultra-wide field of view (UWF)fundus color imagingis a powerful tool for fundus screening. However, manualscreening is labor-intensive and subjective. Based on 2644UWF images, a set of early fundusabnormal screening systems named Deep UWF is developed. The experimental results show that these preprocessing methods are helpfulto improve the learning ability of the networks and achieve good sensitivity andspecificity.

2.1 EXISTING PROBLEM

- A sophisticated interface between the patient and the clinical professional. Like a web application where both the stakeholders will be able to access necessaryresources.
- Accuracy of the existing solution. With the advancement of AI technology, we canmake use of state of the art deep learning algorithms to achieve best results.
- Lack of quality preprocessing which would extensively boost the performance of the solution.

2.2 REFERENCES

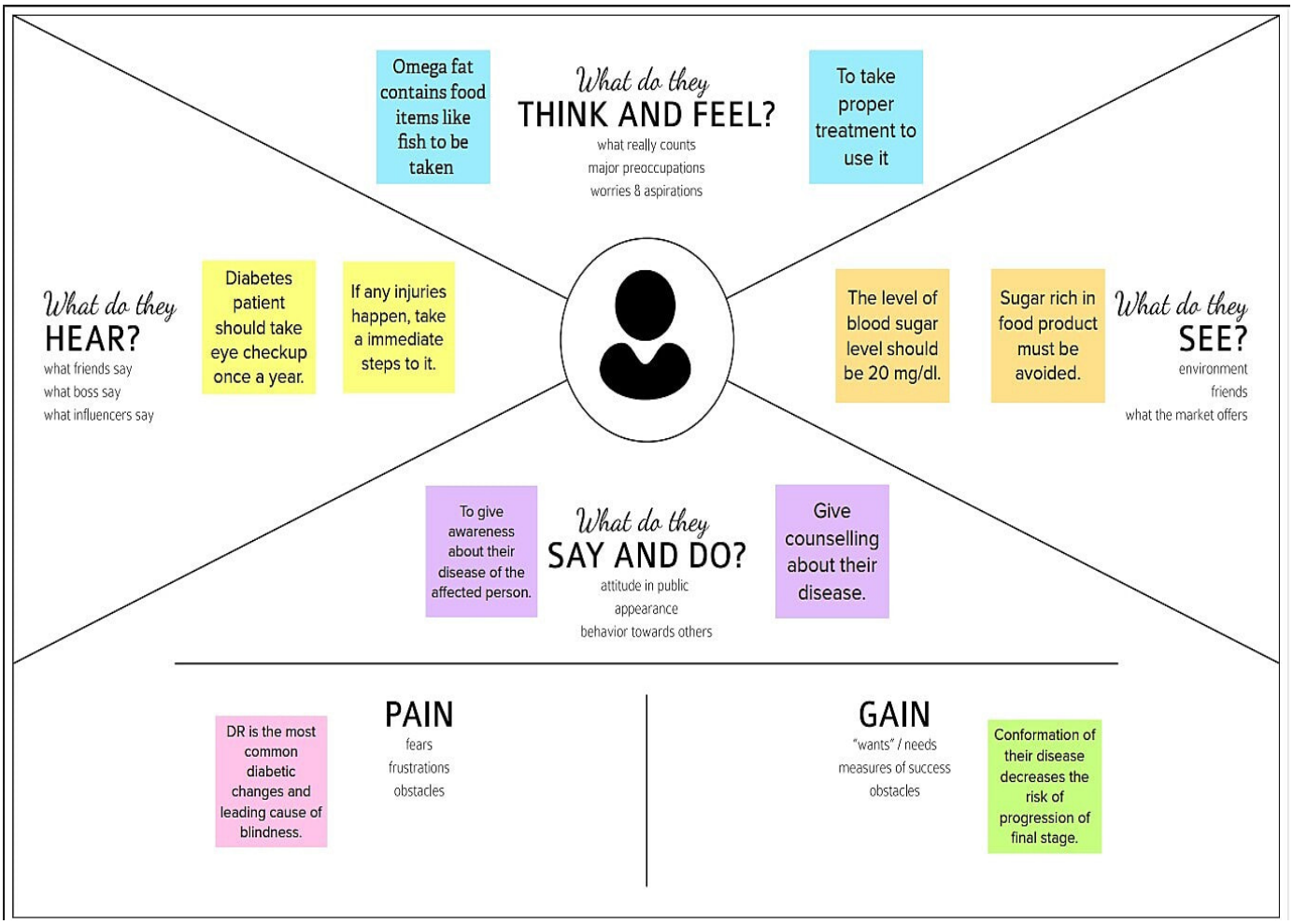
1. *A. Bali and V. Mansotra,"Deep Learning-based Techniques for the AutomaticClassification of Fundus Images: A Comparative Study," 2021 3rd International Conference on Advances in Computing, Communication Control and Networking (ICAC3N), 2021, pp. 351-359, doi: 10.1109/ICAC3N53548.2021.9725464.*
2. *W. Zhang, X. Zhao, Y. Chen, J. Zhong and Z. Yi, "DeepUWF: An Automated Ultra-Wide-Field Fundus Screening System via Deep Learning," in IEEE Journal of Biomedical and Health Informatics, vol. 25, no. 8, pp. 2988-2996, Aug. 2021, doi: 10.1109/JBHI.2020.3046771.*
3. *H. Kaushik, D. Singh, M. Kaur, H. Alshazly, A. Zaguia and H. Hamam, "Diabetic Retinopathy Diagnosis From Fundus Images Using Stacked Generalization of Deep Models," in IEEE Access, vol. 9, pp. 108276-108292, 2021, doi: 10.1109/ACCESS.2021.3101142.*
4. *H. Yeh, C. -J. Lin, C. -C. Hsu and C. -Y. Lee, "Deep-learning based automated segmentation of Diabetic Retinopathy symptoms," 2020 International Symposiumon Computer, Consumerand Control (IS3C), 2020, pp. 497-499,doi: 10.1109/IS3C50286.2020.00135.*
5. *B. Goutam, M. F. Hashmi, Z. W. Geem and N. D. Bokde, "A Comprehensive Review of Deep Learning Strategies in Retinal Disease Diagnosis Using Fundus Images," in IEEE Access, vol. 10, pp. 57796-57823, 2022, doi: 10.1109/ACCESS.2022.3178372.*

2.3 PROBLEM STATEMENT DEFINITION

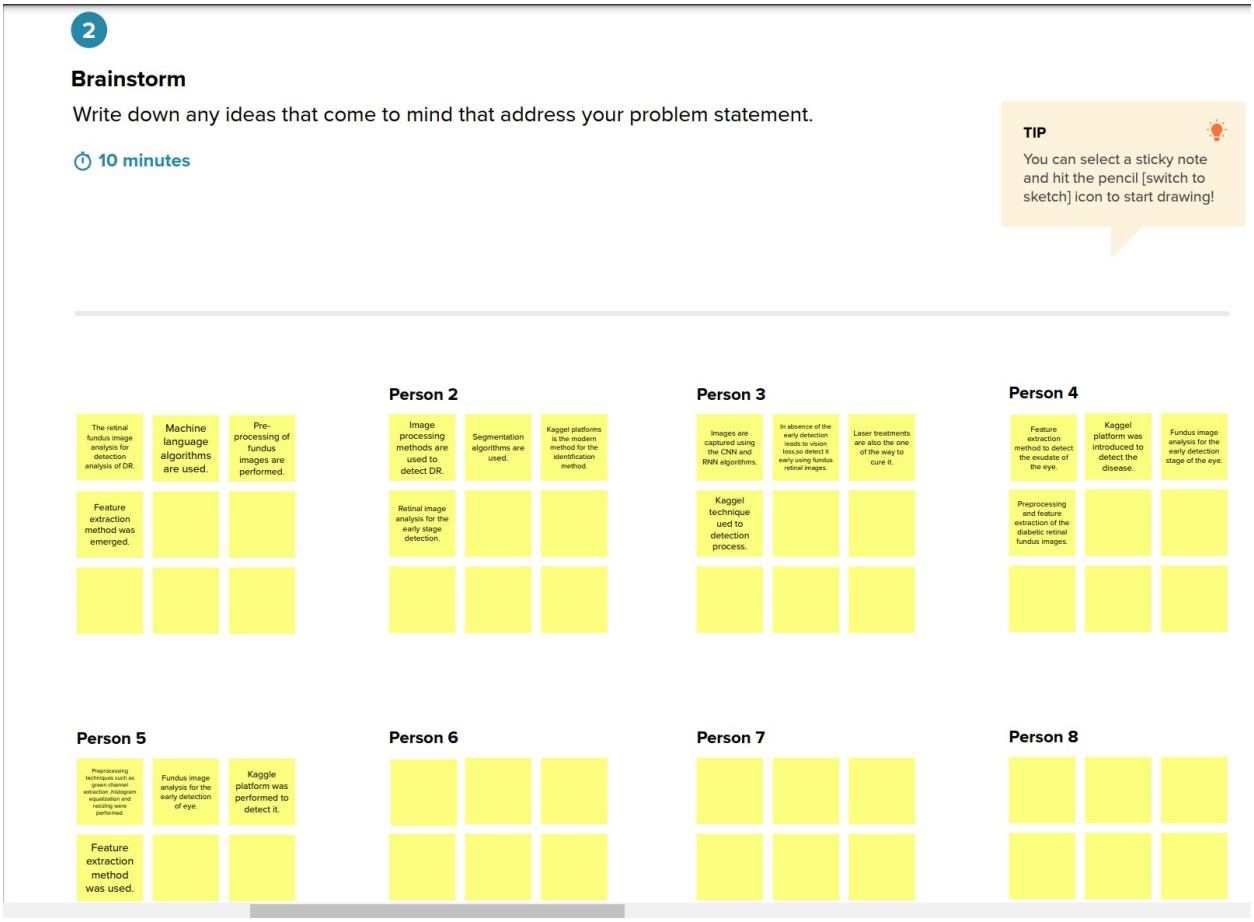
The leading causes of blindness and low vision are primarily agerelated eye diseases such as age-related macular degeneration, cataract, Diabetic Retinopathy(DR), and glaucoma. High blood sugar levels in people with diabetes can damage the blood vessels in the retina and cause blindness. Diabetic affects up to 80 percent of all patients who have had diabetes for 10 years or more. DR can be detected by examining the fundus image by an ophthalmologist. Limited number of ophthalmologists who can analyze fundus image is an obstacle because the number of DR sufferers continues to increase. Therefore, an automated system is needed to help doctors diagnose the disease. In this project we aim to develop an Artificial Intelligence (AI) approach to find DR in fundus images.

3. IDEATION & PROPOSED SOLUTION

3.1. EMPATHY MAP CANVAS



3.2 IDEATION & BRAINSTORMING



3

Group ideas

Take turns sharing your ideas while clustering similar or related notes as you go. In the last 10 minutes, give each cluster a sentence-like label. If a cluster is bigger than six sticky notes, try and see if you and break it up into smaller sub-groups.

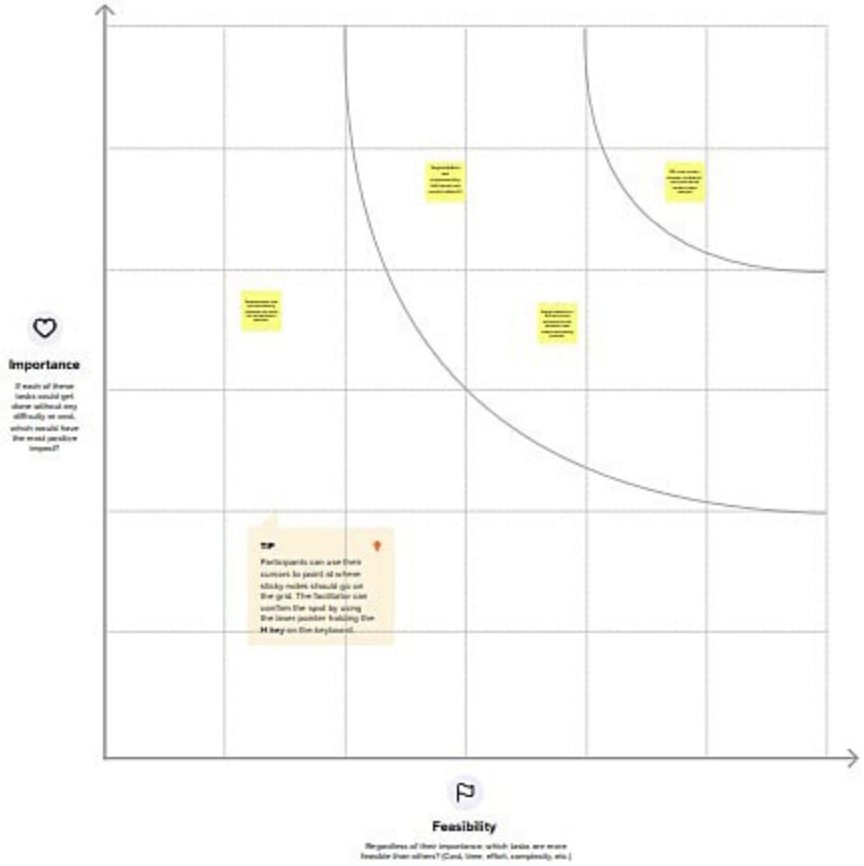
20 minutes

4

Prioritize

Your team should all be on the same page about what's important moving forward. Place your ideas on this grid to determine which ideas are important and which are feasible.

20 minutes



3.3 PROPOSED SOLUTION

Problem Statement

Proposed Solution

S. No.	Parameter	Description
1.	Problem Statement (Problem to besolved)	I am Diabetic Retinopathy patient. I am trying to get rid of this problem for more than5 years but thereis no certain facilities to get rid of it because the solution that I had was not good whichmakes me feel frustrated.
2.	Idea / Solution description	Disease diagnosis from medical imageshas become increasingly important inmedical science. Abnormality identification in retinalimages has become a challenging task in medical science. Effective machine learning and soft computing methods should be used to facilitate Diabetic Retinopathy Diagnosis from Retinal Images.Artificial Neural Networks are widelypreferred for Diabetic Retinopathy Diagnosis from Retinal Images.
3.	Novelty / Uniqueness	Usage of 3 layer conventional neural network for early detection of diabeticretinopathy.

4.	Social Impact/ Customer Satisfaction	As a resultArtificial Neural Networks it is used for the diagnosis from Retinal Images for DiabeticRetinopathy so that patient can get ridof this impairment.
5.	Business Model (Revenue Model)	The government should improve AI technology in healthcare system andthey should allocate fund for the introducing it.
6.	Scalability of the Solution	Patient registered with basic demographic data, base line medical information and unique I'd is created.If patient misses a treatment or they get any issues or queries they can approach nearbyophthalmologist and get clear with that.

3.4 PROBLEM SOLUTOION FIT

1.PATIENTS SEGMENTS

The early detection is used for the patients. The Patients eye can be detected using the fundus image and can be stored in the database. This is more useful than the manual detection by the doctors in older days.

6. PATIENTS LIMITATIONS

It is important to get a comprehensive dilated eye exam at least once a year if the patient is affected has diabetes.

5.AVAILABLE SOLUTIONS

Non efficient image processing algorithms were used in earlier systems. This traditional approach gives lower accuracy and is time consuming. This drawback of the existing system propelled us towards the idea for developing a system that could ease this effort.

2.PROBLEM/PAINS

There are four stages- mild, moderate, non proliferate, proliferate Patients who are not treated for long time may cause the patients to lose a vision.

If the problems can be caught early, treatment can help prevent or reduce vision

9.PROBLEM ROOT/CAUSE

Diabetic Retinopathy is caused by the high sugar levels in blood. Overtime, having too much can damage the patients retina.

The most common cause are diabetes and hypertension.

7.BEHAVIOR

Non efficient image processing algorithms were used in earlier systems. This traditional approach gives lower accuracy and is time consuming.

In our project we identify the patients diseases using fundus image. Then it recommends the treatment to be used. Our project's accuracy is more because we are using Artificial Intelligence.

3.TRIGGERS TO ACT

The Diabetic Retinopathy is the best diagnosed with a comprehensive dilated eye exam. For this exam, drops placed in patients eyes widen(dilate) their pupils to know the better view inside the patients eyes.

4.EMOTIONS

This early detection of Diabetic Retinopathy make the patient to identify his/her disease easily through this diagnosis.

10.YOUR SOLUTION

Patients can reduce their risk of developing diabetic retinopathy by keeping their blood sugar levels, blood pressure and cholesterol levels under control.

8.CHANNELS OF BEHAVIOR

Strategies for preventing Diabetic Retinopathy includes- Effective diabetes management and Regular eye examinations. This will help the patients to delay the development of retinopathy. Early detection and treatment can usually prevent severe vision loss.

4. REQUIREMENT ANALYSIS

4.1 FUNCTIONAL REQUIREMENT

Following are the functional requirements of the proposed solution.

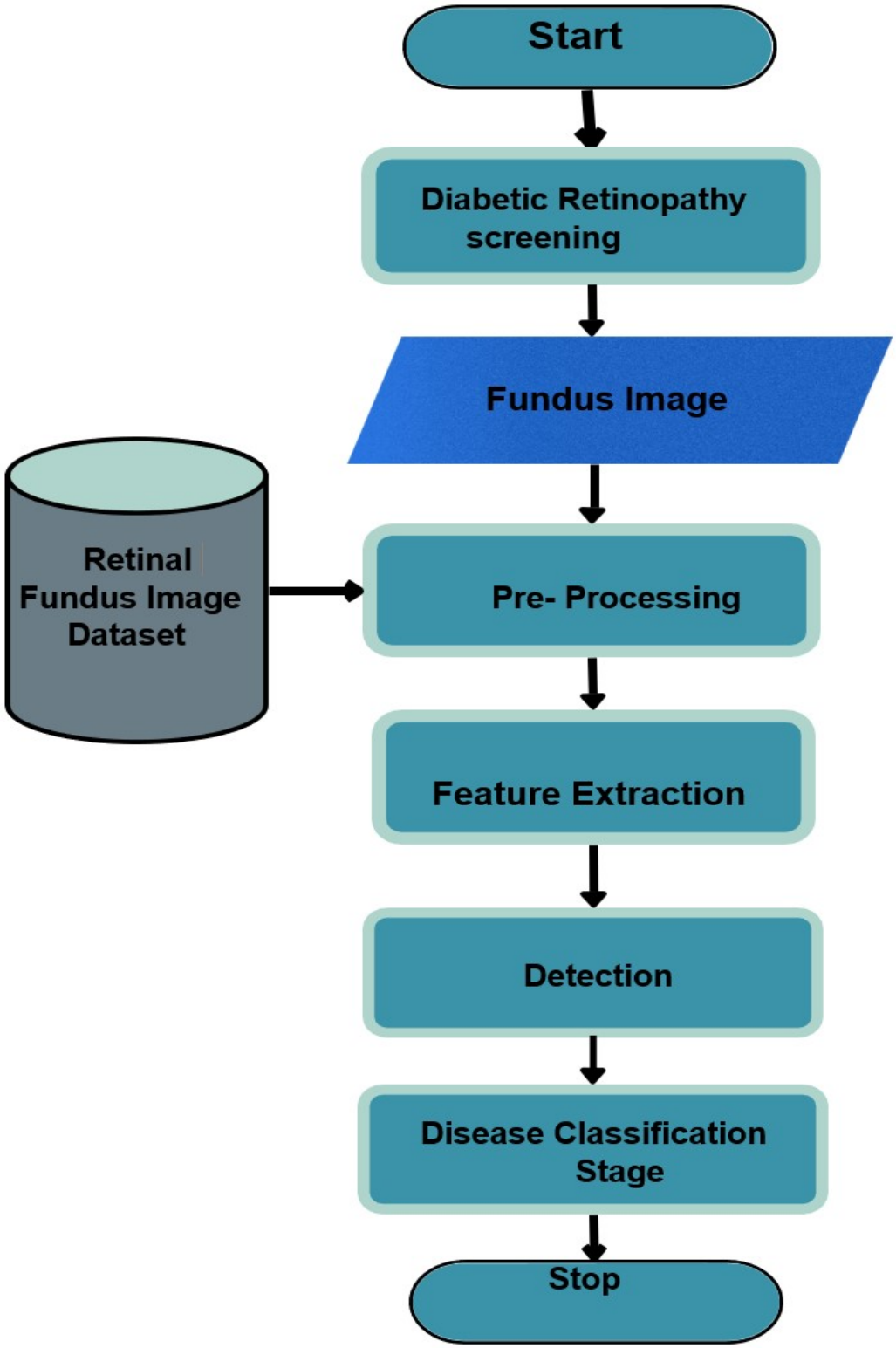
FR No.	Functional Requirement (Epic)	Sub Requirement (Story/Sub-Task)
FR-1	Identifying the population eligible for screening	Determine the group to be screened based on best evidence and use registers to make sure people's details are collected and up to date.
FR-2	Invitation and information	Invite the full cohort for screening, supplying information tailored appropriately for different groups to enable informed choice to participate
FR-3	Testing	Conduct screening test(s) using agreed/recommended Methods
FR-4	Referral of screen positives and reporting of screen-negative results	Refer all screen-positive results to appropriate services and make sure screen negatives are reported to Individuals and they stay in the screening program.
FR-5	Diagnosis	Diagnose true cases and identify false positives
FR-6	Intervention/treatment/follow up	Intervene/treat cases appropriately; in some conditions, Surveillance or follow up will also be required
FR-7	Reporting of outcomes	Collect, analyze and report on outcomes to identify false negatives and improve effectiveness and cost-effectiveness of screening program.

4.2 NON- FUNCTIONAL REQUIREMENTS

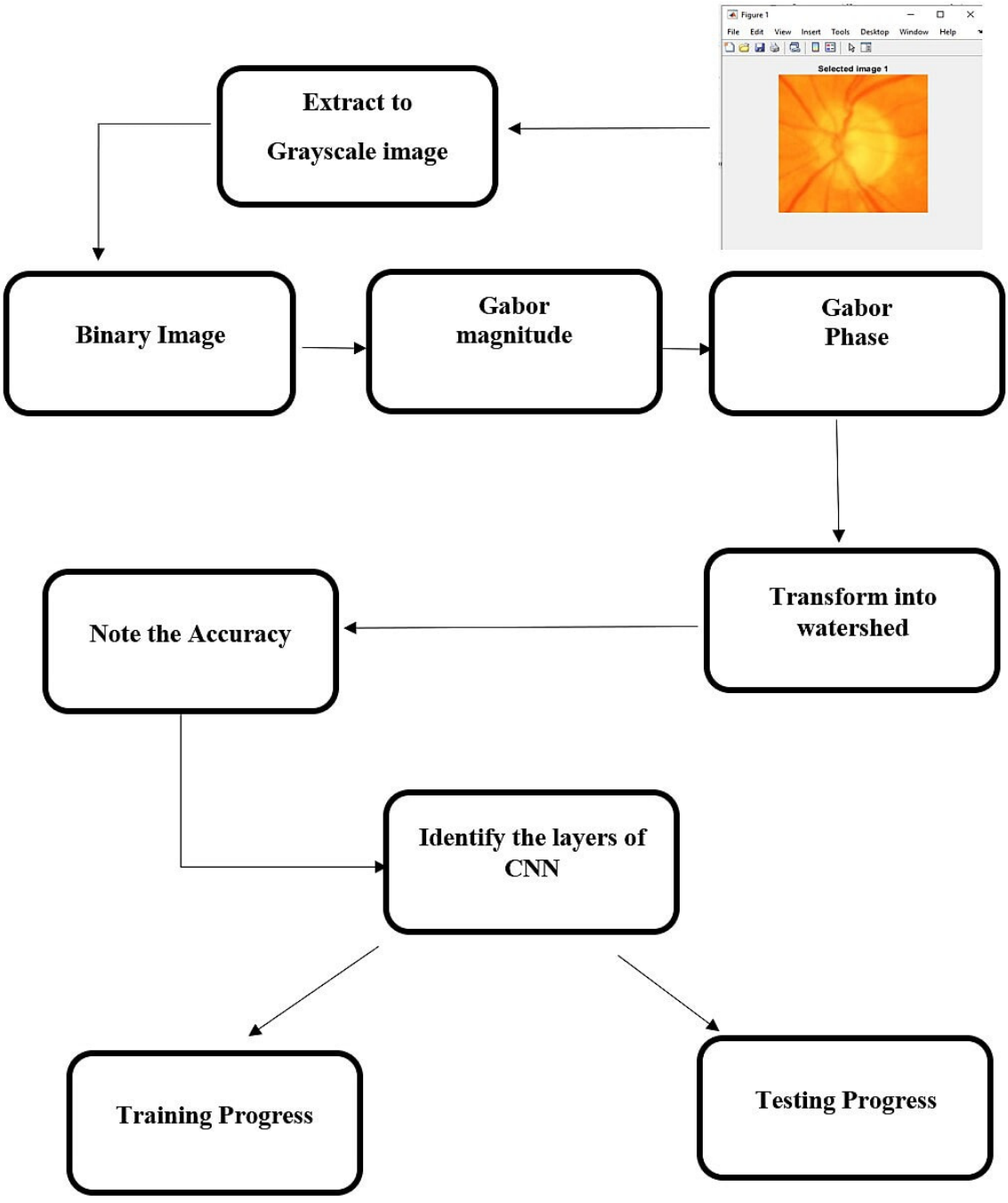
FR No.	Non-FunctionalRequirement	Description
NFR-1	**Usability**	Provides novel results for five different screeningandclinicalgradingsystemsfordiabetic retinopathyincluding state-of-the-art results for accurately classifying images according to clinical five -grade Diabetic retinopathy.
NFR-2	**Security**	Deep Learning using AI can be more precise around sensitive organs and tissues, reduce blood loss, risk of infection, and pain during detection/screening.
NFR-3	**Reliability**	The ability of Deep Learning is to perform pattern Recognition by creating complex relationships based On input data and then comparing it with Performance standards is a big step.
NFR-5	**Availability**	Health care affordability, quality, and accessibility can be amplified using this technology.
NFR-6	**Scalability**	It is possible to build on existing systems and take a Stepwise approach to improving the effectiveness of current approaches so that high-quality systematic diabetic retinopathy screening becomes a universal Offer to all people with diabetes.

5. PROJECT DESIGN

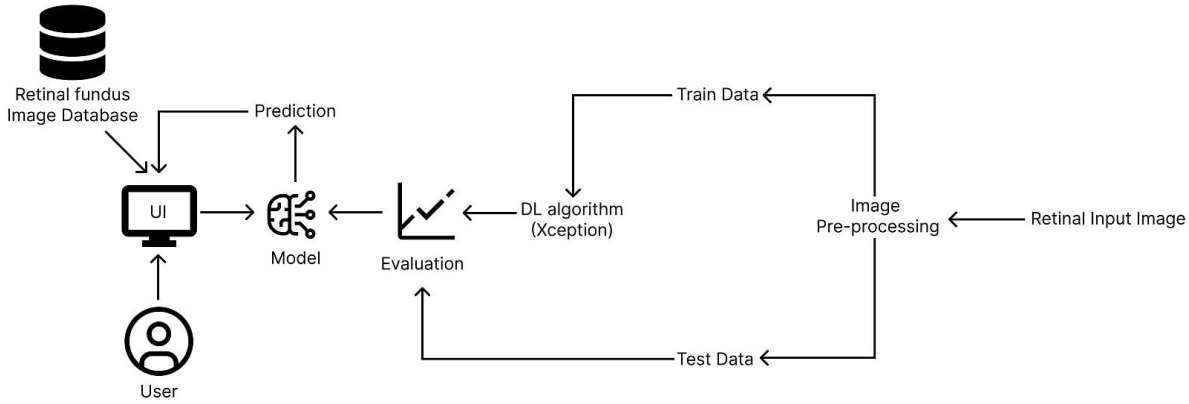
5.1 DATA FLOW DIAGRAMS



5.2 SOLUTION & TECHNICAL ARCHITECTURE



TECHNICAL ARCHITECTURE



5.3 USER STORIES

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Comm on User	Dashboard	USN-1	As a user, Ican I must be able to upload image of my eyes	I can uploador take image	High	Sprint-1
		USN-2	As a user,I will receive the diagnosis as towhether I have retinopathy or not	I can receive the diagnosis	High	Sprint-1
		USN-3	As a user, I receive the severity of the retinopathy	I can receivethe severityof the retinopathy	Medium	Sprint-2
		USN-4	As a user, I can receive thesugge sted remedy	I can receive thesuggest ed remedy	Medium	Sprint-2

6. PROJECT PLANNING & SCHEDULING

6.1 SPRINT PLANNING & ESTIMATION

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	StoryPoints	Priority	Team Members
Sprint-1	Screening method	USN-1	As a user, I can find the methodmore efficientandaccurate.	7	High	Suryanarayan S
Sprint-2		USN-2	Asa user, I can use it withminimal physical interaction with the device.	6	Medium	Thejesh R
Sprint-4	Physical features	USN-3	As a user, I can findit portable andlight weight.	10	Low	Ganesh Pranav LS
Sprint-3	Safety	USN-4	As a user, I can be safe as the detection method is freefrom radiations.	8	High	ValathappanK
Sprint-1	Testing	USN-5	As a user, I canundergo testing without anyfear of pain as this methodis pain-free.	7	Low	Suryanarayan S & Ganesh Pranav LS
Sprint-3		USN-6	As a user, I willbe comfortable as it requiresminimum/no human involvement.	3	Medium	Ganesh Pranav LS & Valathappan K
Sprint-1	Results	USN-7	As a user, I can rely on the results without any suspicion.	6	High	Thejesh R

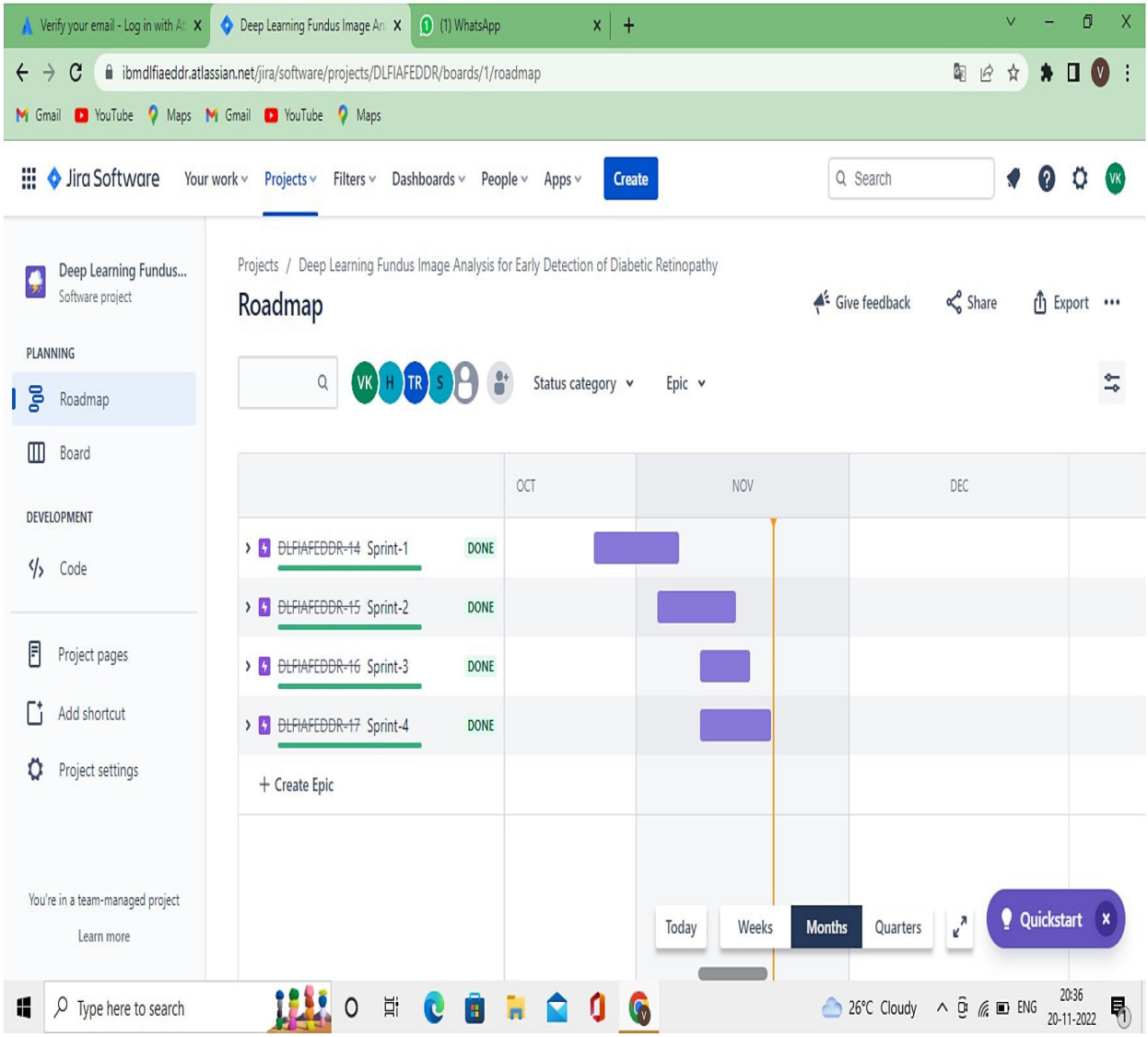
Sprint-3		USN-8	As a user,I can benefit from the result as it will help me know whether treatment isnecessary or not.	8	Medium	Thejesh R & Suryanarayan S
Sprint-2		USN-9	As a user, I can get the resultson the spot immediately after thescreening process.	7	Low	Ganesh Pranav LS
Sprint-4	Results	USN-10	As a user, I can complete the screening process within minutes for a single patient.	10	Medium	Thejesh R & Valathappan K
Sprint-3	Cost-effectiveness	USN-11	Asa user, I can reachmany people sufferingfrom diabetes.	4	Medium	SuryanarayanS & Valathappan K &Thejesh R
Sprint-2		USN-12	As a user,I can createawareness amongdiabetic patients to undergo frequent screening	7	Low	Ganesh Pranav LS &Thejesh R

6.2 SPRINT DELIVERY SCHEDULE

Sprint	Total Story Points	Duration	Sprint StartDate	SprintEnd Date (Planned)	Story Points Completed (as on Planned EndDate)	Sprint Release Date (Actual)
Sprint-1	20	6 Days	24 Oct 2022	29 Oct 2022	20	29 Oct 2022
Sprint-2	20	6 Days	31 Oct 2022	05 Nov 2022	20	05 Nov 2022

Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	20	12 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	20	19 Nov 2022

6.3 REPORTS FROM JIRA



7. CODING & SOLUTIONING

7.1 FEATURE 1

Severity Detection

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

7.2 FEATURE 2

Efficiency (Timetaken to provide results)

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

8. TESTING

8.1 TEST CASES

Test case ID	Feature Type	Component	Test Scenario	Pre-Requisite	Steps To Execute	Test Data	Expected Result	Actual Result	Status
Login Page TC_001	Functional	Login Page	Verify user is able to see the Login/Registration popup when user enters the site.		1.Enter URL and click go 2.Verify login/Sing up popupdisplayed or not	local server	Login/Signup popup should display	Working as expected	Pass
Login Page TC_002	UI	Login Page	Verify the UI elements in Login/Signup popup		1. Enter URL and click go 2. Verify login/Singup popup with below UI elements: a.name text box b.email text box c.password text box d.Login button e.New customer? Registration link	local server	Application should show below UI elements: a. Email text box b.Password text box c.Login button with orange colour d.New customer? Create account link e.Last password? Recovery password link	Working as expected	Pass
Login Page TC_003	Functional	Login page	Verify user is able to log into application with Valid credentials		1. Enter URL and click go 2. Enter Valid username/email in Email text box 3. Enter valid password in password text box 4. Click on login button	Username: check@gmail.com password: Check@123	User should be able to navigate to user account homepage.	Working as expected	Pass
Login Page TC_004	Functional	Login page	Verify user is able to log into application with Invalid credentials		1. Enter URL and click go 2. Enter InValid username/email in Email text box 3. Enter valid password in password text box 4. Click on login button	Username: invalid@gmail.com password: Check@123	Application should show 'Incorrect email or password ' validation message.	Working as expected	Pass
Login Page TC_005	Functional	Login page	Verify user is able to log into application with Invalid credentials		1. Enter URL and click go 2. Enter Valid username/email in Email text box 4. Enter Invalid password in password text box 5. Click on login button	Username: check@gmail.com password: invalidpassword	Application should show 'Incorrect email or password ' validation message.	Working as expected	Pass
Home Page TC_001	UI	Home page	Verify user is able to navigate to the Prediction page	Login to website using Valid credentials	1.Enter URL and click go 2.Enter Home Page using valid credentials 3.Click on the Prediction button to navigate to Prediction page.	local server	Prediction Page should be displayed	Working as expected	Pass

Home Page TC_002	UI	Home page	Verify user is able to navigate to the Logout Page	Login to website using Valid credentials	1.Enter URL and click go 2.Enter Home Page using valid credentials 3.Click on the Logout button	local server	Logout Page should be displayed	Working as expected	Pass
Prediction Page TC_001	UI	Prediction Page	Verify user is able to navigate to the Logout Page	Login to website using Valid credentials and Navigate to Prediction Page	1.Enter URL and click go 2.Enter Home Page using valid credentials 3.Enter on the Prediction Page 4.Click on the Logout button	local server	Logout Page should be displayed	Working as expected	Pass
Prediction Page TC_002	UI	Prediction Page	Verify user is able to navigate to the Home Page	Login to website using Valid credentials and Navigate to Prediction Page	1.Enter URL and click go 2.Enter Home Page using valid credentials 3.Enter on the Prediction Page 4.Click on the Home button	local server	Logout Page should be displayed	Working as expected	Pass
Prediction Page TC_003	Function	Prediction Page	Verify user is able to upload an image	Login to website using Valid credentials and Navigate to Prediction Page	1.Enter URL and click go 2.Enter Home Page using valid credentials 3.Enter on the Prediction Page 4.Upload an image in the given input box 5.Click Submit	Image Input format: Png, jpeg, jpg	Image is uploaded	Working as expected	Pass
Prediction Page TC_004	Function	Prediction Page	Verify user is not able to upload any other image formats	Login to website using Valid credentials and Navigate to Prediction Page	1.Enter URL and click go 2.Enter Home Page using valid credentials 3.Enter on the Prediction Page 4.Upload an image in the given input box 5.Click Submit	Image Input format: tiff	Image is uploaded	Not Working as expected	Fail
LogoutPage_TC_001	UI	Logout Page	Verify User is able to navigate to Login Page	Login to website using Valid credentials and Click Logout button	1.Enter URL and click go 2.Enter Home Page using valid credentials 3.Enter on the Logout Page 4.Click on the Login button	local server	Login Page should be displayed	Working as expected	Pass

8.2 USER ACCEPTANCE TESTING

Defect Analysis

Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Subtotal
By Design	10	4	2	2	18
Fixed	6	2	2	2	12
Skipped	0	0	0	1	1
Won't Fix	0	0	0	1	1
Totals	16	6	4	6	32

Test Case Analysis

Section	Total Cases	Not Tested	Fail	Pass
Print Engine	8	0	0	8
Client Application	17	0	0	17
Security	2	0	0	2
Exception Reporting	2	0	0	2
Final Report Output	5	0	0	5
Version Control	1	0	0	1

9. RESULTS

9.1 PERFORMANCE METRICS

S. No.	Parameter	Values	Screenshot
1.	Model Summary	Total Parameters:21,885,485 Trainable Parameters:1,024,005Non-trainable Parameters:20,861,480	Attached Below
2.	Accuracy	Training Accuracy:0.6979	Attached Below
3.	Confidence Score	Class Detected: N/A Confidence Score:N/A	N/A

SCREENSHOTS

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

Adding Dense Layers

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

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

```
[ ]  model.summary()
     Model : "model"
```

```
...  Output exceeds the size limit. Open the full output data in a text editor
     Model: "model"
     _________________________________________________________________
     Layer (type)                 Output Shape              Param #
     =================================================================
     input_1 (InputLayer)         [(None, 299, 299, 3       0
                                  )]

     block1_conv1 (Conv2D)        (None, 149, 149, 32       864
                                  )

     block1_conv1_bn (BatchNormaliz  (None, 149, 149, 32    128
     ation)                       )

     block1_conv1_act (Activation)  (None, 149, 149, 32     0
                                  )

     block1_conv2 (Conv2D)        (None, 147, 147, 64       18432
                                  )

     block1_conv2_bn (BatchNormaliz  (None, 147, 147, 64    256
     ation)                       )

     block1_conv2_act (Activation)  (None, 147, 147, 64     0
                                  )

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

MODEL TRAINING ACCURACY

```
# fit the model

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:8: UserWarning: `Model.fit_generator` is deprecated and will be removed in a future version. Please use `Model.fit`, which supports generators.


Output exceeds the size limit. Open the full output data in a text editor
Epoch 1/30
3/3 [==============================] - 58s 17s/step - loss: 14.1287 - accuracy: 0.3438
Epoch 2/30
3/3 [==============================] - 48s 14s/step - loss: 7.1767 - accuracy: 0.5729
Epoch 3/30
3/3 [==============================] - 47s 14s/step - loss: 10.7616 - accuracy: 0.3125
Epoch 4/30
3/3 [==============================] - 40s 12s/step - loss: 7.0867 - accuracy: 0.4615
Epoch 5/30
3/3 [==============================] - 48s 15s/step - loss: 10.9142 - accuracy: 0.5729
Epoch 6/30
3/3 [==============================] - 50s 16s/step - loss: 6.9483 - accuracy: 0.6667
Epoch 7/30
3/3 [==============================] - 48s 14s/step - loss: 4.2671 - accuracy: 0.6562
Epoch 8/30
3/3 [==============================] - 48s 14s/step - loss: 10.7949 - accuracy: 0.4896
Epoch 9/30
3/3 [==============================] - 50s 16s/step - loss: 3.1253 - accuracy: 0.6875
Epoch 10/30
3/3 [==============================] - 49s 15s/step - loss: 5.1989 - accuracy: 0.6146
Epoch 11/30
3/3 [==============================] - 48s 14s/step - loss: 6.4308 - accuracy: 0.6771
Epoch 12/30
3/3 [==============================] - 47s 14s/step - loss: 3.4153 - accuracy: 0.7083
Epoch 13/30
...
Epoch 29/30
3/3 [==============================] - 39s 15s/step - loss: 2.5514 - accuracy: 0.6667
Epoch 30/30
3/3 [==============================] - 47s 14s/step - loss: 3.5850 - accuracy: 0.6979
```

10. ADVANATGES AND DISADVANTAGES

Merits

- With the developed application, anyone in the world with an internet connection will be able to access it and upload the fundus image.
- And on the other hand with the assistance of the Deep Learning techniques, we can quickly diagnose whether a patient has Diabetic Retinopathy.
- And the diagnosis will not only contain the detection of Diabetic Retinopathy by also diagnosing the severity of the case under five different classification: not affected, mild, moderate, severe and proliferative

Demerits

- The accuracy of the classification plays an important role in establishing the model. Since it deals with a very crucial idea, it is necessary to have an accurate working model.
- To deal with this situation we are again forced to rely on the help of the clinical professional.
- The steps to further take after diagnosing the condition are still questionable. Which should be the important concern in the future scope.

11. CONCLUSION

One of the world's important causes of vision loss is due to Diabetic Retinopathy. The findings of our study showed that DL algorithms had high sensitivity and specificity for detecting referable DR from retinal fundus photographs. Applying a DL-based automated tool of assessing DR from color fundus images could provide an alternative solution to reduce misdiagnosis and improve workflow. A DL-based automated tool offers substantial benefits to reduce screening costs, accessibility to healthcare and ameliorate earlier treatments and the advancement in technology poses the necessity of developing a solution to address the issue. So bringing in the most advanced technology like the Deep Learning model to design a solution marks a great beginning for the taken action. Now a user from any part of the world with an internet connection would be able to get clinical level attention using this web application. With the diagnoses he or she should be able to take further steps on how to treat the situation. Now the future scope of this project will lie on two aspects. Mainly the performance accuracyof the deep learning model and secondly, when diagnosed the provision for the users to take the necessary steps. This should allow the web application to build a complete infrastructure around this problem.

12. FUTURE SCOPE

The futurescope of the project can be proceeded in two aspects: the performance of the deep learning model and the provisions or features to include for the users to proceed with once they are diagnosed with the Diabetic Retinopathy. With this we will be able to create a complete infrastructure around the diabetic retinopathy to provide for the users who cannot access clinical professionals help. The performance of the deep learning model is crucial as it deals with a very crucial medical matter. If the system detects the patient's case as not affected when he or she actually is affected can topple down the entire purpose of the system. So the accuracy of the system is of the utmost importance for the growth of the project. Building a complete infrastructure around a web application should include features to also detect Glaucoma and other conditions that can be detected using a fundus image. The other aspect of the infrastructure should enable the users to proceed further with what kind of treatment they can take in order to deal with the condition. This can include provisions to get connected with a clinical professional who can guide the patient with what he or she can do in order to deal with the prevention of the condition getting worse.

13. APPENDIX

SOURCE CODE

```
import numpy as np
import os

import numpy as np
from cloudant.client import Cloudant
from flask import Flask, request, render_template
from keras.saving.save import load_model
from tensorflow.keras.applications.inception_v3 import preprocess_input
from tensorflow.keras.preprocessing import image

model = load_model(r"model\Updated-xception-diabetic-retinopathy.h5")

app = Flask(__name__)



#Authenticate using an IAM API key
client = Cloudant.iam('55a4f815-9a4a-4711-b663-d2733b89f3f9-bluemix','Ga7SGlD639xERt-F6egdft3j2dNntgT5CelqppKEgSLp', connect=True)



#create a database using an initialized client
my_database = client.create_database('ibm-deeplearning')
```

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



@app.route('/index')
def home():
    return render_template('index.html')


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

#registration page
@app.route('/register')
def register():
    return render_template('register.html')



@app.route('/afterreg', methods=['POST'])
def afterreg():

    name = request.form.get('name')
    email = request.form.get('emailid')
    password = request.form.get('pass')
```

```
    print(name,email,password)

    data = {
        '_id':email,
        'name':name,
        'psw':password,
    }

    print(data)

    query = {'_id': {'$eq': data['_id']}}

    docs = my_database.get_query_result(query)

    print(docs)

    print(len(docs.all()))

    if(len(docs.all())==0):
        url = my_database.create_document(data)
            return render_template('register.html', pred="Registration successfull, Please login using your details")
    else:
            return render_template('register.html', pred="You are already a member, Please login using your details")
```

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



@app.route('/afterlogin', methods=['POST'])
def afterlogin():

    user = request.form.get('emailid')
    passw = request.form.get('pass')
    print(user,passw)

    query = {'_id': {'$eq': user}}

    docs = my_database.get_query_result(query)
    print(docs)

    print(len(docs.all()))
    if(len(docs.all())==0):
            return render_template('login.html', pred="The username is not found, please Register")
    else:
        if((user==docs[0][0]['_id'] and passw==docs[0][0]['psw'])):
            return render_template('index.html')
        else:
            print('Invalid User')
```

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



#prediction
@app.route('/prediction')
def prediction():
    return render_template('prediction.html',pred=None)



@app.route('/predict', methods=['POST'])
def predict():

    f = request.files['image']
     basepath = os.path.dirname(__file__) #getting the current path i.e. where app.py is
present
    filepath=os.path.join(basepath,'uploads',f.filename)
    f.save(filepath)

    img = image.load_img(filepath,target_size=(299,299))
    x = image.img_to_array(img)
    x=np.expand_dims(x,axis=0)#used for adding one more dimension
    img_data=preprocess_input(x)
    prediction=np.argmax(model.predict(img_data),axis=1)

    print("prediction is", prediction)

     index=['No Diabetic Retinopathy', 'Mild Diabetic Retinopathy', 'Moderate Diabetic
```

```
Retinopathy', 'Severe Diabetic Retinopathy', 'Proliferative Diabetic Retinopathy']

    res = str(index[prediction[0]])

    color = ''
    if res == 'No Diabetic Retinopathy':
        color = 'style=color:#86c881'
    elif res == 'Mild Diabetic Retinopathy':
        color = 'style=color:yellow'
    elif res == 'Moderate Diabetic Retinopathy':
        color = 'style=color:orange'
    elif res == 'Severe Diabetic Retinopathy':
        color = 'style=color:#ff5500'
    else:
        color = 'style=color:#a00000'

    return render_template('prediction.html',pred=res,color = color)

if __name__ == "__main__":
    app.run(debug=False)
```

GITHUB LINK

https://github.com/IBM-EPBL/IBM-Project-43220-1660714305

PROJECT DEMO LINK

https://drive.google.com/file/d/12jnsEnbwp5WNQw7l-u6fqCNJrlsQJSlm/view?usp=drivesdk