A Detailed Study on Diagnosis and Prediction of Diabetic Retinopathy Using Current Machine Learning and Deep Learning Techniques

Dr.R. Hemalatha, Dr.V. Anjanadevi, J. Naren and Dr.G. Vithya

Abstract--- *Diabetic retinopathy is a disease which manifests itself in the retina of the human eye. The effects of the rudimentary stages of this disease include blurred vision, seeing dark spots due to accumulation of blood vessels, and later stages of this disease can cause complete blindness in 90% of cases. The detection and diagnosis of diabetic retinopathy is well established in the field of medicine, and can be performed by professionals. The process is known to be expensive and cumbersome. However, the rise of Machine Learning and AI has paved the path towards disease detection, creating a niche for diabetic retinopathy. This paper reviews the current diabetic retinopathy detection literature and provides an insight of the various computer aided methods of diabetic retinopathy detection.*

Keywords--- *Deep Learning Techniques, Diagnosis and Prediction, Diabetic Retinopathy.*

I. INTRODUCTION

Diabetic retinopathy is the medical condition where the small blood vessels and neuro n cells of the eye are dilapidated. The primary symptoms are the tapering of the retinal arteries, which cause minima l blood flow, neural dysfunction of the inner retina. The advanced stages exhibit differences in the outer retinal function, along with minor changes in the subject's ability to see, dysfunction of the blood-retinal barrier, which covers the retina from immune cells leaking in the blood. The dilapidation of blood vessels and neurons in the eye can be detected better, faster and more accurately by using the techniques in machine learning.

In the field of machine learning, classification is grouping of a new observation to an already existent, predefined category by using a data set for training whose category membership is prerequisite knowledge. Specifically, in the problem of diabetic retinopathy, a classifier must learn from a training data set consisting of fundus images of the human eye having the disease and images without the same. This paper presents a critical evaluation of the a fore mentioned techniques in the following manner: The gathering of fundus images from dataset and their pre- processing. Then, we focus on feature extraction of the fundus images. The various taxonomies and features in this step of the process a represented. After this, we shift to the commonly used algorithms or techniques for diabetic retinopathy detection. The popular classifiers for diabetic retinopathy detection are built on the basis of Machine Learning, Deep Learning, Convolutional Neural

Dr.R. Hemalatha, Associate Professor, Department of CSE, St. Joseph's College of Engineering, Chennai. E-mail: hemes.kumar@gmail.com
Dr.V. Anjanadevi, Associate Professor, Department of CSE, St. Joseph's College of Engineering, Chennai. E-mail: anjanadevi.aby06@gmailcom
J. Naren, Assistant Professor, School of Computing, SASTRA Deemed University, Thanjavur, Tamil Nadu, India. E-mail: naren.jeeva3@gmail.com
Dr.G. Vithya, Professor, School of Computing, KL University, Vijayawada, AP, India. E-mail: vithyamtech@gmail.com

Received: 16 Nov 2018 | Revised: 25 Dec 2018 | Accepted: 10 Jan 2019

Networks and Support Vector Machines. The imminent need for cheap, robust, error- free tools for disease detection is the motivation behind using computer algorithms. In addition, we evaluate the advantages and drawbacks of each method and thereby providing further scope.

II. Prediction And Diagnosis Of Diabetic Retinopathy Using Machine Learning

Sohiniet.al [1] proposed a method that analysed fundus images that were ta ken in various lightings and produces a severity measure for diagnosis of diabetic retinopathy using machine learning methods. The classifiers used include Gaussian Mixture Model and Support Vector Machines (SVMs). Lesions were classified from non lesions as well. The striking development that this paper introduces is that it reduces number of features used for classification of lesions. It proposes a method where from the images bright lesions are classified as hard exudates and red lesions, microaneurysms. She used the MESSIDOR dataset. The team achieved 100% sensitivity 53.16% specificity. The system also reduced the time required for calculating severity grade for each image from 59.54s to 3.46s.

Karan et.al [2] developed a system to predict the presence of the disease by applying ensemble of machine learning classifying algorithms on data of features extracted from output of different retina l image processing algorithms like diameter of optic disk, lesion specific (microaneurysms, exudates), image level (pre -screening, AM/FM, quality assessment). Finally the prediction was performed with the help of alternating decision tree, AdaBoost, Naïve Bayes, Random Forest and SVM.

Va lliappanet.al [3] proposes a method to detect the abnormal features in fundus images, image enhancement, classification of abnormalities into microaneurysms, hard exudates and soft exudates and classify DR into mild, severe, proliferative and non-proliferative using machine learning methods. One of the most efficient methods developed for detection of Diabetic Retinopathy was by Harry et.al [4]. In this work he takes up a Convolutional Neural Network approach to diagnosing Diabetic Retinopathy from fundus pictures. He uses data augmentation techniques to detect and extract intricate features needed for the classification task. He trained this neural network to predict Diabetic Retinopathy using a high end Graphics Processing Unit (GPU) and produced a result of 95%sensitivity and 75% accuracy on a dataset of 80,000 images.

Saeed et.al [5] developed a new ‘confidence margin’ ensemble technique that combines techniques based on computer and also normal predictive models using mathematics specifically statistics. He claims that it outperforms the existing ensemble models. He suggests that diabetic neuropathy, creatinine serum, blood urea nitrogen, glucose serum plasma, and hematocritare the most important variables in detecting DR. He uses artificial neural networks (ANNs) to train over the oversampled data. They have achieved 92.76% accuracy. Although others have achieved even 97% accuracy, this method is cost effective and easy to use.

Javeriaet.al [6] address the issue of imp roving feature extraction fro m fundus images of existing datasets. The retinal images are pre-processed using Gabor filter- a linear filter used for texture analysis, which means that it basically analyses whether there are any specific frequency content in the image in specific direct ions in a localized region around the point or region of analysis - to the grey scale image which makes it useful for lesion enhancement. Classifiers from 4 families have been used ranging from probabilistic, k-nearest neighbour(KNN) to tree- based ones. All these 4 are tested on various databases and analysed on AUC basis. The results show an average AUC of 0.98 and accuracy as high as 98.5%[7].

III. DIAGNOSIS AND PREDICTION OF DIABETIC RETINOPATHY USING DEEP LEARNING

Deep Learning techniques are widely prevalent in the field of analysing medical imagery. In particular, convolutional networks, have quickly rose to ascension as a methodology of choice for examining medical images. It is used for image classification, object detection, segmentation, and other feature extraction techniques. The fundus images of the retina are, therefore, no hurdle to any computerised approach that aims to detect abnormalities via a Deep Learning Technique.

Juan Shan et.al [8] aimed to detect the micro aneurysms in the eye, due to leakage of retinal blood vessels. This is an early warning of the onset of diabetic retinopathy. This particular method employs the use of a Stacked Sparse Autoencoder for microaneurysm detection is mentioned. Small image patches are generated fro m fundus images, based on which the SSAE learns fro mpixe l intensities to distinguish the features of a microaneurysm and therefore classify them. The dataset used is the publicly available DIARETDB to provide the test data and the training data. 89 images were used, 2182 image patches had microaneurysm lesions, 6230 without. An accuracy of 91.3% and 96.2% was achieved during 10 - fold cross valuation.

Ro many F. Mansour[9] has made good use of computer aided diagnostics (CAD) for detection of diabetic retinopathy. AlexNet DNN, a tool whose underlying principle is based on Convolutional Neural Networks, was used to enable an optimal diabetic retinopathy CAD solution. The DR mode l applies a multilevel optimization measure that classifies diabetic retinopathy into five classes. They are: pre-processing, adaptive-learning-based Gaussian Mixture Model (GMM), component analysis based region of interest (ROI), principal component analysis (PCA), linear discriminant analysis (LDA)-based feature selection. The results with the Kaggle fundus datasets reveal that the proposed AlexNet DNN- based DR performs better with LDA feature selection, where it exhibits a DR classification accuracy of 97.93% with FC7 features, while with PCA, it shows 95.26% accuracy.

Darshit Doshi et.al [10] is able to automatically diagnose and classify the five stages of diabetic retinopathy (based on severity) by designing and implementing GPU accelerated deep convolutional neural network. The dataset used in the paper is the free, open sourced, platform for screening DR called EyePA Cs. The dataset consists of 35,126 labeled high - resolution colour fundus retinal images classified in correspondence to the five stages of the disease. The test set consists of 53,576 images out of which 5,000 have been utilized. The single model accuracy o f the convolutional neural networks presented in this paper is 0.386 on a quadratic weighted kappa metric and the working assemblage of three such simila r mode ls resulted in a better score of 0.3996.

IgiArdiyantoet.al [11] proposed a deep learning-based low-cost embedded system to assist medical professionals for grading the severity of the DR from the retina l images. A petite DL algorithm named Deep DR-Net which fits on an embedded board. The essence of the Deep-DR-Net is that a cascaded encoder-classifier network is arranged using residual style for ensuring the small model size. The usage of different types of convolutional layers subsequently guarantees the features richness of the network for differentiating the grade of the DR. Experimental results show the capability of the proposed system for detecting the existence as well as grading the severity of the

DR symptoms. The used dataset is the FINDe RS dataset, has a total of 315 images organised into five grades based on severity, 175 images of no DR, 52 of mild NPDR, 32 of moderate NPDR, 18 of severe NPDR, and 38 of PDR. The algorithm achieved the accuracy of 60.28%, sensitivity of 65.40%, and specificity of 73.37%. This is like ly due to the fact that the dataset used contained very few images.

Gargeya R et.al [12] developed and deployed a data- driven deep learning algorithm as a new diagnostic tool with regard to automated DR detection. The algorithm could process colour fundus images of the human retina and classify them as healthy or possessing diabetic retinopathy. A total of 75,137 publicly available fundus images from diabetic patients were used to train and test the proposed model to differentiate healthy fundi from those with DR. The model was also tested with M ESSIDOR 2 and E-Ophtha databases for further substantiation. An automatically generated heat map would show the subregions within each fundus image. The model achieved 0.97 AUC (area under the receiver operating characteristic curve – a metric for accuracy) score with 94% to 98% sensitivity and specificity with the local dataset. The AUC results with the MESSIDOR 2 and E- Ophtha databases were 0.94 and 0.95 respectively.

IV. Diagnosis And Prediction Of Diabetic Retinopathy Using Big Data

Big data is defined as extremely large datasets that cannot be analysed by traditional data processing methods. Big data needs to be captured, stored, analysed, searched etc. Big data also refers to the predictive analytics, user behaviour analytics to extract value fro m data of late. Big data techniques in ophthalmic research has aided in areas such as disease surveillance, study of disease causes and health services utilizations.

A novel framework for the accurate and foolproof feature extraction and analysis of a list of vascular geometric features in the retina is proposed by Georgios Leontidis [13]. The the existing lesions and bifurcations in the retina of a patient during the consecutive progress ion from diabetes (no DR) to DR have been observed so that changes may be identified in the vascular region of the eye. The framework proposed in this paper- called FriAReD (frame work for retinal imaging and feature analysis for retinal diseases)- includes the feature extraction from imagery, image registration and segmentation, classification models the statistical analytics of the fundus images. Statistical analysis and the consequent inferences are are made using Boruta algorithm and regularised random forests, LMMs, elastic-net logistic regression for the classification and feature selection.

The vein and artery equivalents in the retina present at the centre, these special geometric features are different from patient to patient and thus have good discriminative potential. Therefore, these are part of the classification system. The results of the classification system with the AUC values ranging from 0.821 to 0.968, across the different examined combinations.

The highlight of Leontidis's work is the development of radical framework that is based on machine learning. The research also provides an in-depth study that culminates a multitude of geometric features present in the retinal vasculature to detect the severity of diabetic retinopathy. When the framework is made to work in tandem with correct clinical substantiation, the decision support system assists with the diagnosis of the progression of diabetic retinopathy in the patient. This claim is corroborated by the performance of the classification systems that the author proposes.

Received: 16 Nov 2018 | Revised: 25 Dec 2018 | Accepted: 10 Jan 2019

V. IMPLEMENTATION DETAILS

The following architecture was proposed by Darshit Doshi et.al [10]

Table 1.1: CNN Architecture of 3 Models

Layers	Model 1	Model 2	Model 3
input	1x512x512	1x512x512	1x512x512
conv 1	16x256x256	16x256x256	16x256x256
conv 2	16x256x256	16x256x256	16x256x256
pool 1	16x128x128	16x128x128	16x128x128
dropout 1	16x128x128	16x128x128	16x128x128
conv 3	32x64x64	32x64x64	32x64x64
conv 4	32x64x64	32x64x64	32x64x64
pool 2	32x32x32	32x32x32	32x32x32
dropout 2	32x32x32	32x32x32	32x32x32
conv 5	48x32x32	64x32x32	64x32x32
conv 6	48x32x32	64x32x32	64x32x32
conv 7	48x32x32	64x32x32	64x32x32
pool 3	48x16x16	64x16x16	64x16x16
dropout 3	48x16x16	64x16x16	64x16x16
conv 8	64x16x16	128x16x16	96x16x16
conv 9	64x16x16	128x16x16	96x16x16
conv 10	64x16x16	128x16x16	96x16x16
pool 4	64x8x8	128x8x8	96x8x8
dropout 4	64x8x8	128x8x8	96x8x8
conv 11	128x8x8	256x8x8	128x8x8
conv 12	128x8x8	256x8x8	128x8x8
pool 5	128x4x4	256x4x4	128x4x4
dropout 5	128x4x4	256x4x4	128x4x4
hidden 1	400	256	256
maxout 1	200	128	128
dropout 6	200	128	128
hidden 2	400	256	256
maxout 2	200	128	128
output	5	5	5

The following results were obtained:

Model	Quadratic kappa score
Model 1	0.291
Model 2	0.32
Model 3	0.35

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Received: 16 Nov 2018 | Revised: 25 Dec 2018 | Accepted: 10 Jan 2019

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Received: 16 Nov 2018 | Revised: 25 Dec 2018 | Accepted: 10 Jan 2019