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A Survey on techniques for Diabetic Retinopathy Detection & Classification

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Abstract - *Diabetes is a very prevalent disease that is concerning a lot of people of varied age groups with poor or low insulin production levels, ultimately causing high sugar level in blood. The diabetic patients are suffering from a severe microvascular complication that is Diabetic Retinopathy (DR) which is a cause of tension in only diabetic patients. DR affects the retina of patient and leads to permanent, partial or complete blindness if not detected and cured at a nascent stage. But predicting the presence of Microaneurysms in the fundus images identification of DR in nascent stage has always been a tough task for decades. The time consuming approaches of traditional and manual screening delays the detection process of DR leading disease to advance to further stages in the prescribed time and it is not always accurate. Now with the progress of Deep Learning (DL), especially in medical imaging, results are seen to be more accurate as it performs automatic feature extraction. Under it, Convolutional Neural Networks (CNNs) are the widely used deep learning method in the analysis of medical image. This article will be followed by surveys and reviews of the latest research works about the precise diagnosis as well as classifying DR into various categories from mild to severe based on different techniques utilizes for image pre-processing, disease identification and classification form fundus image datasets.*

Key Words: **Convolutional Neural Network (CNN), Deep Learning, Machine Learning, Diabetic Retinopathy, Medical imaging**

1. INTRODUCTION

Diabetes is an acute ailment that happens due to the inability of pancreas to produce insulin. About 442 million people worldwide have diabetes as estimated by WHO. A large part of these people contribute to the overall capital worldwide. These patients have a huge chance of having DR which can lead to permanent visual loss in the future. By the time of 10-15 years of the ailment, around 10% of patients become blind and close to 2% have permanent visual disorder. It ranks 6th in the list of reasons that lead to partial vision loss among the youngsters. Close to 90% of people can be cured by using appropriate screening and doing timely checkups. The different phases of DR ranges from mild, moderate and severe.

Inspecting the pictures of retina manually is a very tough and time taking thing to do. These traditional methods are expensive, time-consuming, laborious & aren't always accurate. In order to get better results, different new techniques have come into use in the last few years which have helped the ophthalmologists in inspecting the uncommon retinas. Machine learning (ML) and Deep learning (DL) algorithms have been a prevalent choice in the prediction of various diseases. Deep Learning contributes majorly in classifying, localizing, segmenting and predicting medical images. Deep Learning has given much better results within lesser amount of time in the detection of Diabetic Retinopathy.

Convolutional Neural Networks (CNNs) are used all over the world by a large number of research workers in performing medical imaging. In the CNN layers, various filters combine in order to get the image features which will then be used to generate the feature maps. After that comes the pooling layers in which the measurements of the feature maps are reduced by the help of average or max-pooling method. Then the fully connected layers are used which generates the entire image feature set. Finally, the classification is accomplished by using any of the two activation functions, sigmoid (binary classification) or softmax (multi-classification). Initially, the data can be obtained, preprocessed to increase the image details, augmentation can be done if necessary when the data samples are small. Then, the data can be provided to the model that generates the image features and classifies them according to the severity levels.

2. LITERATURE SURVEY

1. "Early Detection of DR Using PCA-Firefly Based DL Model"

The paper[1] published in MDPI 2020 used Deep Neural Network for detection and classification of Diabetic Retinopathy. A total of 64,000 Fundus Images are collected from the University of California ML Repository and Messidor for training of DNN model. The model detects if DR is present and classify it into two categories – (i) Proliferative (PDR) & (ii) Non-Proliferative DR (NPDR). The algorithm used for training DNN model is 'PCA & firefly algorithm'. The model results with an accuracy of 96%.

2. "Diabetic Retinopathy Detection using Prognosis of Microaneurysm and Early Diagnosis System for Non-Proliferative Diabetic Retinopathy Based on Deep Learning Algorithms"

In this paper [2], Deep Convolutional Neural Network (DCNN) is used for prognosis of Microaneurysm and early diagnostics system. A semantic segmentation algorithm is performed on 35K images taken from Kaggle to improve DR detection and accuracy. The model is integrated with LOG and MF filters along with post-processing procedures to provide an effective lesion identification system.

3. "Diagnosis of DR Using DNN"

In [3], Deep CNN is used to grade the severities of retinal fundus images and classify then into No DR, NPDR, Mild and Severe PDR. This model uses ReLU, Inception v3 & Resnet algorithms. It focuses on various location of DR images. The model is trained on a combination of 130 images taken from E-ophtha and 88K images from Kaggle source. The author claimed to have an accuracy of 94% in the proposed model.

4. "Computer Assisted Diagnosis for DR Based on Fundus Images Using Deep CNN"

The paper [4] proposed the use of DCNN methodology to develop a model for diagnosis of DR and classify it into NPDR & PDR. A total of 34K raw fundus images are taken from Kaggle dataset source. For image pre-processing purpose, techniques like re-scaling colour divergence removal & periphery removal are used and further fractional max-pooling & support vector machine (SVM) with TLBO is used to train & run the model. The model provides a high accuracy of 91% and specificity of 99%.

5. "DL Fundus Images Analysis of DR and Macular Edema Grading"

In the articles published in springer [5], the author studied the use of Deep learning methods to analyze fundus images of DR. The dataset used to train the model consists of 41K retinal fundus images taken from Digi-Fundus Ltd. source. The model used the inception v3 algorithm along with several grading methods to classify macular edema using Deep CNN. The overall accuracy was 91% and the output is classified as referable & non-referable DR.

6. "A Deep Learning Method for the detection of diabetic retinopathy

The article in paper[6] proposed a model to automatically detect DR and classify patients into NPDR and PDR. A total of 30 high resolution raw fundus images were used to train the model out of which 15 were healthy and 15 were suffering from DR. The model made use of Adam Optimizer algorithm in the learning process of the Deep CNN. The author claimed to have an accuracy of 91% that works with a small dataset.

7. "A Deep Learning Ensemble Approach for Diabetic Retinopathy Detection"

In [7], A combination of 5 deep CNN models - resnet50, Inception V3, Xception, Dense121, and Dense169 were proposed to get a high accuracy result. The models are concatenated into one to improves the classification of DR stages. A total of 35,126 high resolution fundus images were used from kaggle dataset for training, testing & validation purposes.

8. "Diabetic Retinopathy Stage Classification using CNN"

This paper [8] proposed a concatenated model of VGG16, AlexNet & InceptionNet V3 that provides a result of 81.1 % accuracy. The model is trained on 500 retinal fundus images from Kaggle data set. Histogram Equalization filtering algorithm is used in pre-processing for downsizing and resizing images & stochastic gradient descent with momentum optimization algorithm is used for training purpose. The model is highly optimized with a huge number of parameters in stochastic gradient descent.

9. "Classification of Diabetic Retinopathy Images by Using Deep Learning Models"

In [9] the researchers proposed models to identify the background of Diabetic Retinopathy. The dataset used is from Kaggle. The model was trained on 2000 high resolution raw fundus images with 3 times back propagation neural networks – BNN, DNN & CNN (VGGNet). The hybrid model is used with fuzzy C-means clustering edge detection technique for image processing & DL to improve the result for predicting DR. The output is classified into mild, moderate and severe PR.

10. "An enhanced diabetic retinopathy detection and classification approach using deep convolutional neural network"

In [10], The classification of diagnoses was done using DL & CNN. The HE & CLAHE for image enhancement were used. The dataset used is from MESSIDOR having 400 images. The model has high accuracy and specificity.

11. "Convolutional Neural Networks for Diabetic Retinopathy"

In this paper [11], A study was carried out on the use of micro-aneurysms, exudate & hemorrhage features to detect DR. A total of 80k images were used from kaggle dataset source. A CNN methodology is used along with stochastic gradient descent algorithm with Nestrov momentum. The method used can easily detect healthy eye. The model has low specificity and skewed datasets.

12. "Automatic Detection and Classification of Diabetic Retinopathy stages using CNN"

In [12], the authors proposed a CNN model for DR screening using retinal fundus images as input. Features like microaneurysms & hemorrhages are used with LeNet5 algorithm to detect DR. The model is trained on 30000 fundus images from Kaggle. A small problem with this model was that the dataset was highly imbalanced and it classified most of the class1 & class 2 images as class 0.

13. "Detecting Diabetic Retinopathy using Deep Learning"

The purpose of research [13] paper was to detect of DR using Deep Learning. The model was based on the inception-v3 algorithm that is popularly used for image recognition and have accuracy greater than 78.1%. The Normalization mean subtraction and PCA is used for image pre-processing. Kaggle dataset consisting of 40k images are used for training the CNN model. The results has an accuracy of 88% along with high sensitivity and specificity.

14. "Optimal feature selection based diabetic retinopathy detection using improved rider optimization algorithm enabled with deep learning"

In [14], the authors analyzed the retinal abnormalities like haemorrhages, soft exudates and Micro aneurysm on dataset used in DIARETDB1. The dataset contains 89 high resolution fundus images. The pre-processing of images was performed using RGB image conversion to green channel and image enhancement using CLAHE procedure. The Deep Belief Network (DBN) algorithm was used to classify the images into four categories depending upon the seriousness of DR. called Modified Gear & Steering-based Rider Optimization Algorithm was used for optimal feature selection.

15. "Automatic Detection of Diabetic Retinopathy in Retinal Fundus Photographs Based on Deep Learning Algorithm"

In this article [15], the authors proposed an auto DR detection in fundus retinal images using a deep transfer learning approach. A CNN based algorithm – 'Inception-v3' network is used to obtain high accuracy of 93.49% accuracy. For image processing, pixel scaling, downsizing and contrast enhancement were performed using CLAHE. The model is trained with Messidor-2 dataset.

16. "Detection of Diabetic Retinopathy Using Bichannel Convolutional Neural Network"

The researchers in the paper [16] presented their work on Bi-channel CNN-based DL system to detect & classify DR into no apparent DR, mild NPDR, moderate NPDR, severe NPDR, and PDR. The dataset used is the Kaggle dataset. The UM technique is used for image processing to amplify the high-frequency parts of the gray level and the green component of the fundus image before computing. The model performed with an accuracy of 87.8%.

17. "Diabetic Retinopathy Detection using Machine Learning"

The authors in [17] proposed a hybrid machine learning model, a combination of SVM, KNN & RF to detect DR in retinal images. They Kaggle dataset containing 100 images is used to train the proposed model. The performance has an average accuracy of 82%. An accurate image preprocessing is needed for better results.

18. "Diabetic Retinopathy Detection through Image Mining for Type 2 Diabetes"

The article in paper [18] proposed a KNN machine learning model for fundus image classification. DIARETDB1 dataset is used for training purpose. The image processing, data mining, texture & wavelet features are extracted for DR detection. DWT Transform & GLCM algorithms are used for image pre processing (feature extraction). The model outperformed other ML based model with a high accuracy of 97.7% and high sensitivity of 100%.

19. "Automated detection of diabetic retinopathy using SVM"

The aim of this research in [19] was to automatically classify the stages of NPDR for any retinal fundus image. For this, SVM algorithm was used and in image processing stage, the blood vessels, microaneurysms & hard exudates are isolated to extract features for figuring out the retinopathy grade of each retinal image.

20. "Automatic Diabetic Retinopathy Screening via Cascaded Framework Based on Image- and Lesion-Level Features Fusion"

The main goal of this paper [20] was to detect and classify DR Screening using Cascaded Framework Based on Image- and Lesion-Level Features Fusion. For this, Naïve Bayes and SVM classifier is used. The model was trained on Messidor dataset and Adaptive histogram equalization technique was used for image processing.

21. "Automated DR Detection Based on Binocular Siamese-Like CNN"

The researchers [21] proposed an auto-DR detection model to classify the retinal images into five grades. The model is based on Binocular Siamese-like CNN algorithm and is trained on the Inception V3 algorithm. The model uses EyePacs dataset consisting of 35000 images after pre-processing techniques like scaling, normalization & high-pass processing on the retinal fundus images to classify them into different groups depending on the presence & DR severity.

22. "Diabetic Retinopathy Detection by Extracting Area and Number of Microaneurysm from Colour Fundus Image"

In this paper [22], the research is primarily based on classification of DR by linear Support vector machine. An improved algorithm for the detection of diabetic retinopathy is proposed by accurate determination of number and area of microaneurysm. The model was trained and tested on Messidor-2 dataset. Principal component analysis (PCA), contrast limited adaptive histogram equalization (CLAHE), morphological process, averaging filtering are the techniques used for image preprocessing. The observed specificity is 92% and sensitivity is 96%. The output is classified into two categories i.e. DR and NDR.

23. "Deep Neural Network for Diabetic Retinopathy Detection"

The proposed paper [23] is based on a CNN methodology for diabetic retinopathy classification. The model uses ConvNet based algorithm to automatically identifies the pattern and classifies the retina images into five classes – Normal, mild, moderate, severe and proliferative DR. The architecture of neural network consists of convolutional layer that convolve the input and then passed to pooling layer. The process is repeated several times to extract multiple features for each input. The Kaggle dataset is used to train this deep learning model. This model has improved validation accuracy despite less amount of dataset is used.

24. "Diabetic Retinopathy Detection using ensemble deep Learning and Individual Channel Training"

The work presented in this paper [24] performs better in classifying all stages of DR compared to existing algorithms that use the same dataset. The model proposed uses ensemble deep learning with five different CNN algorithm including ResNet, DenseNet, Inceptionv3 and Xception. It is trained on EyePACS dataset fundus images from Kaggle and classifies them into five stages of DR. Each channel of the image RGB (Red, Green, Blue) is fed separately to all the models and the effect of individual channel on the result is analyzed.

25. "A Deep Learning Approach for Diabetic Retinopathy detection using Transfer Learning"

In [25], Pre-trained models of DCNN namely, SEResNeXt32x4d and EfficientNetb3 are used on ImageNet dataset. The images processing are performed using AUGMIX and pooled using GeM. The output is classified into 5 categories based on the severity of DR. The model provides better efficiency as a result of transfer learning and the viability of using pre-trained models. The training accuracy goes as high as 0.91.

3. CONCLUSIONS

The use of Automated Diabetic Retinopathy systems have made it easier as they are available at a lower cost when compared to other systems. This system is time efficient and it helps the ophthalmologists to cure the retinal disabilities and along with that it provides time to time checkups to minimize problems in the coming times. These technologies have played a major role in curing the ailments more precisely. This article surveyed 25 research & survey articles that discuses and survey the major techniques used for the diagnosis & classification of Diabetic Retinopathy. The survey reviewed various techniques in all the stages such as Pre-processing, Feature extraction as well as Classification. It also highlighted some major improvements achieved by these algorithms. The survey showed that, for clinical purposes, Machine Learning or a deep-learning method can be more favourable and effective in minimizing the progression of diabetic retinopathy among patients and allowing the ophthalmologist to accelerate further care of the retina. This survey will assist the researchers in this field to know about the already available techniques and methods for detecting & Classifying DR and will help them to drive their research ahead.

REFERENCES

[1] Neelu K., S. Bhattacharya, "Early Detection of DR Using PCA-Firefly Based DL Model", MDPI Switzerland, 2020.

[2] Lifeng Qiao, Ying Zhu, Hui Zhou, "Diabetic Retinopathy Detection using Prognosis of Microaneurysm and Early Diagnosis System for Non-Proliferative Diabetic Retinopathy Based on Deep Learning Algorithms", IEEE Access, 2017.

[3] JIE LI, JIXIANG GUO, "Diagnosis of DR Using DNN", IEEE, January 2019.

[4] Yung-Hui Li, Na-Ning Yeh, " Computer Assisted Diagnosis for DR Based on Fundus Images Using Deep CNN", Hindawi publisher for tech & science journals, 2019.

[5] Joel J, J Kivinen, "DL Fundus Images Analysis of DR and Macular Edema Grading", Springer, 2019.

[6] Navoneel Chakrabarty, "A Deep Learning Method for the detection of diabetic retinopathy", IEEE, 2018.

[7] SehrishQummar, Fiaz Gul Khan, Sajid Shah, Ahmad Khan, ShahaboddinShamshirband, Zia Ur Rehman, Iftikhar Ahmed Khan, WaqasJadoon, "A Deep Learning Ensemble Approach for Diabetic Retinopathy Detection", IEEE, 2019.

[8] Nikhil M N, Angel Rose A, "Diabetic Retinopathy Stage Classification using CNN", IRJET, 2019.

[9] Suvajit Dutta, Bonthala CS Manideep, Syed MuzamilBasha, Ronnie D. Caytiles and N. Ch. S. N. Iyengar, "Classification of Diabetic Retinopathy Images by Using Deep Learning Models", IJGDC, 2018.

[10] D. Jude Hemanth, Omer Deperlioglu, UtkuKose, "An classification approach using deep convolutional neural network", Springer, 2018.

[11] Harry Pratta, FransCoenenb, Deborah M Broadbentc , Simon P Hardinga, YalinZhenga, "Convolutional Neural Networks for Diabetic Retinopathy", International Conference On Medical Imaging Understanding and Analysis, 2016.

[12] Ratul Ghosh, Kuntal Ghosh, SanjitMaitra, "Automatic Detection and Classification of Diabetic Retinopathy stages using CNN", International Conference on Signal Processing and Integrated Networks, 2017.

[13] Yashal Shakti Kanungo, Bhargav Srinivasan, Dr. Savita Choudhary, "Detecting Diabetic Retinopathy using Deep Learning", IEEE International Conference on Recent Trends in Electronics Information & Communication Technology (RTEICT), 2017.

[14] Ambaji S. Jadhav, Pushpa B. Patil, Sunil Biradar, " Optimal feature selection based diabetic retinopathy detection using improved rider optimization algorithm enabled with deep learning" Springer, 9 April 2020.

[15] Feng Li, Zheng Liu, Hua Chen, Minshan Jiang, Xuedian Zhang, and Zhizheng Wu, "Automatic Detection of Diabetic Retinopathy in Retinal Fundus Photographs Based on Deep Learning Algorithm", tvst.journals, 2019.

[16] Shu-I Pao,Hong-Zin Lin,Ke-Hung Chien, Ming-Cheng Tai,JiannTorngChen, and Gen-Min Lin, "Detection of Diabetic Retinopathy Using Bichannel Convolutional Neural Network", Hindawi publications, 2020.

[17] Revathy R, Nithya B, Reshma J, Ragendhu S, Sumithra M D, "Diabetic Retinopathy Detection using Machine Learning", IJERT, 2019.

[18] Karkhanis Apurva Anant, Vimla Jethani, Tushar Ghorpade, " Diabetic Retinopathy Detection through Image Mining for Type 2 Diabetes", ICCCI, 2017.

[19] Enrique V. Carrera, Andres Gonz´alez, Ricardo Carrera, "Automated detection of diabetic retinopathy using SVM", IEEE, 2017.

[20] Cheng-Zhang Zhu,Rong-Chang Zhao, "Automatic Diabetic Retinopathy Screening via Cascaded Framework Based on Image- and Lesion-Level Features Fusion" , Springer, 2019.

[21] Yuan Luo, Wenbin Ye, "Automated DR Detection Based on Binocular Siamese-Like CNN" , IEEE, March 2020.

[22] Shailesh Kumar,Basant Kumar, " Diabetic Retinopathy Detection by Extracting Area and Number of Microaneurysm from Colour Fundus Image", SPIN, 2018.

[23] Mamta Arora, Mrinal Pandey, "Deep Neural Network for Diabetic Retinopathy Detection", Com-IT-Con, 2019.

[24] Harihanth K, Karthikeyan B, "Diabetic Retinopathy Detection using ensemble deep Learning and Individual Channel Training", IEEE, 2020.

[25] Satwik Ramchandre, Bhargav Patil, "A Deep Learning Approach for Diabetic Retinopathy detection using Transfer Learning", IEEE, 2020.