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Machine Learning Technique for Feature Extraction and Segmentation of Retinal Blood Vessels

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Abstract **: *The term Diabetic retinopathy is the serious issue that is caused by the diabetes, which affects the eyes that may lead to blindness. DR takes place due to damaged arteries and veins that are a part of the fundus of the eye. Although DR can be prevalent now days, its prevention remains challenging. Visual analysis of the funds and consideration of colour photographs Ophthalmologists directly examine the existence and severity of DR. This process is expensive as well as time consuming as there are huge number of diabetes affected people worldwide. The automatic Diabetic Retinopathy system is expanded to predict various related diseases that are analysed. The proposed methodology uses EYEPACS dataset that consists on 35,126 fundus images. These images are pre-processed and sent to neural network that detects type of DR. CNN detects clusters of pixels that are damaged in the macula region and in turn evaluates the overall damaged area in the macula from the retinal images. The retinal fundus images present structural and impulsive noise.***

Keywords **: *Diabetic retinopathy, Fundus Imaging, Abnormal features, Machine Learning.***

I. INTRODUCTION

The terminology DR-Diabetic Retinopathy is known as progressive pathology and it is found in individuals who have diabetes mellitus for many years. It causes a group of lesions in the retina. The number as well as types of lesions that are available on the retina can determine the severity and probability of the disease. It is a disease which is responsible for insufficient insulin - a hormone that transfers the sugar into the cells from the blood. As a result, more sugar prevails in the blood which can harm the entire body including blood vessels. Fig 1. shows fundus images with diabetic retinopathy-DR.

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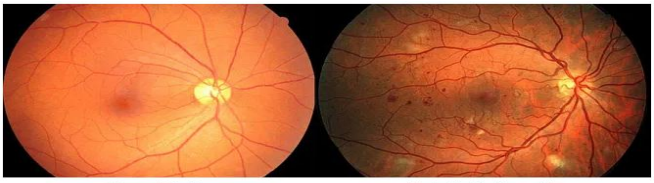

Fig 1. a) Healthy fundus image, (b)Fundus image having DR

1) Non Proliferative DR (NPDR):

This type is of milder form and usually it is symptomless.

2) Proliferative DR (PDR):

Many blood vessels in the retina stop do not provide sufficient blood flow due to which it grows new abnormal blood vessels.

II. DIABETIC RETINOPATHY PREDICTION

Diabetic retinopathy (DR) is encountered in people having diabetes for a long period of time. Damage to the blood vessels in retina causes DR. People having very high and uncontrolled blood sugar are more likely to have DR. The DR is divided into Proliferative DR(PDR) and Non Proliferative DR(NPDR). NPDR is further classified into Mild NPDR, Moderate NPDR and Severe NPDR.
Following are the stages of DR :

0 - No DR

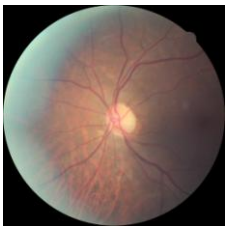

Fig 2. No DR

1 - Mild non proliferative retinopathy: Microaneurysms (swelling of blood vessels), appear at this stage These micro aneurysms may release some kind of fluid or blood into the retina.

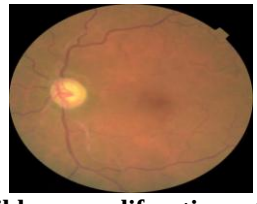

Fig 3. Mild non proliferative retinopathy

2 - Moderate non-proliferative retinopathy: Blood vessels in retina swell up.

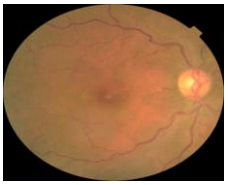

Fig 4. Moderate non-proliferative retinopathy

3 - Severe non proliferative retinopathy : Blood vessels get blocked in turn blocking the blood supply to retina.

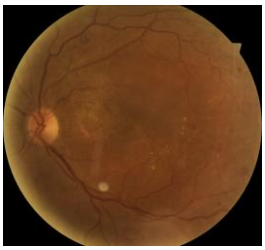

Fig 5. Severe non-proliferative retinopathy

4 - Proliferative diabetic retinopathy (PDR) : Many blood vessels in the retina stop do not provide sufficient blood flow due to which it grows new abnormal blood vessels.

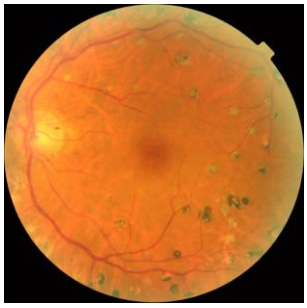

Fig 6. Proliferative diabetic retinopathy

III. LITERATURE REVIEW

Pilar P´erez Conde, Jorge de la Calleja, Antonio Benitez, Ma. Auxilio Medina et al [1] discovered a methodology to divide fundus images into two classes : NPDR and PDR. This methodology is divided into three steps :

A. Image processing : In this step two image processing mechanisms are used : Canny edge finder and the histogram adjustment technique.

1) The Canny edge finder : It is a technique used to find out various edges in the image.

2) Histogram equalizer: This strategy uses a indirect mapping which reallocates the estimations of pixels in the information image.

B. Lessening of images and extracting the features : Here a eigen fundus image is formed. The critical data of every image is encoded, the encoded images and informational index are contrasted.

C. SVM approach for classification: They used the dataset having 151 fundus eye images of size of 2588×1958 pixels. These images are divided into two classes 109 as NPDR and 42 as PDR by a retinologist.

"Santhakumar R", et.al [1] has developed a tool that makes patch level image and level prediction. They have used the feature plot using PCA for visualization of parameter value for the different classes. The patch level prediction are made using multi class Support Vector Machine. One of the limitation in this technique dual quadratic problem when functions having high complexity are used.

METHOD : Detection of Diabetic Retinopathy using Neural Networks.

Xiyang Liu, et al [4] has developed a framework for classifying images by identifying the region that has features that will help in the classification of DR and using a deep learning convolutional neural network (CNN). The ROI of the lens was found using Candy detection and Hough transform . CNN was used to investigate the slit-lamp image.

METHOD: - Features Extraction Using SVM (Support Vector Machine)

R. Adalarasan, et al [3] turn the filters to find the part of vessel to be extracted in green channel images. Biogeography Based Optimization Algorithm was used for classifying exudate pixels.

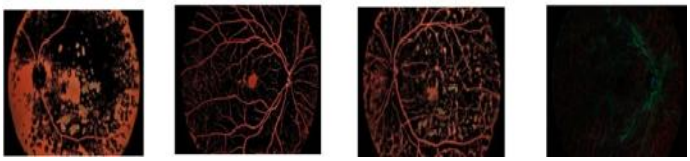

Fig 7. Color based approach. [3]

Ramon Pires, et al [9] directly trained a classifier for DR detection. They have used BossaNova and Fisher Vector. These features extend the classical Bags of Visual Words. Is simple to implement, test, and deploy.

IV. PROPOSED METHODOLOGY

We propose a novel system for severity classification of DR images using CNN. Figure 8 shows our proposed system architecture. The objectives of the proposed system are as follows:

1. To detect type of DR (0 normal 4=cataract)
2. To identifying damaged pixels in the macula.
3. Detect exact area of degenerated pixels in fundus camera image.
4. Provide a platform to detect the disease from the retinopathy image.

A. System Architecture

1) Original Retinal image:

a. Each image has been resized and cropped to have a maximum size of 1024px.
b. Images have a subject id as well as if it is left or right fundus image.
c. Images maybe out of focus, underexposed, or overexposed.

2) Pre-processing

a. The images have been resized to 512*512 pixels.
b. The dataset is not balanced so a sampling method is used to use equal number of images from each class.
c. Tensorflow augmentor is used to perform augmentations like flipping , contrast on the images.

3) Model Architecture

a. We implement attention mechanism to turn pixels in the GAP on an off before the pooling and then rescale the results based on the number of pixels.

b. We use Inception V3 model as base pretrained model and implement a trained model about it.

4) Identification of type of eye Disease Using CNN

Images are classified into the following stages:
0 - No DR, 1 – Mild NPDR, 2 – Moderate NPDR, 3 – Severe NPDR, 4 - Proliferative DR.

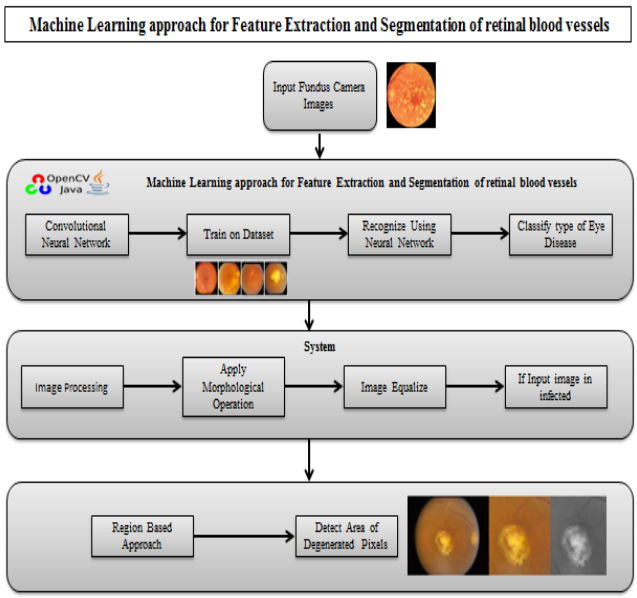

Fig 8. Proposed System Architecture

Algorithm Used

Algorithm 1:- Inception v3 Model

Inception v3 is a built in model in additional to CNN. Inception v3 network piles up 11 inception modules. Each module consists of pooling layers and convolutional filters and rectified linear units are used as activation function.

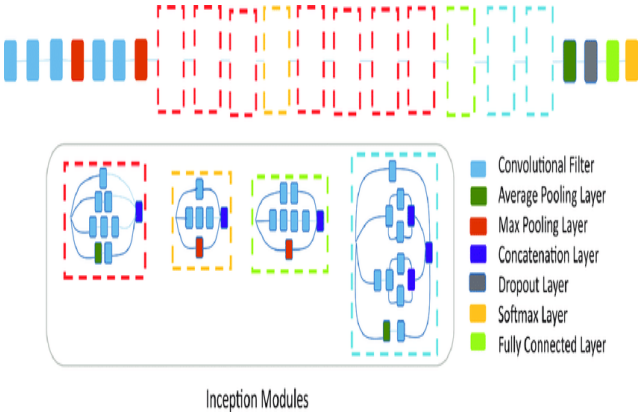

Fig 9. Inception v3 Model

- The input of the model is two-dimensional images of 16 horizontal sections placed on 4 3 4 grids as produced by the preprocessing step.
- Three fully connected layers of size 1024, 512, and 3 are added to the final concatenation layer.
- A dropout with rate of 0.6 is applied before the fully connected layers as means of regularization.
- The model is pre-trained on Image dataset and further fine-tuned with a batch size of 8 and learning rate of 0.0001.
- Model using Inception v3 model and trained model.

```
Model: "trained_model"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
feature_input (InputLayer)   (None, 4, 4, 2048)        0
_________________________________________________________________
batch_normalization_95 (Batc (None, 4, 4, 2048)        8192
_________________________________________________________________
global_average_pooling2d_1 ( (None, 2048)              0
_________________________________________________________________
dropout_1 (Dropout)          (None, 2048)              0
_________________________________________________________________
dense_1 (Dense)              (None, 128)               262272
_________________________________________________________________
dropout_2 (Dropout)          (None, 128)               0
_________________________________________________________________
dense_2 (Dense)              (None, 5)                 645
=================================================================
Total params: 271,109
Trainable params: 267,013
Non-trainable params: 4,096
_________________________________________________________________
```

Fig 10. Trained Model

V. RESULTS

The working of the architecture is assessed in terms of accuracy , precision, sensitivity and specificity in respect to images in all stages of DR. The model is trained for 18,000 images and tested on 9632 images. We trained the network for 15 epochs. We have used Google Colab to test our model. TP means an DR affected image is correctly classified as having DR, TN means a DR affected image is correctly classified as having DR, FP means no DR image is wrongly classified as having DR and FN means an Dr affected image is wrongly classified as having no DR. Accuracy achieved on test data is 62%.

	Precision	Recall	F1-score	Support
0	0.71	0.86	0.78	6721
1	0.11	0.07	0.09	827
2	0.21	0.09	0.13	1569
3	0.11	0.03	0.05	259
4	0.15	0.14	0.14	200
Accuracy			0.62	9576
Macro avg	0.26	0.24	0.24	9576
Weighted avg	0.55	0.62	0.58	9576

Fig 11. Classification Report

$$Sensitivity = \frac{TP}{TP+FN}$$

$$Specificity = \frac{TN}{TN+FP}$$

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN}$$

The severity of the disease is measured depending on the area calculated from the pre-processing and feature extraction and also from the CNN algorithm, Depending on the severity, there are four categories such as mild, moderate, severe and cataract stage.

VI. CONCLUSION AND FUTURE SCOPE

Diabetic Retinopathy is a result of diabetes and is a major reason of vision loss. Early diagnosis helps in early treatment, which is important for preventing total blindness. As there are less no of specialist against the growing diabetic population there is a need to have a system that detects DR accurately.

Neural networks can help in detecting DR as they work well with image datasets. Real time dataset has enhanced the effectiveness of the retinopathy detection technique used by us. We were able to achieve a good test accuracy in very less number of epochs. We also trained our model on large set of fundus images. We will work further on using different pretrained networks along with our trained model. We will also focus on increasing the classification accuracy for the different stages of PDR.

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