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DIABETIC RETINOPATHY DETECTION USING DEEP LEARNING AND INCEPTION-V3 MODEL

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ABSTRACT

Diabetic retinopathy is a complication of diabetes that targets the eyes by damaging the retinal blood vessels. Primarily occurs when the blood sugar level is unmanageable. Therefore, the person with diabetes mellitus is always at a high risk of acquiring this disease. The present work considers a deep learning methodology specifically a Densely Connected Convolution Network iNCEPTION-v300, which is applied for the early detection of diabetic retinopathy. It classifies the funds images based on its severity levels as No DR, and Yes DR. The datasets that are taken into consideration are Diabetic Retinopathy Detection 2015 and Aptos 2019 Blindness Detection which are both obtained from Kaggle. Our proposed model achieved 88.1% of accuracy. The main aim of this work is to develop a robust system for detecting DR automatically.

Keywords: Diabetic Retinopathy, Blindness, Deep Learning, Inception-V3, Retina Image.

I. INTRODUCTION

Diabetes is one of the most common diseases and its prevalence has increased worldwide. It is primarily associated with the production of insulin and high blood sugar of the body[1] resulting in the anomalous metabolic functions and complications like cardiovascular diseases, kidney failures, neural disorders and diabetic retinopathy (loss of vision), etc. Diabetic retinopathy is a crucial eye condition which results in loss of vision that cannot be reversed or corrected once experienced. The people who have a long history of diabetes are more prone to get afflicted with this disease, no matter whether a person is type1 or type2 diabetic, the probability of the disease increases as the age increases [2]. According to WHO, DR is an intense eye disease that requires urgent contemplation at an international level. According to a report, in India there are about 12,000 ophthalmologists for 60 million diabetics with eye disorder. The main reason for such an alarming number of patients is the result of the fact that mostly people are oblivious that they are suffering from this disorder. They also show insensitivity and an incautious attitude towards this disease. About 18% of people with diabetes are suffering from DR and the possibility of procurement of DR in a diabetic person is 25 times more than that of a healthier one [3]. The detection of this disorder is difficult to diagnose at an initial stage, owing to the fact that it is asymptomatic or shows very mild symptoms thus leaves a person in oblivion and eventually leads to vision impairment. Thus to detect DR at an early stage is pivotal in averting the complexities of this disorder. The diagnostics of this illness requires the professionals and specialists with highly effective equipment's and techniques that foster the advancements in leveraging the prognosis of this condition. The image of normal retina and the Retina with Diabetic retinopathy is shown in figure 1 and figure 2 respectively [4]. Since an unerring automatic detection technique is required to classify and circumspect the severity level of DR. Mostly research in the area of DR was carried out on the basis of feature extraction using machine learning approaches, but the problem rose with the manual feature extraction which prompted researchers towards deep learning.

The further research in medical fields paved path for many computer aided technologies like data mining, image processing, machine learning and deep learning. However, the Deep Learning has gained popularity in recent years in various fields like sentiment analysis, hand written recognition, stock market prediction and medical image analysis, etc. CNN in deep learning tends to provide constructive results when it come to the job of image classification. The architecture of CNN with its different layers is given in the figure 3[5].

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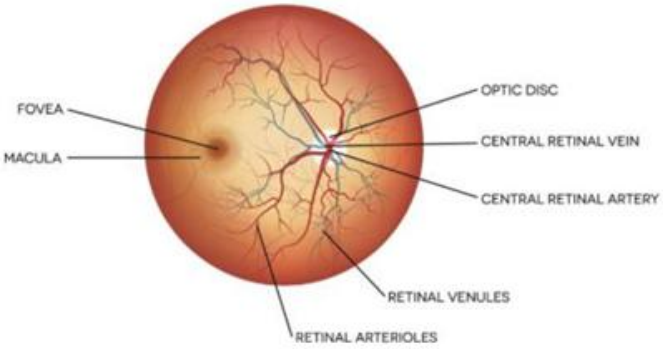

Fig. 1. Normal Retina

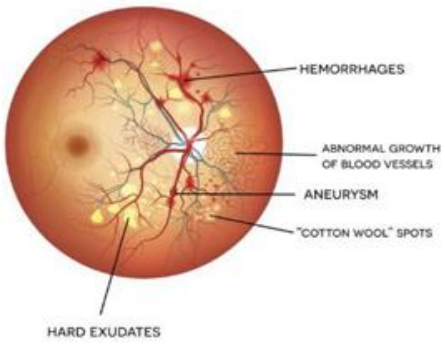

Fig 2. Diabetic Retinopathy

The present research employs deep learning methodology especially CNN variant DenseNet, which extracts the features automatically, rather than manually for the classification of fundus (eye) images based on the severity level. A Combination of the data set of "Diabetic Retinopathy Detection" 2015 from Kaggle and "Aptos 2019 Blindness Detection" from Kaggle was assembled for this study.

The paper is organized into various sections as: section 2 presents the recent work in this field. Section 3 gives the proposed solution for detecting DR. Section 4 will discuss the results of the research. Section 5 will provide a conclusion based on the research carried out in this study and finally Section 6 will conclude the paper by stating the limitation and future work for further study.

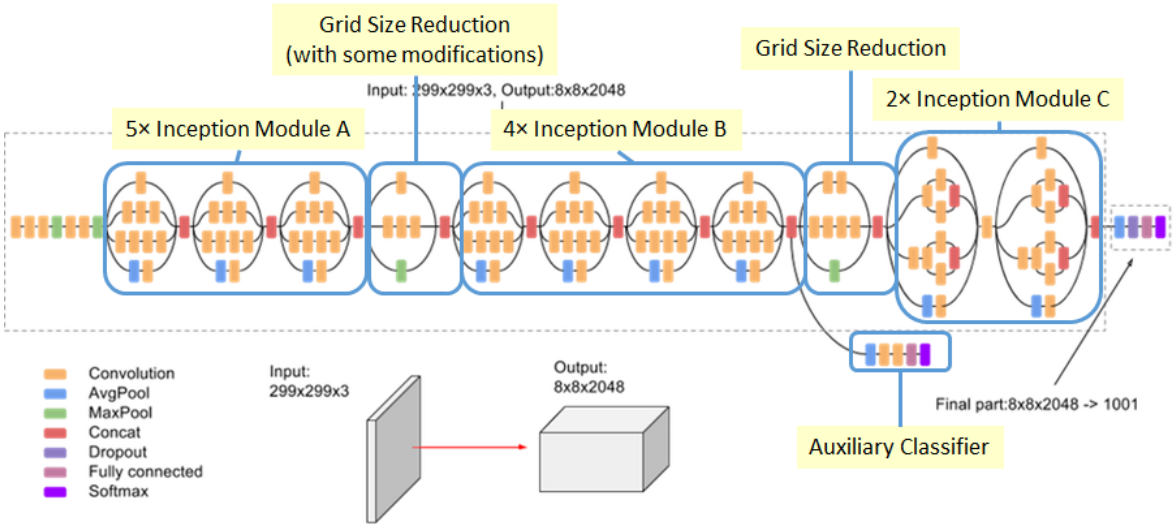

Fig 3. Inception-V3 CNN Architecture

II. LITERATURE SURVEY

J.calleja.et al [6] in their work used a two staged method for Diabetic retinopathy detection: LBP (Local Binary Patterns) for feature extraction and Machine Learning specifically SVM and Random Forest for classification purpose. The results obtained by the random forest outperformed the SVM with an accuracy of 97.46%. However, the dataset used in this study was quite small with 71 images. U.Acharya.et al[7] used features like blood vessels, micro aneurysms, exudates, and hemorrhages from 331 fundus images using SVM with an accuracy of more than 85%. K. Anant.et al[8] in their literature used texture and wavelet features for DR detection by making use of data mining and image processing on a database DIARETDB1 and achieved 97.95% accuracy. M.Gandhi.et al[9] proposed a method for automatic DR detection with SVM classifier by detecting exudates from fundus images. Some works try to integrate manual feature extraction with deep learning feature extraction for DR. one of such work include J.Orlando.et al [10] where CNN with hand crafted feature are used for feature extraction for detecting red lesion in the retina of an eye. S.Preetha et al.[11] In their literature predicted various diabetic related diseases using Data Mining and machine learning methods specifically for heart disease and skin cancer prediction while considering both advantages and disadvantages.

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While many researches or works are there about using machine learning approaches or data mining approaches, a quite different approach also came into the way of detection of diabetic retinopathy. S.Sadda et al. [12] make use of quantative approach to identify new parameters for detecting proliferative diabetic retinopathy. It is based on the hypothesis that location, number and area of lesions can improve the forecasting process of Retinopathy. The methods used for this study were Subjects and Imaging Data, Ultra wide Field Image Lesion Segmentation, Quantitative Lesion Parameters and Statistical Analysis. Comparison of lesions were made on the basis of Lesion number, Lesion surface area, Lesion distance from the ONH center and Regression analysis. The work presented by J.Amin et al. [13] provides a review of various methodologies for diabetic retinopathy by detecting hemorrhages, micro aneurysms, exudates and also blood vessels, and analyzes the various results obtained from theses methodologies experimentally in order to give in-depth insight of ongoing research. The study carried out by Y.Kumaran and C.Patil [14] focuses on the different types of preprocessing and segmentation techniques mostly and gives an in detail procedure for detection of diabetic retinopathy in human eye consisting of number of systems and classifiers. M.Chetoui et al.[15] Proposes a diagnostic method for DR using machine learning specifically SVM and Texture features. Texture features used were LTP (Local Ternary Pattern) and LESH (Local Energy-based Shape Histogram) that provided better results when compared to Local Binary Pattern (LBP). The accuracy of 90.4% was obtained by LESH with SVM.

III. METHODOLOGY

The main objective of this work is to build a stable and noise compatible system for detection of diabetic retinopathy. This work employs the deep learning methodology for detecting the diabetic retinopathy based on severity level (No DR, Mild, Moderate, Severe and Proliferative DR). Many processes were carried out before feeding the images to the network. We trained two models in this work: our proposed model and the regression model and then a comparison was made between the accuracies obtained by the two models. Though our proposed model performed better than the regression model. The figure 4 shows the proposed methodology.

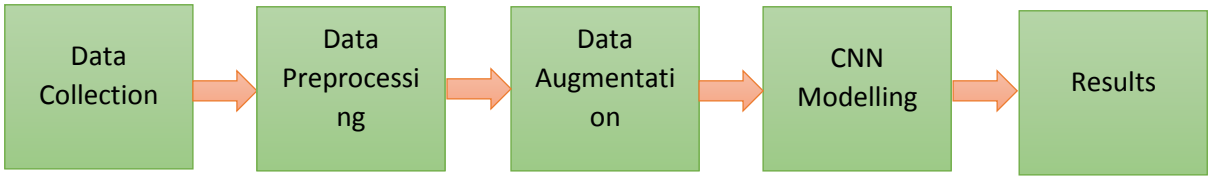

Fig 4. Proposed Methodology

A. Data Source: Data used for this study has been taken from Diabetic Retinopathy Detection 2015[21] and APTOS 2019 blindness detection [22] from kaggle. Both the datasets contains thousands of retinal images under different conditions. For every subject, two images of both the eyes are given as left and right. As the images come from different sources like different cameras, different models, etc. It has an abundance of noise associated with it, which apparently needs to be removed, thus, requiring a number of preprocessing steps. The diabetic retinopathy associated with each image has been rated on the scale of 0-4 as: 0 - No DR 1 - Mild 2 – Moderate 3 - Severe 4 - Proliferative DR Figure 5 shows the retinal images with ratings on the basis of severity level from 0-1.

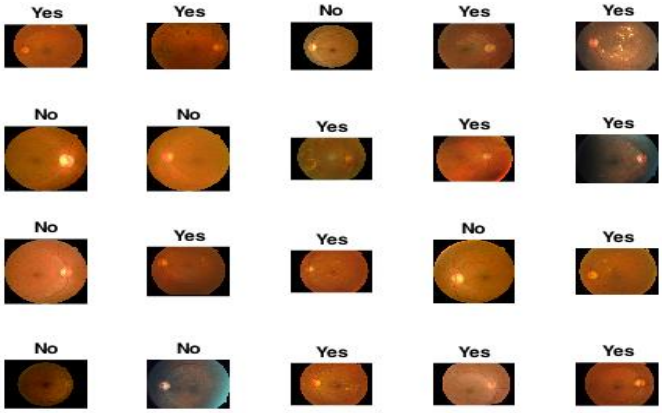

Fig 5. Image samples based on severity from dataset:

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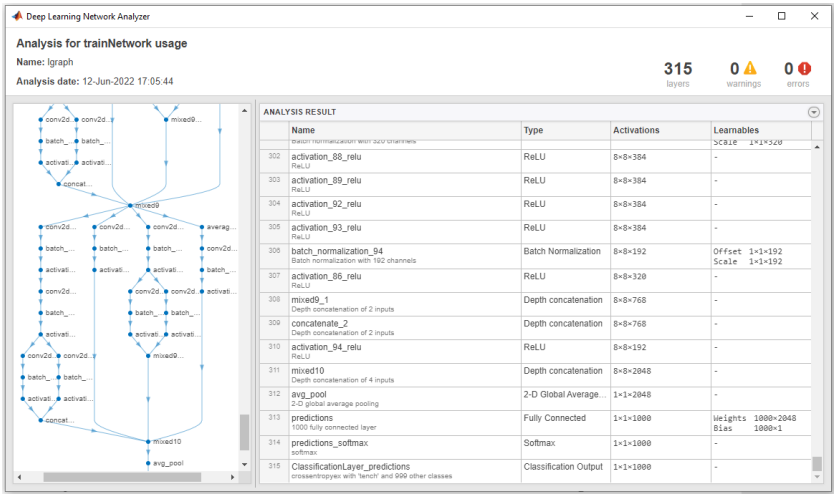

Fig. 6. Summary of the model.

Modelling: We used a DenseNet-169 (Densely connected convolutional neural network) and Regression model for training purpose. In DenseNet-169 weights are loaded into the network without the top or last layer. When modelling the network, initially there is no last layer. We design this layer by using Global Average Pooling 2D, a Dropout layer set at 0.5 and an output comprising of five nodes for each class. Global Average Pooling 2D is same as that of 2D average Pooling in operation, but it considers the entire input block size as pool size. A Dropout layer address the issue of over-fitting. Adam optimization algorithm is used for optimizing the weights on training this model. A sequential modelling approach is used for adding layers and customizing the layers like convolutional, dropout, dense, optimizers, etc.

IV. RESULT AND DISCUSSION

We trained our proposed model using DenseNet-169 on a combination of dataset from Diabetic Retinopathy Detection 2015[21] and APTOS 2019 blindness detection[22] from kaggle. There was a lot of noise associated with the images provided by the dataset therefore, preprocessing was needed. For preprocessing, we first removed the black border of the images in order to focus more on the fundus image only, black corners of images was also removed, then the images were resized to a standard format of 256*256 of width and height. At last a Gaussian blur was applied to the images in order to remove the Gaussian noise. After preprocessing we analyze that the data is highly unbalanced among the severity classes, majority of data belonged to the class '0'i.e. No DR. in order to address this issue, we used data augmentation, which gives us 7000 images from each severity class and made the data balanced. After preprocessing and augmentation of images, data was finally fed to the DenseNet-169 for training the model. After evaluating our model the training accuracy of 0.953 was obtained, while as validation accuracy of 0.9034 was achieved. We also calculated the Cohen Kappa score which comes out to be 0.804. We also applied a regression model to our dataset and compute its validation saccuracy which is 0.789. Our proposed model outperforms the regression model. The results of our model are summarized in table 1.

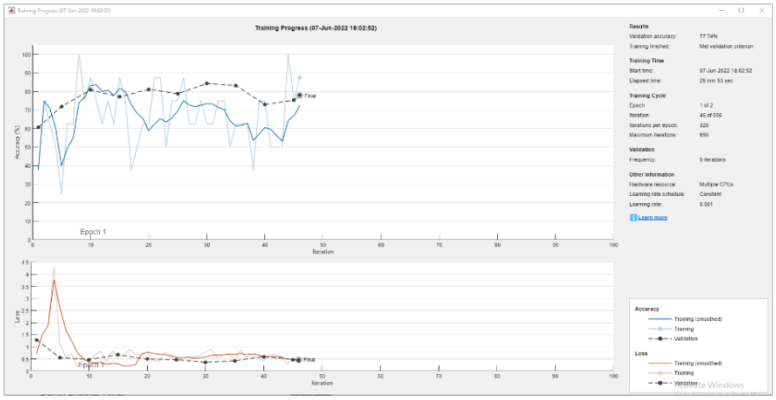

Fig. 7. Training of the proposed model

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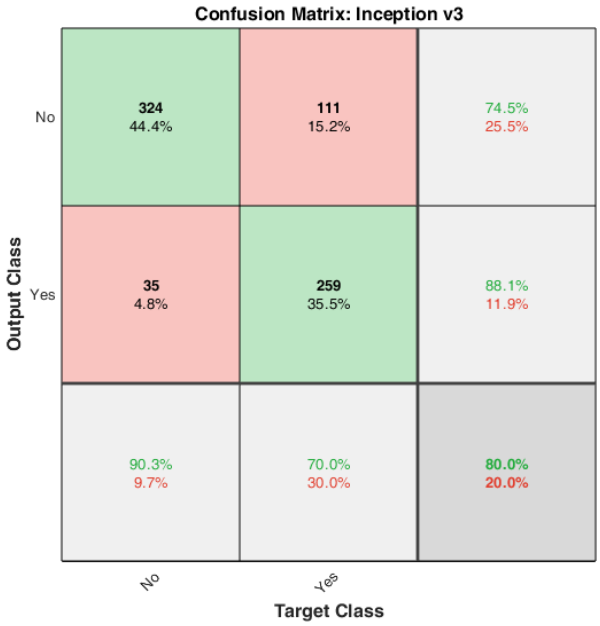

Fig 8. Confusion matrix of the classification result

V. CONCLUSION

Traditional method for detection of DR is prolonged, challenging and costly, thus many researches were brought up to automate the detection process by using machine learning and deep learning approaches. In this work, we presented a comprehensive study of various methodologies for detecting diabetic retinopathy automatically and attempted to propose our own deep learning approach for the early diagnosis of retinopathy by using a DenseNet169 (which is a new CNN architecture, having many deep layers). Two datasets: 'Diabetic Retinopathy Detection 2015'and 'APTOS 2019 blindness detection' from kaggle were used together for this study. A lot of preprocessing and augmentation was done to standardize the data in a desired format and to remove the unwanted noise. Beside DenseNet-169 classifier, we also used a regression model to draw the comparison between the results. Moreover, machine learning classifiers like SVM, DT and KNN were compared with the proposed system. Where the best accuracy among all was obtained by the proposed model and it also classifies the images into more no of classes. Our proposed model performed better than the regression model by achieving the accuracy of 90% however, 78% accuracy was yielded by the regression model.

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