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# A Deep Learning Approach in Detecting Diabetic Retinopathy Using Convolutional Neural Network on Gaussian Filtered Retina Scanned images

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*Abstract*— Diabetic retinopathy is a diabetes complication that affects eyes. It is caused by damage to the blood vessels of the light-sensitive tissue at the back of the eye (retina). At first, diabetic retinopathy may cause no symptoms or only mild vision problems however, it can cause blindness. The condition can develop in anyone who has type 1 or type 2 diabetes. It may lead to poor vision and subsequently to complete blindness. This paper presents a Deep Learning approach in detecting Diabetic Retinopathy on Gaussian Filtered Retina Scanned images. We used a Gaussian filtered scan retina image dataset which was downloaded from kaggle.com. This dataset contains five image folders which are Mild folder that contains 370 images of patients with lesser risk to Diabetic Retinopathy (early stage), Moderate Folder contains 999 images of patients having 12%-27% risk of Diabetic Retinopathy, the Severe Folder contains 193 images of patients whose blood vessels have become more blocked, the Proliferate Folder contains 295 images of patients which are on the verge of going on a permanent blindness, the last folder is the No Diabetic Retinopathy folder which contains 1805 images of patients who have no Diabetic Retinopathy. After building and training our convolutional neural network model, the results obtain by the model shows an accuracy of 81.35% at an epoch number of 8. The trained model was saved and tested using flask framework. This model can be deployed to web for detecting and classifying the various categories of diabetic retinopathy.

***Keywords***— Gaussian filtered images, Diabetic Retinopathy, Convolutional Neural Network

## I. INTRODUCTION

Diabetic Retinopathy is a diabetes complication that affects the eyes. It is caused by damage to the blood vessels of the light-sensitive tissue at the back of the eye (retina). At first, diabetic retinopathy may cause no symptoms or only mild vision problems but eventually, it can cause blindness. The condition can develop in anyone who has type I or type II diabetes. The longer you have diabetes and the less controlled your blood sugar is, the more likely you are to develop this eye complication. Diabetic Retinopathy is a disease of the retina which occurs due to diabetes. It may lead to poor vision and subsequently to complete blindness. The blood vessels in the eye become weak and blood will leak out in the centre of the eye and cause blurry vision. Diabetic Retinopathy (DR) is the ocular manifestation of end-organ damage in diabetes mellitus. Eduard Jaeger first described the visible retinal changes of Diabetic Retinopathy in 1856, but the causal relationship between retinal exam findings and diabetes mellitus was controversial until 1875 when Leber confirmed the findings [1]. Today, Diabetic Retinopathy is a leading cause of visual impairment in the United States and most part of Africa. In 2005, 5.5 million people had diabetic retinopathy, and 1.2 million people had vision-threatening Diabetic Retinopathy. The centre for Disease Control and Prevention (CDC) projects that by 2050 those numbers will triple, to 16.0 million and 3.4 million, respectively. Fortunately, a better understanding of the risk factors contributing to the development of Diabetic Retinopathy, the pathology of the disease, and its functional manifestations has allowed for significant advances in the prevention and treatment of diabetic retinopathy.

Diabetic retinopathy involves the abnormal growth of blood vessels in the retina. Complications can lead to serious vision problems such as Vitreous haemorrhage where new blood vessels may bleed into the clear, jelly-like substance that fills the centre of your eye. If the amount of bleeding is small, one might see only a few dark spots (floaters). In more-severe cases, blood can fill the vitreous cavity and completely block your vision. Vitreous haemorrhage by itself usually doesn't cause permanent vision loss. The blood often clears from the eye within a few weeks or months. Unless your retina is damaged, your vision may return to its previous clarity. Retinal detachment**,** the abnormal blood vessels associated with diabetic retinopathy stimulate the growth of scar tissue, which can pull the retina away from the back of the eye. This may cause spots floating in your vision, flashes of light or severe vision loss. Glaucoma, the new blood vessels may grow in the front part of your eye and interfere with the normal flow of fluid out of the eye, causing pressure in the eye to build up (glaucoma). This pressure can damage the nerve that carries images from your eye to your brain (optic nerve). Blindness**,** eventually, diabetic retinopathy, glaucoma or both can lead to complete vision loss.

According to World Health Organization in 2005-2006, Diabetic Retinopathy (DR) accounts for 5% of all blindness, affecting 2 million people globally, and it is the leading cause of blindness in people aged between 15 – 64 years in industrialized countries. Diabetic retinopathy can be classified into two broad categories: Non-Proliferative Diabetic Retinopathy (NPDR) and Proliferative Diabetic Retinopathy (PDR). PDR and Diabetic Macular Edema (DME) are both sight-threatening and can result in visual impairment and/or blindness. The major risk factors for Diabetic Retinopathy are long duration of diabetes, poor glycaemic control and hypertension [2], and there is evidence from clinical trials that early treatment of PDR and DME can preserve visual acuity [3]. Visual loss from Diabetic Retinopathy is, therefore, potentially avoidable. Indeed, it has been estimated that blindness from Diabetic Retinopathy could be reduced by as much as 90% if agreed treatment protocols and standardized care for diabetics were to be implemented. Retinal images acquired through fundal camera with back mounted digital camera provide useful information about the consequence, nature, and status of the effect of diabetes on the eye. These images assist ophthalmologist to evaluate patients in order to plan different forms of management and monitor the progress more efficiently. The retinal microvasculature is unique in that it is the only part of human circulation that can be directly visualized non-invasively in vivo, and can be easily photographed for digital image analysis [4]. This paper proposes a deep learning approach using Convolutional Neural Network in detecting Diabetes Retinopathy from fundus images.

## II. RELATED WORK

Automated Detection of Diabetic Retinopathy using Deep Learning [5], demonstrated the use of Convolutional Neural Networks (CNNs) on colour fundus images for the recognition task of diabetic retinopathy staging. Their network models achieved test metric performance comparable to baseline literature results, with validation sensitivity of 95%. They additionally explored multinomial classification models, and demonstrate that errors primarily occur in the misclassification of mild disease as normal due to the CNNs inability to detect subtle disease features. They also discovered that preprocessing with contrast limited adaptive histogram equalization and ensuring dataset fidelity by expert verification of class labels improves recognition of subtle features. Transfer learning on pretrained GoogLeNet and AlexNet models from ImageNet improved peak test set accuracies to 74.5%, 68.8%, and 57.2% on 2-ary, 3-ary, and 4-ary classification models, respectively.

Approach for Diabetic Retinopathy Analysis Using Artificial Neural Networks [6], reviewed an automatic segmentation method used to detect cotton wool spots in the retinal images for diabetic retinopathy disease which affects up to 80 percent of all patients who have had diabetes for least 10 years or more. Early detection and proper treatment of Diabetic Retinopathy is important to prevent further complication or to control the progression of the disease. The retinal image has been preprocessed to enhance the quality of image. A feature extraction method was used to take useful elements from the retinal image. A neural network model was used for learning task and tested by k fold cross validation. Their approach is to analyze Diabetic Retinopathy image by using one of the Multilayer perception neural network, Support vector machine, Generalized Feed Forward Neural Network methods to get the 100% result.

Detection and Classification of Diabetic Retinopathy using Retinal Images [7], identified haemorrhages and classify different stages of diabetic retinopathy into normal, moderate and non-proliferative diabetic retinopathy (NPDR). The basis of the classification of different stages of diabetic retinopathy is the detection and quantification of blood vessels and haemorrhages present in the retinal image. Retinal vascular was segmented utilizing the contrast between the blood vessels and surrounding background. Haemorrhage candidates were detected using density analysis and bounding box techniques. Finally, classification of the different stages of eye disease was done using Random Forests technique based on the area and perimeter of the blood vessels and haemorrhages. Accuracy assessment of the classified output revealed that normal cases were classified with 90% accuracy while moderate and severe NPDR cases were 87.5% accurate.

Convolutional Neural Networks for Diabetic Retinopathy [8], proposed a Convolution Neural Network approach in diagnosing Diabetic Retinopathy from digital fundus images and accurately classifying its severity. They developed a network with Convolutional Neural Network architecture and data augmentations which can identify the intricate features involved in the classification task such as micro-aneurysms, exudate and haemorrhages on the retina and consequently provide a diagnosis automatically and without user input. They train the network using a high-end graphics processor unit (GPU) on the publicly available Kaggle dataset and demonstrate impressive results, particularly for a high-level classification task. On the dataset of 80,000 images used their proposed Convolutional Neural Network achieved a sensitivity of 95% and an accuracy of 75% on 5,000 validation images.

Diagnosis of Diabetic Retinopathy Using Deep Neural Networks [9], developed a model to detect Diabetic Retinopathy using fundus images that have been labelled by the proper treatment method that is required. Using this fundus images dataset, they trained a deep convolutional neural network models to grade the severities of Diabetic Retinopathy fundus images. They were able to achieve an accuracy of 88.72% for a four-degree classification task in the experiments. They deployed their models on a cloud computing platform and provided pilot Diabetic Retinopathy diagnostic services for several hospitals; in the clinical evaluation, the system achieved a consistency rate of 91.8% with ophthalmologists, demonstrating the effectiveness of their work.

Classifying Diabetic Retinopathy using Deep Learning Architecture [10], proposed deep learning approach using Deep Convolutional Neural Network (DCNN) in classifying Diabetic Retinopathy. DCNN gives high accuracy in classification of these diseases through spatial analysis. A Deep Convolutional Neural Network is a more complex architecture inferred more from human visual precepts. Amongst others, they used supervised algorithms in their proposed solution to find a better and optimized way to classifying the fundus image with little pre-processing techniques. Their proposed system architecture deployed with dropout layer techniques yields around 94-96 percent accuracy and was tested with popular databases such as STARE, DRIVE, kaggle fundus images.

Computer-Assisted Diagnosis for Diabetic Retinopathy Based on Fundus Images Using Deep Convolutional Neural Network [11], presented a novel algorithm based on deep convolutional neural network (DCNN). Unlike the traditional DCNN approach, they replace the commonly used max-pooling layers with fractional max-pooling. Two of these DCNNs with a different number of layers are trained to derive more discriminative features for classification. After combining features from metadata of the image and DCNNs, they trained a support vector machine (SVM) classifier to learn the underlying boundary of distributions of each class. For the experiments, they used the publicly available Diabetic Retinopathy detection database provided by Kaggle. They used 34,124 training images and 1,000 validation images to build their model and tested with 53,572 testing images. The proposed Diabetic Retinopathy classifier classifies the stages of Diabetic Retinopathy into five categories, labelled with an integer ranging between zero and four. The experimental results show that their proposed method can achieve a recognition rate up to 86.17%, which is higher than previously reported in the literature. In addition to designing a machine learning algorithm, they also develop an app called “Deep Retina.” Equipped with a handheld ophthalmoscope, the average person can take fundus images by themselves and obtain an immediate result, calculated by our algorithm. It is beneficial for home care, remote medical care, and self-examination.

## III. METHODOLOGY

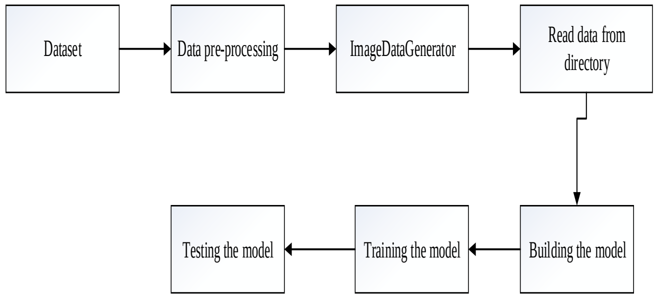


Figure 1: Architectural Design of the proposed system

The design methodology and the system implementation process are as follows:
**Dataset:** This dataset was downloaded from kaggle.com and it’s created by Sovit Ranjan Rath, 2020 This consist of a Gaussian filtered retina scan images folder of which consist of diabetic retinopathy images which can be categorized into five severities/stages. The severities are as follows; Mild Stage which indicates that lesser risk of a patient having diabetic retinopathy except the patient has confirmed of a diagnosis of Diabetic Macular Edema (DME). The Moderate Stage indicates 12% to 27% risk of a patient having a Diabetic Retinopathy. In the Severe Stage, patients have intraretinal haemorrhages (>20 in each quadrant), venous bleeding in two or more quadrants. The last stage is the Proliferate Diabetic Retinopathy which a patient has either neovascularization of the disc/elsewhere or vitreous/preteretinal haemorrhage.

**Data pre-processing:** This has to do with transforming the dataset into machine readable (0s and 1s) form since the machine does not understand images.

**Image Data Generator:** This class has to do with generating batches of tensor image data with real time data augmentation. This also can be used with a lot of built-in-pre-processing such as scaling, shifting, rotation, noise, whitening etcetera so we used the rescale attribute in rescaling the image tensor between 0 and 1.

**Read data from directory:** we used ImageDataDenerator class function in reading each of the image folders using the flow directory function.

**Building the Model:** The model was built with an input shape of 200 x 200 with a 3 bytes colour, five hidden layers, 178 input neurons and 5 output layers representing the of stages of Diabetic Retinopathy and one output layer showing that there is no Diabetic Retinopathy. Relu was used as the activation in each of the five hidden layers while Maxpooling2D (This down samples the input representation by taking the maximum value over the window defined by the pooling_size=(2,2) for each dimension along the feature axis) was used making the resulting output_shape= (input_shape-pool_size +1)/strides). Softmax is being used as the activation for each of the five output layers.

 

**Training the Model**: The model was trained using a Convolutional Neural Network with an epoch of value of 9, 128 batch size.

**Testing the Model:** The trained model was deployed into a web application using flask which is a micro framework in python where users can upload retina scan images.

## IV. RESULTS AND DISCUSSION

In this paper, a Gaussian filtered image dataset was used which contains a total number of 3368 scan retina images to detect Diabetic Retinopathy.The images were process using ImageDataGenerator in rescaling the image by 1/255. The images were read from directory using the flow_from_directory(). The images were further resized to 200 x 200 following a batch size of 128. After preprocessing, the model was built with a total of 178 input neurons, five hidden layers and five output layers which will detect if the patient have no Diabetic Retinopathy disease or he/she have a Diabetic Retinopathy which can further be categorized into any of the four stages which are Mild stage, Moderate stage, Severe stage and Proliferate stage. The model was trained using a Convolutional Neural Network with 9 numbers of epoch. The Convolutional Neural Network gave an accurate result of about 81.35% accuracy at an epoch number of 8.

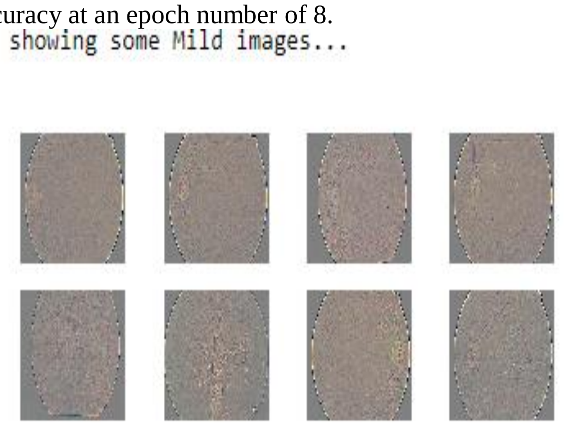


Figure 2: showing some images of the mild stage of Diabetic Retinopathy


Figure 3: showing some images of the moderate stage of Diabetic Retinopathy


Figure 4: showing some images of the Severe stage of Diabetic Retinopathy


Figure 5: showing some images of the advance stage of the Diabetic Retinopathy which can cause permanent blindness

```
model.summary()

Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 198, 198, 16)      448
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 99, 99, 16)        0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 97, 97, 32)        4640
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 48, 48, 32)        0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 46, 46, 32)        9248
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 23, 23, 32)        0
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 21, 21, 32)        9248
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 10, 10, 32)        0
_________________________________________________________________
conv2d_4 (Conv2D)            (None, 8, 8, 64)          18496
_________________________________________________________________
max_pooling2d_4 (MaxPooling2 (None, 4, 4, 64)          0
_________________________________________________________________
flatten (Flatten)            (None, 1024)              0
_________________________________________________________________
dense (Dense)                (None, 128)               131200
_________________________________________________________________
dense_1 (Dense)              (None, 5)                 645
=================================================================
Total params: 173,925
Trainable params: 173,925
Non-trainable params: 0
```

Figure 6: showing the summary of the training model

```
Epoch 1/9
26/26 [==============================] - 222s 9s/step - loss: 1.1899 - acc: 0.4992
Epoch 2/9
26/26 [==============================] - 216s 8s/step - loss: 0.8185 - acc: 0.6999
Epoch 3/9
26/26 [==============================] - 236s 9s/step - loss: 0.6640 - acc: 0.7592
Epoch 4/9
26/26 [==============================] - 218s 8s/step - loss: 0.6557 - acc: 0.7613
Epoch 5/9
26/26 [==============================] - 219s 8s/step - loss: 0.5895 - acc: 0.7953
Epoch 6/9
26/26 [==============================] - 219s 8s/step - loss: 0.5586 - acc: 0.7999
Epoch 7/9
26/26 [==============================] - 213s 8s/step - loss: 0.5385 - acc: 0.8098
Epoch 8/9
26/26 [==============================] - 231s 9s/step - loss: 0.5191 - acc: 0.8135
Epoch 9/9
26/26 [==============================] - 228s 9s/step - loss: 0.5014 - acc: 0.8098
```

Figure 7: showing training epochs of the model with a loss and accuracy values of the model

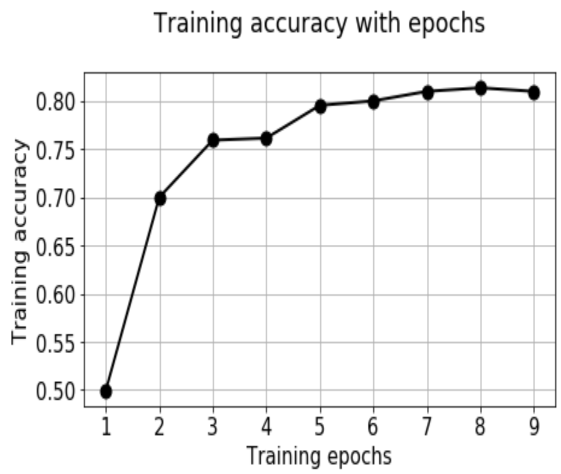


Figure 8: showing a graphical representation of training accuracy against training epochs

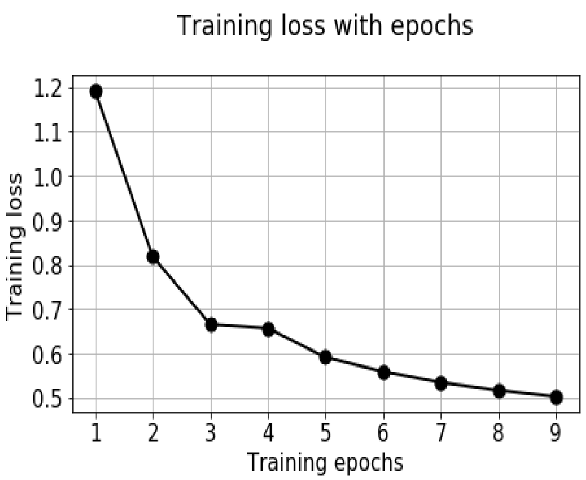


Figure 9: showing a graphical representation of loss values against training epochs

## V. CONCLUSION AND FUTURE SCOPE

This study presents a convolutional neural network model in detecting Diabetic Retinopathy on Gaussian filtered images which contains scan retina images. After building and training our convolutional neural network model, the model had an accuracy of 81.35% at an epoch number of 8. This research could be further studied by increasing the number of training epochs to check if a more accurate result can be obtained or by using another Deep learning algorithm and also, by deploying the trained model for use in real systems to detect the stages of Diabetic Retinopathy.

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