Journal of Informatics
Electrical and Electronics Engineering, 2021,
Vol. 02, Iss. 02, S. No. 016, pp. 1-5
ISSN (Online): 2582-7006

Deep Learning based Method for Multi-class Classification of Diabetic Retinopathy

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How to cite this paper: K. Damodara, A. Thakur (2021) Deep Learning based Method for Multi-class Classification of Diabetic Retinopathy. *Journal of Informatics Electrical and Electronics Engineering, Vol. 02, Iss. 02, S. No. 016, pp. 1-5, 2021*.

https://doi.org/10.54060/JIEEE/002.02.016

Received: 07/04/2021
Accepted: 27/05/2021
Published: 09/06/2021

Abstract

Diabetes mellitus is a form of diabetes with secondary microvascular complication leading to renal dysfunction and retinal loss also termed as diabetic retinopathy. Retinopathy is grave form of retinal disease. It is the leading cause of blindness in the world. Blockage of tiny minute retinal blood vessels due to the high blood sugar level is the reason why retinopathy leads to blindness or loss of vision. This study serves the purpose of deep learning-based diagnosis of Diabetic retinopathy using the fundus imaging of the eye. In this study architectures such as VGG 16 and VGG 19 are deployed in order to classify the images into 5 categories. The performance of the two models were compared. The highest accuracy is 77.67% when using the VGG 16 pre-trained model.

Keywords

Multi-class classification, Diabetic retinopathy, VGG 16, VGG19

1. Introduction

Convolutional Neural Networks have been recently used in diagnosing of diabetic retinopathy through fundus imaging of the eyes. Considering diabetes mellitus, Diabetic retinopathy is a major complication which results in the blind or loss of vision. Tiny minute blood vessels supplying blood to the retina are damaged or blocked due to the increased blood sugar level leading to loss of vision. DR is classified into five stages which are non-diabetic retinopathy, mild form of DR, moderate form of DR, proliferate-DR and the last stage is the severe form of DR.

In the early stages of retinopathy, the walls of the blood vessels in retina weaken. Tiny bulges started to protrude from the vessel walls, sometimes leaking or oozing fluid and blood into the retina. Nerve fibers in the retina may also swell, producing white spots in the retina. As diabetic retinopathy progresses, new blood vessels may grow and threaten the vision of the eye

[1]. Common techniques for the detection of Diabetic retinopathy is done by ophthalmologists by dilation of the eye. The other techniques include fluorescein angiography, fundus photography and optical coherence tomography. The current technique of diagnosing retinopathy is subjective and needs to be looked upon later by the doctor. Patients tend to turn up a stage where it is difficult to reverse the retinopathy, due to inadequate access to the detection and later eye care services. Hence this calls for a noninvasive diagnostic system that is not only capable of detecting but also garde them according to the stage described above.

Acharya et al introduced machine learning based detection and classification of DR. A SVM classifier was used to identify the normal, mild, moderate, severe and proliferate form of retinopathy. An accuracy of 82% along with specificity of 82% was obtained [5]. Pratt et al proposed a CNN Model with data augmentation that could identify features of the images such as microaneurysms, macular edema. The training was done with the help of publically available image data set on Kaggle. The proposed model had an accuracy of 75% and specificity of 95% [6]. Computer aided diagnosis method was proposed to detect microaneurysm on the fundus images by Mizutani et al [7]. Algorithm to retrieve retinal vasculature to obtain and detect blood vessels was proposed by Tan et al. Dekhil et al proposed a fine-tuned VGG-16 trained on Kaggle image database [3].

In this paper CNN architecture is proposed that classify images with high accuracy into the 5 controls (normal, mild, moderate, severe and proliferate). Pre-trained VGG 16, VGG 19 were deployed and was used on the Kaggle database consisting of 3662 images. The performance was measured by obtaining the accuracy of the model

2. Materials and Method

2.1. Data Set Description

The fundus images used for this study has been obtained from Kaggle APTOS Blindness Detection Competition 2019 [12]. A total of 3662 fundus images were chosen. Images were graded on a scale of 0 to 4 representing the stages of diabetic retinopathy. It is mentioned in the table below

Table 1. Stages of Retinopathy

Stage	Description
0	No Diabetic Retinopathy
1	MildDR
2	Moderate DR
3	Severe DR
4	Prolferate DR

2.2. Model description

The proposed model VGG 16 and VGG 19 were considered after the literature review. The architecture consists of many convolutional layers followed by activation function. The first layers of convolutional are required to learn the edges of the images. Later as the layer increases the convolutional layer learn the features of the fundus images. The activation function used is the MaxPool2D of kernel size 3x3.

After the last convolutional block, the network Is reduced or flattened into 1-dimension. This is followed by the dense layers and dropout so as to reduce the problem of overfitting [13-18]. The last dense layer classifies the 5 controls (No-DR, Mild DR, Moderate Dr, Severe and Proliferate DR). The softmax activation function is applied at this layer. The model was compiled keeping the learning rate as 0.0001 and categorical cross entropy is used as a loss function.

2.3. Training

Pre-trained VGG 16, VGG 19 were used (trained on Imagenet). Data Augmentation (rescale= 1./255.0 , horizontal_flip = true , validation_split = 0.2) were applied to the dataset. After training the results are obtained in the form of graphs as discussed in section III**.**

3. Results

A total of 731 images were used for validation. The network implemented on Python google colab yielded a training accuracy of 76.69% of VGG 16 model. Whereas VGG 19 gave us an accuracy of 74.72%.

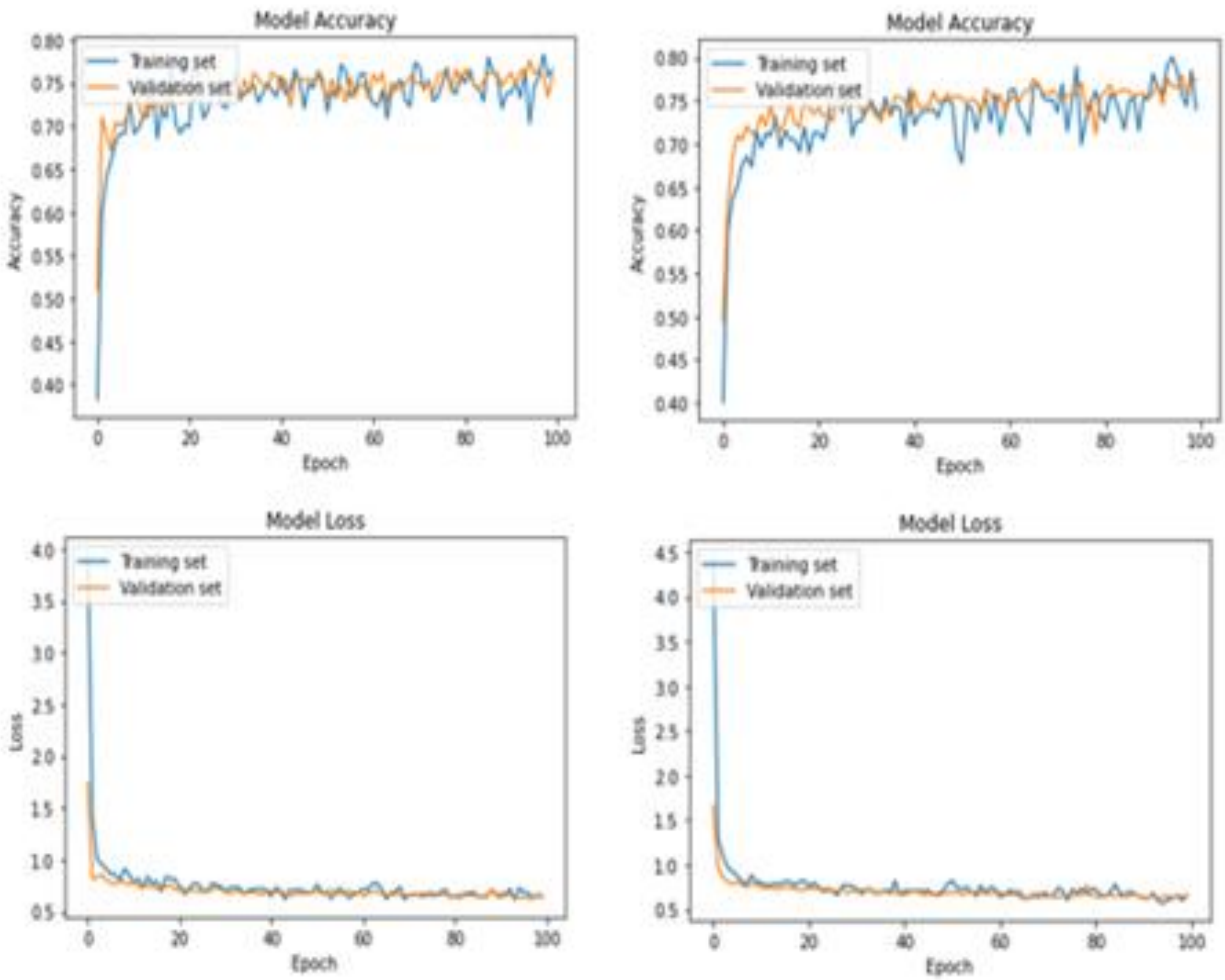

Figure 1. Accuracy and Loss plots for VGG 16 and VGG 19

Table 2. Training Results

MODEL NAME	Training accuracy	Training loss
VGG 16	0.7669	0.6460
VGG 19	0.7472	0.6340

Table 3. Validation Results

MODEL NAME	Validation accuracy	Validation loss
VGG 16	0.7579	0.6509
VGG 19	0.7502	0.6547

4. Conclusion

The use of convolutional neural network in the field of medicine has been successfully studied. Pre-trained models of VGG 16 and VGG 19 were used to implement multi-classification of diabetic retinopathy based on fundus images. The future scope allows us to use and analyses the soft computing techniques in the prediction of disease and to define a relation between the diagnosis, prognosis, and the treatment.

5. References

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