Classification of Diabetic Retinopathy Phase using Convolutional Neural Network

S. Kanagaraj[1], K. Vaishaali[2], N. Aadish[3], S. Sudhira[4]

[1]Associate Professor, Department of Information Technology, Kumaraguru College of Technology, Coimbatore, India

[2]Student, Department of Information Technology, Kumaraguru College of Technology, Coimbatore, India

[3]Student, Department of Information Technology, Kumaraguru College of Technology, Coimbatore, India

[4]Student, Department of Information Technology, Kumaraguru College of Technology, Coimbatore, India

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Abstract - *Diabetic Retinopathy is a medical condition that affects the eye for people who are diabetic. It weakens and damages the blood vessels in tissues of the retina. This condition highly affects people who do not manage their blood sugar and pressure level properly. The symptoms include floaters, blurriness, difficulty in seeing colors which can ultimately lead to blindness. The damaged blood vessels leak and cause dark spots in the vision of those who are affected. So, this is done manually by the doctor by placing drops in the patient's eyes to dilate the pupil so that they get a better view of the inside and it will help them take a better look. This is where Machine Learning comes into play. In our project, we propose a solution that distinguishes the features from a MESSIDOR dataset using Convolutional Neural Network (CNN) as the input features for classification.*

Key Words: Diabetic Retinopathy, Classification, Machine Learning, MESSIDOR, Convolutional Neural Network.

1.INTRODUCTION

According to recent surveys, India is set to emerge as the diabetic capital of the world in a few years. Diabetes is said to be the fifth leading cause of blindness in the whole world. Visual Impairment is majorly caused by Diabetic Retinopathy and it is reported that based on statistics of 2013 the affected population was 382 million, and it is expected to cross 592 million by 2025. Diabetic retinopathy is affecting nearly 18% of India's diabetic population. The fact is that only a very little percentage of the population undergoes frequent eye check-ups, and also there are only a handful of centers with the retinal laser equipment and vitrectomy machines or a better automated solution to treat the disease. This lack of awareness and late diagnosis leads to a severe impact that causes blindness. Diabetic Retinopathy is often detected at an advanced stage when the symptoms are perceptible and this symptom is unfortunately the complete loss of vision. Sadly, Diabetic Retinopathy cannot be completely reversed with the available medical condition and also there is no known cure for the disease as of now. Usual symptoms include floaters, blurriness, dark spots in vision and finally complete blindness. There are four most common stages in Diabetic Retinopathy :

1.Mild Non-proliferative Retinopathy: In this stage there is a ball-like swelling in the retina's blood vessels.

2.Moderate Non-proliferative Retinopathy: In this stage, the blood vessels are blocked.

3.Severe Non-proliferative Retinopathy: Multiple blood vessels are blocked, thus depriving the blood flow inside the retina.

4.Proliferative Retinopathy: The blood vessels are abnormal and fragile, there will be leak in blood vessels, the walls of blood vessels become thin and result in blindness.

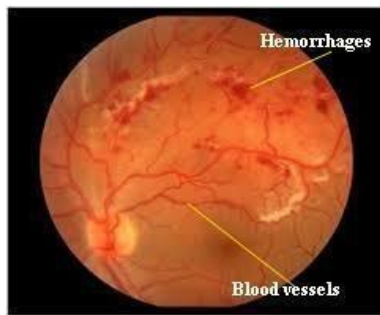**Fig -1**: Retinal Fundus Image

Fig -2: DR affected fundus image

2. LITREATURE SURVEY

2.1. GRAPHICAL USER INTERFACE FOR ENHANCED RETINAL IMAGE ANALYSIS FOR DIAGNOSING DIABETIC RETINOPATHY

To diagnose Diabetic Retinopathy, a Graphical User Interface (GUI) window was developed in which all the processes were integrated. A fundus camera was used to get the retinal images and all other processes were all done in a single window. But in this, only the image analysis was accurate and there wasn't any automated diagnosis.

2.2. MORPHOLOGY BASED EXUDATES DETECTION FROM COLOR FUNDUS IMAGES IN DIABETIC RETINOPATHY

Later a method in which morphology based exudates detection from Color Fundus images was used. The primary sign is exudates so if that was detected at an early stage blindness can be prevented

2.3.COMPUTER AIDED APPROACH FOR PROLIFERATIVE DIABETIC RETINOPATHY DETECTION IN COLOR RETINAL IMAGES

Based on texture and the vessel-ness features to detect Diabetic Retinopathy in colour retinal images, a computer aided approach was provided.

2.4. AUTOMATED DETECTION OF DIABETIC RETINOPATHY USING SVM

Using Support Vector Machine(SVM), Diabetic Retinopathy was detected with a sensibility of 95% and it was classified with an average accuracy of 85% but it did not integrate the presented algorithms in a tool for diagnosing Diabetic Retinopathy and soft exudates were not detected .From color fundus image, there was

accurate determination area and number of microaneurysm for detecting Diabetic Retinopathy but the system was better for Non-proliferative Diabetic Retinopathy and not for Proliferative Diabetic Retinopathy, and it couldn't classify the stages of Diabetic Retinopathy.

3. METHODOLOGY

In the proposed design, we have trained a model that classifies the retinal image as mild, moderate, severe , proliferative phase of Diabetic Retinopathy or absence of it using CNN. We feed the training and test datasets to our model. First, the pre-processing of the datasets happens, it will include rescaling, shear and horizontal flip and zooming. This helps in training the model to recognize similar images. We train the model using the training dataset to test the model. Test datasets are then provided to assess the performance of the model and may also play a role in feature selection.The last step is providing an image that is taken from the real world and fed into the system. Now, this image is taken as the test image. Then, CNN classifies the Diabetic Retinopathy and puts it into different categories.

4.DATASET

For this analysis, the MESSIDOR dataset is used for detecting and classifying Diabetic Retinopathy. The dataset was derived from three sources. The disc boundary and optic cup of the fundus images have been marked manually by ophthalmologists themselves. And out of these images, we have chosen six parameters to be extracted and assessed for this experiment. The parameters are optic disk, blood vessels, macula, exudates, haemorrhage, microaneurysm. The dataset consists of 3220 images from Base 12.
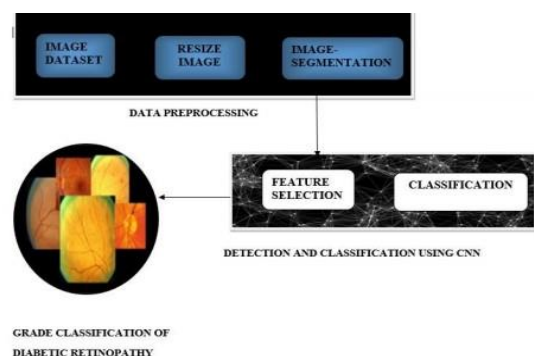

Fig -3: Proposed Method Design

5. PRE-PROCESSING

The fundus images are first cropped to a size of 512 x 512 for making them suitable inputs for Convolutional Neural Network(CNN) so that we can have consistent data images. Then the background and other noise in the images will be filtered and removed. Then the fundus images are segmented which makes it easier to concentrate only on the main features of Diabetic Retinopathy which are exudates (hard, soft), haemorrhages, and microaneurysm.

6.DETECTION AND CLASSIFICATION

6.1.CONVOLUTIONAL NEURAL NETWORKS

Visual imagery is specially analysed by CNN. With the given training data, It is computationally efficient. Achieving the efficiency by interspersing the convolutional layers with pooling layers. Main advantage of using CNN is it will decide the features which are important by itself which leads to the accuracy of the model. Mainly, two parameters which define the convolutional networks are: the size and the number of kernels. Generally, the size is 3×3, but may raise to 5×5 or 7×7. The number of kernels is arbitrary, which leads to the result of the depth of the output feature maps being determined.

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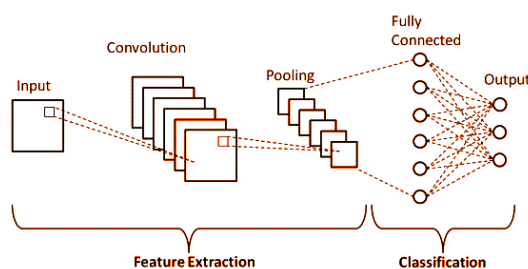

Fig -4: CNN Architecture

Multiple types of layers are commonly used in CNN,

Convolution layer - Apply the convolution operation on an image with a defined stride and padding

Pooling layer - For Max Pooling, we will create a pool size of 2x2. This helps us to reduce the feature map size while not losing important image information.

Fully Connected layer - This is the traditional neural network which is used at the end stem of the neural network.

Dropout layer - This is used for reducing overfitting. Randomly it turns off some neurons during the training at each pass

Batch Normalisation - This is used to normalise the output values which reduce computation time and this will introduce regularisation effect

6.2 ACTIVATION FUNCTION

"Output_dim" is the first parameter that is the number of nodes in the hidden layer. To fit the model, you will need more computing resources which require a high number of dimensions. To pick the number of nodes in powers of two is a common practice. Activation function is the second parameter. Usually we use the " **ReLu**" activation function in the hidden layer.

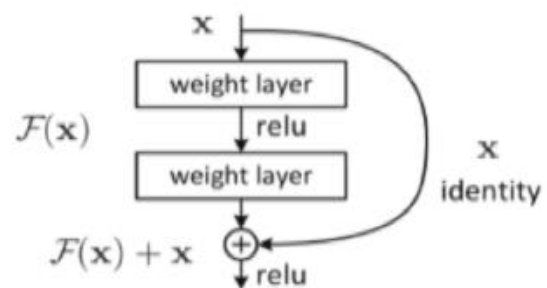```
classifier.add(Dense(units = 128, activation = 'relu'))
```



**Fig -5:** Activation Function

Output layer is the next layer we have to add. Here in this case, use the "**Sigmoid**" activation function since we are expecting a binary outcome. For more than two outcomes we should use "**Softmax**" function

classifier.add(Dense(units = 1, activation = 'sigmoid'))

## 7. DRAWBACKS OF EXISTING SYSTEM

The existing system classifies the grade of Diabetic Retinopathy using Fractal Analysis and Random Forest classification. Random Forest is a non-parametric model ,which means that the complexity increases with an increase in the number of training samples. Accuracy in RF is less for problems such as image classification. Though it was simpler to develop the model using the above-mentioned algorithms, this model also failed to distinguish mild diabetic retinopathy to severe diabetic retinopathy.

## 8. IMPLEMENTATION

We have used a framework developed by Google, TensorFlow as our Backend library and Keras , an open source Neural Network library that runs on the top of TensorFlow. All low-level computation such as tensor products, convolutions and many other things are handled by TensorFlow whereas Keras is a Low level wrapper.

For pre-processing we have used ImageDataGenerator from Keras that generates batches of tensor image data with real-time data augmentation. Our classifier is Sequential as we plan to put forth a linear stack of layers and we define all the layers in the constructor. We have used 2 sets of Convolutional and pooling layers and one each of Flatten and Dense layers. We have used activation functions 'relu' and 'sigmoid'. Our compiler is '**adam'** and we have used **binary crossentrophy** as loss.

We have created a convolution for each of the phase or category of Diabetic Retinopathy each with a single epoch(entire dataset is passed both forward and backward through the neural network once),samples in one epoch is 64 and steps per epoch is 80.Accuracy differs for each of the phases with highest accuracy being 98%.
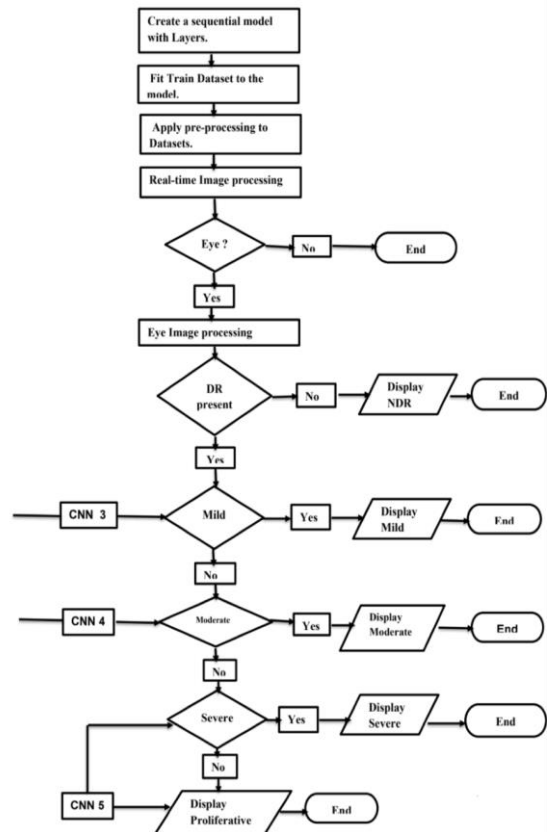


**Fig -6:** Proposed Method Workflow
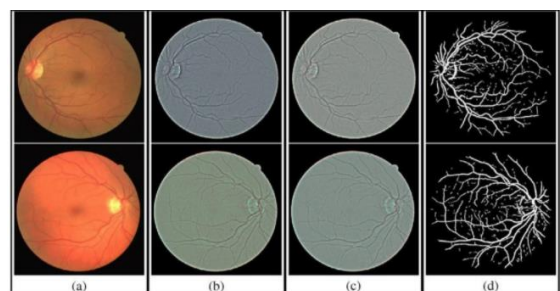
## 8.1 DATASET PREPROCESSING
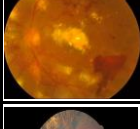


**Fig -7:** Dataset Pre-processing
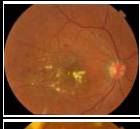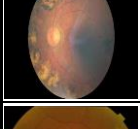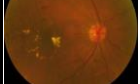
## 8.2 TRAINING CNN

```
Epoch 1/2
290/290 [==============================] - 21s 72ms/step - loss: -2937941.2500 - accuracy: 0.2310
Epoch 2/2
290/290 [==============================] - 21s 72ms/step - loss: -546139200.0000 - accuracy: 0.2345
DR
Found 68 images belonging to 2 classes.
Found 0 images belonging to 0 classes.
Epoch 1/2
68/68 [==============================] - 5s 80ms/step - loss: 1.0048 - accuracy: 0.7059
Epoch 2/2
68/68 [==============================] - 5s 79ms/step - loss: 0.6154 - accuracy: 0.7353
Found 89 images belonging to 2 classes.
Found 0 images belonging to 0 classes.
Epoch 1/2
89/89 [==============================] - 7s 78ms/step - loss: 0.6997 - accuracy: 0.4719
Epoch 2/2
89/89 [==============================] - 7s 78ms/step - loss: 0.6924 - accuracy: 0.6292
Found 62 images belonging to 2 classes.
Found 0 images belonging to 0 classes.
Epoch 1/2
62/62 [==============================] - 4s 57ms/step - loss: 0.5250 - accuracy: 0.8226
Epoch 2/2
62/62 [==============================] - 4s 59ms/step - loss: 0.1422 - accuracy: 0.9516
```

Fig -8: Training CNN

8.3 RESULTS

EXPERIMENTAL RESULTS		
IMAGE	CATEGORY	ACCURACY
	MILD	73.53%
	MODERATE	60.67%
	SEVERE	98.39%
	PROLIFERATIVE	95.16%
	NO DR	59.15%

9. CONCLUSION

Our Project aims to provide a highly accurate classification and detection of Diabetic Retinopathy. For high accuracy we use deep learning, (CNN). Finally the classification will result in absence or presence of Diabetic Retinopathy which includes either of the four classes of diabetic retinopathy which include Mild, Moderate, Severe, Absent. Future improvements will be built on these successes to further reduce the risk of vision loss and will lead to early diagnosis and less invasive treatments. In five to ten years DR treatment will have become increasingly individualized and targeted. Further improvements in our research include integrating all these processes under one window to make it easier, less cost and maintenance.

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