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DIABETIC RETINOPATHY USING MACHINE LEARNING

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Abstract:*Diabetic Retinopathy (DR) is an eye disease associated with chronic diabetes. It is the leading cause of blindness in people. People with diabetes have been diagnosed with some stage of diseases. This disease results from complications of Type 1 and Type 2 diabetes. This disease can develop if the blood sugar levels are left uncontrolled for a prolonged period of time. It is caused by the damage of blood vessels in the retina of the patient's eyes Diabetic Retinopathy (DR) is still screened manually by ophthalmologist which is a time consuming process and automatic diagnosis of the disease into its different stages using deep learning, machine learning and image processing techniques . Development to the vision damage can be slowed down or reversed if Diabetic Retinopathy (DR) is detected on time.*

I. INTRODUCTION

Diabetes mellitus is a metabolic disease in which the person's body produces an inadequate amount of insulin to produce high blood sugar. The people who are suffering from diabetes for more than 10 years have a 60% chance of causing diabetic retinopathy. According to the International diabetes Federation, the number of diabetes in the world is estimated to be 650 million by the year 2030.

Diabetic retinopathy is a state of eye infirmity in which damage arises due to diabetes mellitus. The increased blood sugar causes the blood vessels present damage in their capillaries due to the loss of pericytes, which are contractile cells that wrap capillary endothelial cells in the body's venules. Excess glucose molecules cause this damage in the blood, which clump together in the vessels disrupting circulation. This process leads the vessels to lose their impermeability properties and two major problems occur in the retina .

The first problem is vascular endothelial growth factor which is cytokine protein production and it generates new blood vessels from existing ones known as neo vessels. The problem with this protein lies in the growth of the retina's surface. Since there is no blood circulation, these areas will only grow until they burst, producing bleeding in the retinal and vitreous cavity. Tissue expansion results in the patient's blindness.

The second problem is plasma leakage. Due to lipid sweating, a fat accumulation begins to occur, altering the macula and leading to vision loss. This could be detected by a detection method using a deep learning algorithm. Most of the new cases could be reduced with proper medication as well as frequent monitoring of the eyes. It primarily affects the retinas of both the eyes, which can lead to vision loss if it is not treated. Poorly controlled blood sugar level increases the risk of developing diabetic retinopathy.

II. IMPORTANCE OF THE RESEARCH WORK

Diabetic Retinopathy (DR) is proliferative when the damages result in blood vessels growing beyond the retina. Diabetic Retinopathy (DR) is developed when a patient has diabetes for at least 10 years without diagnosis and unaware of it. Therefore, the Diabetic Retinopathy (DR) can be prevented if it is detected early enough by health checkups and systematic treatment of diabetes.

Diabetic retinopathy can be classified from the earliest to the most advanced stages once examined the retina's fundus condition. Based on the International Clinical Diabetic Retinopathy disease severity scale, the

presence of Diabetic Retinopathy (DR) has five divisions such as None (Normal), Mild, Moderate, Extreme and proliferative.

Mild Diabetic Retinopathy (DR) is distinguished by the existence of micro aneurysms that have a diameter of 10 micrometer to 100 micrometer which is less than normal veins diameter in the eyes. The intermediate stage between severe and mild Retinopathy is a moderate Diabetic Retinopathy (DR). Several eye retina objects are close to the shape and size of the micro aneurysms which is often difficult to find appropriately.

Digital retina fundus images were used with computer vision techniques to automatically detect DR in different stages, and by using deep learning image processing methods. Deep learning is a proven methodology that automatically extracts features from images processed by a layer stack of a convolutional Neural Network. These features can determine what is present in the image, and it is useful for classification purposes. Deep learning models showed a higher capability in recognizing objects than the human eye.

Convolutional Neural Networks (CNN) consistently have been developed to detect the objects, segmentation and classification. Convolutional Neural Network (CNN) is a class of artificial neural networks that are proven to be highly efficient in cases of image classification and recognition.

III. SYSTEM ANALYSIS

PROBLEM DEFINITION

Individual screening for timely detection and appropriate treatment of Diabetic Retinopathy (DR). Retinopathy screening is done by fundus image examination by ophthalmologists with the help of color fundus photography using conventional fundus cameras operated by trained eye technicians or optometrists.

The primary issue is grading of the retinal images by ophthalmologists who are retinal specialists or by trained persons whose numbers are very short in supply compared to the load of patients requiring screening. These issues can be solved with provision of an automated imaging system within easy reach of the patient. Hence, there has been an increasing interest in the development of automated analysis healthcare projects using computer machine learning, deep learning, image processing and artificial intelligence for analysis of retinal images in people with diabetes thus solving at least some part of the problem.

The solution to this problem is basically teaching a machine to process and recognize specific patterns. It has been used for various technical tasks including accurate classification of high-resolution images. The machine learning techniques are more utilized in ophthalmology and their process includes mainly three parts, training, validation and testing datasets.

Machine learning process occurs by providing a large number of training datasets with thousands of retinal images of varying grades of Diabetic Retinopathy (DR) to the system as the training set. After training datasets which would be tested by using Convolutional Neural Network (CNN) and provide outcome with high accuracy in a short span of time. After being exposed to numerous annotated retinal images the machine learns to grade Diabetic Retinopathy (DR) by itself by building a model of complex relationships between input data and generalizing a performance standard.

EXISTING SYSTEM

In the existing system, it has been practically applied for prediction of diabetes but not for Retinopathy detection. Diabetic Retinopathy (DR) detection using machine learning projects exists only in research papers and not implemented realistically. Very few projects exist in predicting Diabetic Retinopathy (DR) but accuracy has not been sustained.

In the existing system, they have proposed the blood vessel density, number of microaneurysm, actual number of microaneurysm, standard deviation of red component, green component and blue component. Dataset with 300 images have been used that are divided into three subsets.

In Convolutional Neural Network (CNN), it does not encode the position and orientation of the object. Due to lack of ability to be spatially invariant to the input data. Lots of training data is required. The existing project mainly focuses on the prediction of this disease called as Diabetic Retinopathy (DR). Deep learning algorithms were not applied only in research papers; there is an explanation on detection retinopathy using algorithms of deep learning and image processing techniques.

There is a need for a proposed system where diabetic screening will be recognized using image classification, computer vision, machine learning, artificial intelligence, Artificial Neural Network and deep learning algorithms used to find the accuracy rate. There is a lack in proficiency and equipment which are

required in areas where the rate of diabetes in local populations are high and diabetic retinopathy detection is needed.

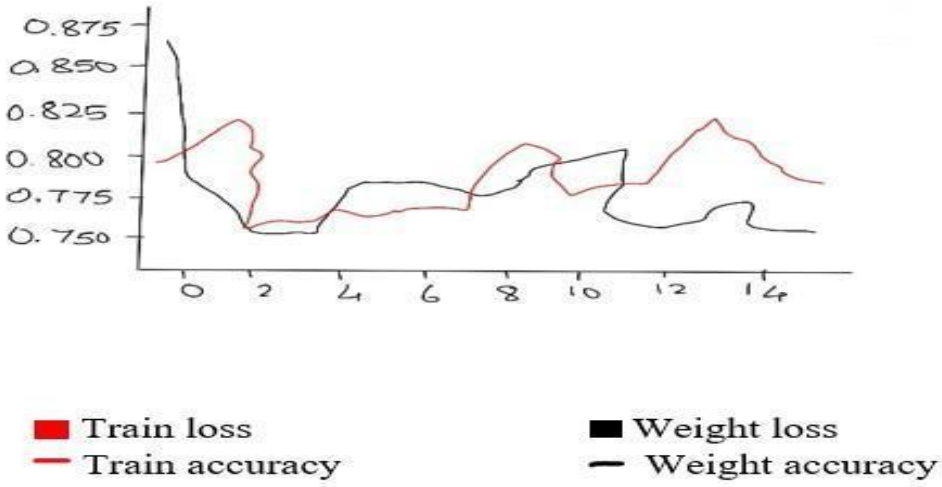

Fig 1: Underfitting

UNDERFITTING OF DATA SET:

Underfitting which smashes the deep learning model where the occurrence of this would give incorrect accuracy when fewer data set been used. Underfitting can be prevented by using more data set as well as reducing the features by using feature selection. The underfitting happens when size of the training dataset used is small and model that has been applied on training the dataset is simple. If training data is not cleaned well if it has noises even after data cleaning then underfitting arises. The underfitting is avoided by removing noise completely and increasing the number of epoch while training the image dataset to get better accuracy. Feature extraction is applied more in order avoid inaccuracy due to underfitting.

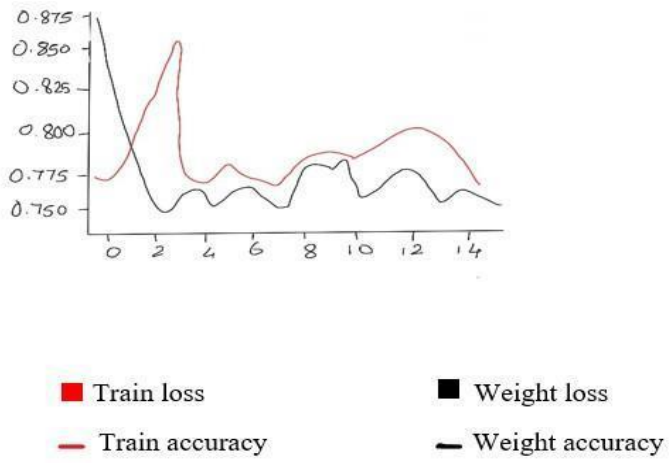

Fig 2: Over fitting

OVER FITTING OF DATA SET

Over fitting is applicable when more data set has been used. When a model uses a lot more data than it actually needed where it starts searching for the noisy data which leads to the inaccurate data values. The efficiency and accuracy of the model decreases. Overfitting where it has to estimate the accuracy of the performance of model when new data has been used. The accuracy should be estimated until it has been actually tested. Overfitting has to be avoided by early stopping because while training a model it measures the performance of the model based on each replication. The model overfits the training data as it weakens after each replication and the accuracy of the result is inappropriate.

PROPOSED SYSTEM

In recent years most of the image processing researchers indulged in the development of machine learning and deep learning approaches. In the proposed system, it is based on the key aspects of disease severity

classification from image classification. In proposed Diabetic Retinopathy (DR) detection using machine learning and deep learning models are considered and its building blocks are,

- Data exploration
- Data visualization
- Data augmentation
- Convolutional Neural Network algorithm
- Build residual model (residual network)
- Training deep learning models

The proposed system overcomes the drawbacks of the existing projects because based on the patient's diabetes condition their medical reports are examined and taken as datasets. This data is preprocessed and an appropriate deep learning algorithm such as Convolutional Neural Network is applied. There are certain packages and libraries which are imported. By applying a deep learning model which gives high accuracy using image classification and recognition methods.

Convolutional Neural Network (CNN) consists of multiple layers of artificial neurons. Where an input image is used, each layer generates several activation functions that are passed on the next layer. The proposed system helps the ophthalmologist to identify the diabetic retinopathy by the presence of lesions which cause abnormalities. While detection of diabetic retinopathy using machine learning and deep learning would be effective.

Convolutional Neural Network (CNN) has been effectively used to solve medical image problems and it can fix the automatic analysis of retinal images. This algorithm uses the classified retinal injury to an appropriate degree and extracts the features of retinal images. The goal of this diabetic retinopathy detection is to make an automated detection system to detect this disease at an early stage otherwise which leads to loss of vision and it saves time.

DATASET AND LIBRARIES

Dataset is added to the system from the web where the dataset consists of images belonging to five categories. Categories that are present in the data are normal, mild, moderate, severe and proliferative. This Kaggle Dataset used for Diabetic Retinopathy Detection.

The dataset was created with images taken from publicly available retinopathy detection datasets. The Kaggle dataset contains 1000 images with diabetic retinopathy and without diabetic retinopathy. From the total images we have chosen images with diabetic retinopathy and normal images. Datasets are imported and there are certain libraries such as pandas, numpy, tensorflow, matplotlib , seaborn and sklearn.

PRE-PROCESSING

In image pre-processing has to find exudates where the image from the dataset is converted into HSV. Color space conversion is converting an image that is represented in one color space to another color space, the goal being to make the translated image look as similar as possible to the original.

Red, Blue, Green channels in the given image to Hue, Saturation, Value. It is useful to extract coloured exudates from RGB images when we convert RGB to HSV. Then edge zero padding, median filtering and adaptive histogram equalization is done.

DATA EXPLORATION AND VISUALIZATION

Images that are taken as datasets are preprocessed and used to explore and visualize data to expose insights from the patterns of the images. Data exploration is used to explore and visualize data to uncover insights from the start and identify the patterns to know more. Using data exploration, users can better understand the bigger picture and get to insights faster.

Heat map depicts the correlations between the features and the targeted variable. These correlation of heat maps contain a solid diagonal line which represents the correlation of each feature with itself. These plots aim to identify highly correlated features shown in the diagonal values quickly.

DATA AUGMENTATION

By using this technique, it is used to increase the amount of data by adding modified copies of already existing images. Data augmentation creates newly synthetic data as an information that is manufactured artificially and algorithmically from existing data. Data augmentation is useful to improve performance and

outcomes of machine learning models by forming new and different examples to train datasets. It helps to reduce overfitting when training a machine learning and deep learning model. If the dataset is a machine learning model which performs better and accurately.

CONVNET NETWORK MODEL

Convolution Neural Network (CNN) is used in image recognition and processing that is designed to process pixel data. It forms a Convolutional layer and a pooling layer is added after this layer. Input image is a convolutional layer where there is another layer known as the pooling layer which reduces the spatial size of the input image. Then the pooling layer is flattened. After flattening a fully connected layer is formed that determines the best possible outcomes.

BUILD RESIDUAL DEEP NEURAL NETWORK

Deep Neural Networks which result in improved accuracy and performance. In the case of recognizing images, the first layer may learn to detect edges, the second layer may learn to identify textures and similarly the third layer can learn to detect objects. Keras are used to build Convolutional Neural Network models. The problem of training very deep networks has been alleviated by the introduction of residual networks. Resnets or residual networks are made up from residual Blocks. Displays every single layer that had been created in other modules.

TRAIN DEEP LEARNING MODEL

Compiling the model takes two parameters: optimizer and loss. The optimizer controls the learning rate where Adam is used as an optimizer and it adjusts the learning rate throughout training. Learning rate determines the optimal weights for the modules that are calculated. A smaller learning rate leads to more accurate results but the time it takes to compute the weights will be longer. Categorical cross entropy is a loss function used to classify the tasks.

IV. DIABETIC RETINOPATHY USING MACHINE LEARNING

The Main idea of this research work is to provide easy screening of diabetic retinopathy which is a prominent reason for blindness among people who suffer from diabetes. An appropriate detection should be available to healthcare professionals because the manual process of detecting this disease takes longer time. There are several modules in the proposed system which will help the user to interact with the system with ease. These are the key modules that are integrated with the project,

1. Data exploration
2. Convolutional Neural Network algorithm
3. Train deep learning model

DATA EXPLORATION

In this module, it is used to have a deeper understanding of the dataset and identify the patterns and areas that are uncovered. After exploration data is visualized where the data would be represented in graphical format.

CONVOLUTIONAL NEURAL NETWORK ALGORITHM

Convolution neural networks are mainly used for image classification and image analysis. It consisted of one or more convolutional layers and then followed by one or more fully connected layers. The CNN consists of an input, hidden and output layer. The input layer basically consists of arrays of pixels. The hidden layer is the most important layer as it plays the main role in image computation. Hidden layer comprises activation functions and biases. The output layer helps us to determine the class score. The benefit of CNN's is that they are easier to train with providing high accuracy.

TRAIN DEEP LEARNING MODEL

This module covers the work of data cleaning and splitting the data set into five categories such as normal, mild, moderate, severe and proliferative diabetic retinopathy. It trains a deep learning model to detect retinopathy from a dataset.

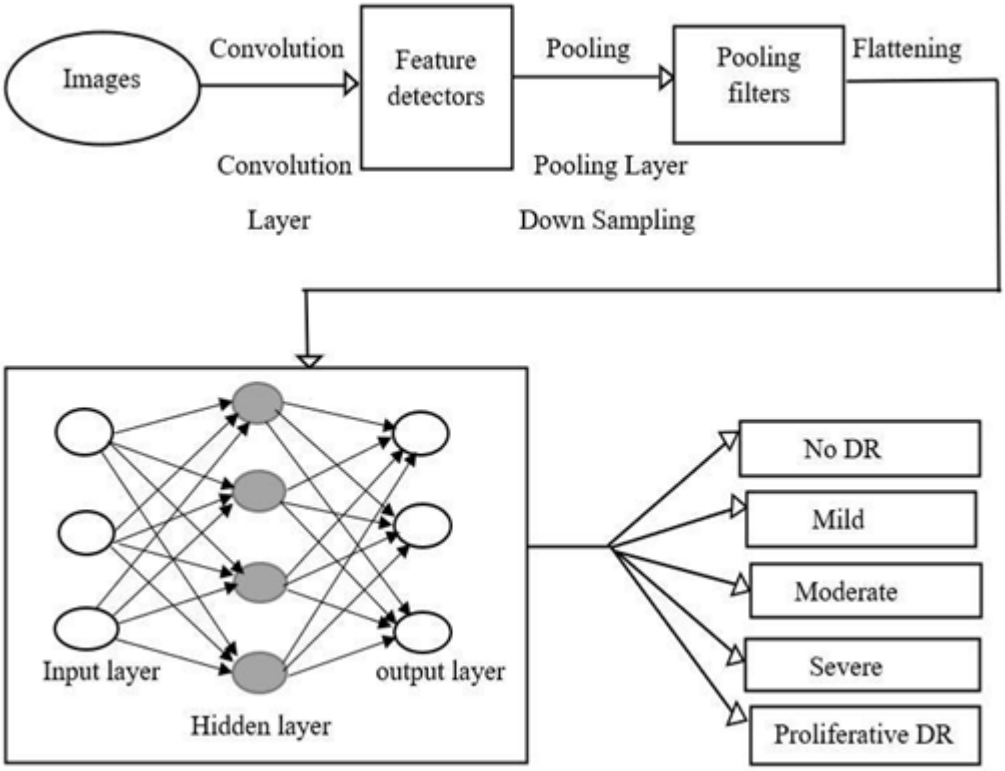

Fig 3: Fully Connected Layers

The training loss is a metric which is mainly used to assess how a deep learning model fits the training data where the error of the model occurs while training an image data set. The training set is a part of a dataset where it initially trains the model. Training loss has been calculated by adding the sum of errors of each while training the data set. The training loss is measured after each iteration and then visualized by plotting a curve of the training and validation loss. The validation loss is another kind of metric where it is used to access the performance of a deep learning model while validating the image set. The validation loss is another part of the dataset which is been set to validate the performance of the Convolutional Neural network (CNN) model. The validation loss is similar to the training loss as well as it is calculated from a sum of the errors of each validation. Recall is a function used for pattern recognition by training data set and then it has been validated by using this function

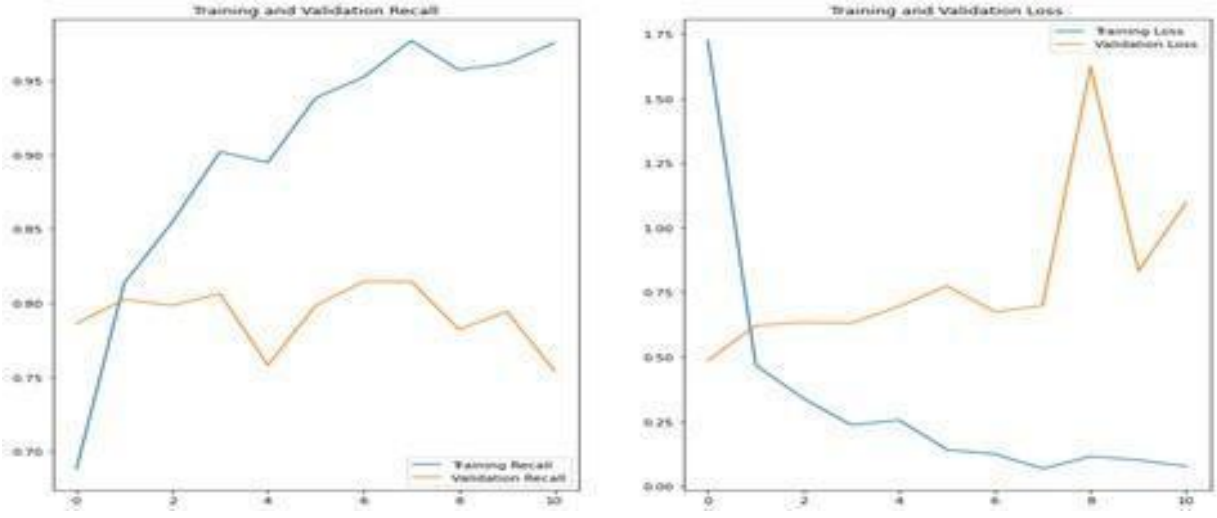

Fig 4(a): Train and validation Recall (b) Train and validation loss

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PSEUDO CODE

Pseudo code in machine learning and deep learning is often used to do programming and apply algorithms based on fields. It follows a methodology that allows the programmer to represent the implementation of an algorithm. Algorithms are represented with the help of pseudo codes as they can be interpreted by programmers.

- Import packages and data
- Data cleaning
- Build a model to detect

IMPORT PACKAGES AND DATA

Step 1: Import required packages
Step 2: load images from kaggle dataset

DATA CLEANING

Step 3: Removal of noise from images
Step 4: Find bounding boxes from the pre-processed image

BUILD A MODEL TO DETECT

Step 5: cv ← openCV2

V.RESULTS AND DISCUSSIONS

Python is used as front end and tensor flow for Convolutional Neural Network backend where it measures the accuracy of the training model. Binary cross entropy is a loss function which is used to solve problems by using multi-label classification. Multi-label classification used to find whether the given images belong to the class or not where it is been categorized into five classes such as Healthy, Mild DR, Moderate DR, Severe DR and Proliferative DR.

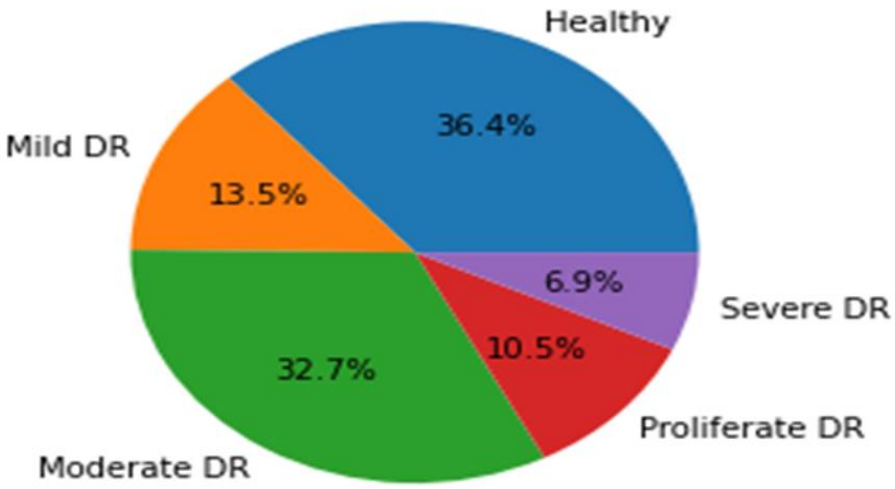

Fig 5: Pie chart of five classes

The above pie chart is divided into five categories such as healthy, Mild DR, Moderate DR, Severe DR and Proliferate DR. From the above analysis more number of patient's fall into this Healthy (No DR) category, then comes Moderate DR followed by Mild DR. The count of Proliferate DR patient's is much more when compared to Severe DR. In Overall analysis, the highest count would be Healthy whereas least count would be Severe DR.

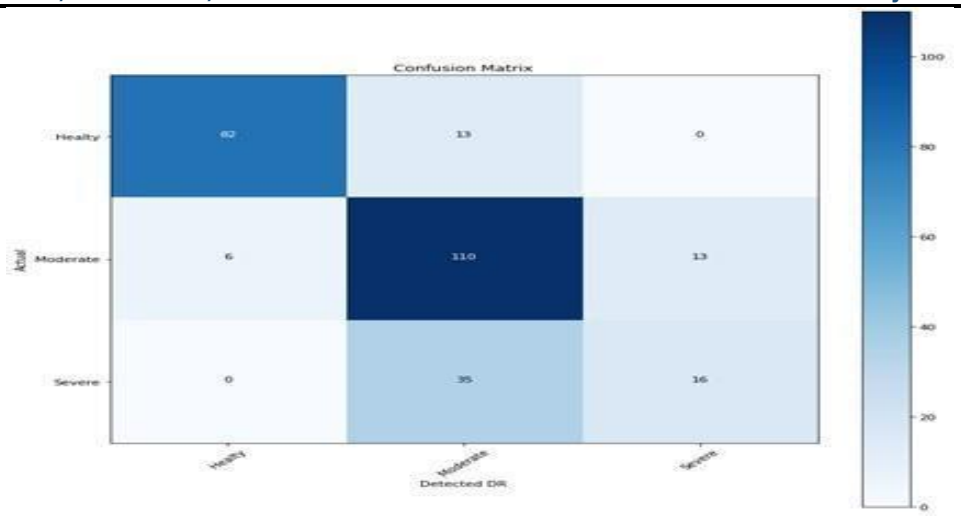

Fig 6: Confusion Matrix chart on diagnosis

Confusion Matrix where it has been divided into three categories by taking as an average value of two categories into one. Healthy means Normal, Moderate where it takes an average value of mild and moderate DR and then severe where again it takes average value of severe and proliferate DR. This matrix used to classify all these three categories to get better insights of this disease and would be easier to predict the number of patients who are diagnosed with this disease based on their medical condition.

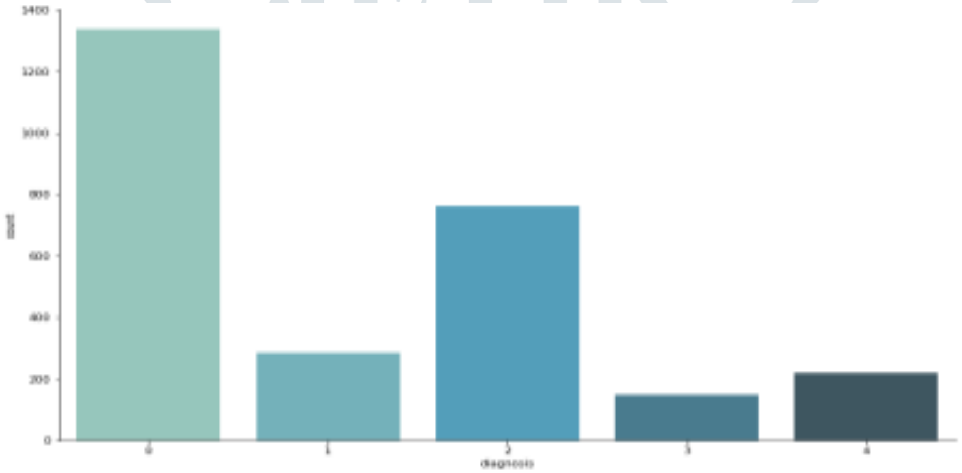

Fig 7: Bar chart on diagnosis

VI. CONCLUSION

Diabetes leads to other health complications including heart disease, chronic kidney disease, nerve damage, and other problems with feet, oral health, vision, hearing, and mental health. Diagnosis of diabetic retinopathy has improved utilizing Convolution Neural Network (CNN) which is an architecture and contains channels that come under deep learning algorithms. The portrayal of the results shows that the proposed model is at greater accuracy. The execution of the proposed system could deal with the requirement of the manual screening process. The Analysis from this proposed system has been categorized into five different classes for better screening of diabetic retinopathy as part of Convolutional Neural Network (CNN) strategy.

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