IES International Journal of Multidisciplinary Engineering Research

Diabetic Retinopathy Detection Using Machine Learning Techniques

Gaya Nair P[1], Dr. Lanitha B[2]

[1]*Research Scholar, Department of Computer Science & Engineering, Karpagam Academy of Higher Education, Coimbatore , Thamilnadu*
[2]*Associate Professor, Department of Computer Science & Engineering, Karpagam Academy of Higher Education, Coimbatore , Thamilnadu*

Email_id: gsgayasajeev@gmail.com, lanitha.nandakumar@kahedu.edu.in

Abstract

Diabetic Retinopathy (DR) is an eye disease, occurs because of diabetes that makes lesions in the retina and affect vision. If it is not noticed early, it will be led to blindness. If DR could find out early and get treated, the vision loss can be avoided. Manual diagnosis process takes long time, more cost effective and it is more complicated. Therefore, Computer Aided Diagnosis Systems can be used to reduce cost, time, and other serious complications. Many studies are taking place in this area, by using the Traditional Machine Learning Methods like Support Vector Machine (SVM), Random Forests (RF), Logical Regression (LR) etc. The researchers are now a days focusing to keep the security and privacy and to increase the efficiency and accuracy, hence Federated Learning (FL) is a good method for this. FL ensures Patient's data Security and Privacy and also ensure accuracy of the Result.

Keywords: Deep Learning, Convolutional Neural Network, Diabetic Retinopathy, Federated Learning, Support Vector Machine.

DOI: https://doi.org/10.5281/zenodo.17461850

1. Introduction

In the healthcare field, detecting the diseases in the early stages and treat as early as possible, is the effective way; especially diabetes because it gradually affects our all-body organs like Retina, Heart, Nerves, Kidneys etc. [1,2]. Diabetic Retinopathy is happening because of the increased Blood Sugar Level due to less of production of Insulin. This affects the blood vessels in the Retina of Eye which causes swell and thereby fluids and blood leakage and this reasons blindness [3,4].

DR is seemed to be different types of lesions in the retina like Microaneurysms (Ma's), Hemorrhages (H's), Soft Exudates and Hard Exudates.

Microaneurysms (Ma's**)** : This is the first lesion of DR which seems to be small circles or red dots with different sizes. Its size shall be lesser than the width of blood vessels.

Retinal Hemorrhages (H's**):** Hemorrhages is the actual bleeding in Retina either due to ruptured MA's or due to leak of blood from the blood vessels. These are larger than MA's with uneven edges and colours. Figure 1 shows the different types of sample images of this. [6,7]. Figure -2 shows two types of HM.

Hard exudates (HE's): These are white or yellow fat deposit as part of Ma's leakage. It doesn't have correct shape and size also varies. I also having hard edges and fatty appearance.

Soft exudates (SE's): These are also called cotton wool spots. These lesions are found white color spots.

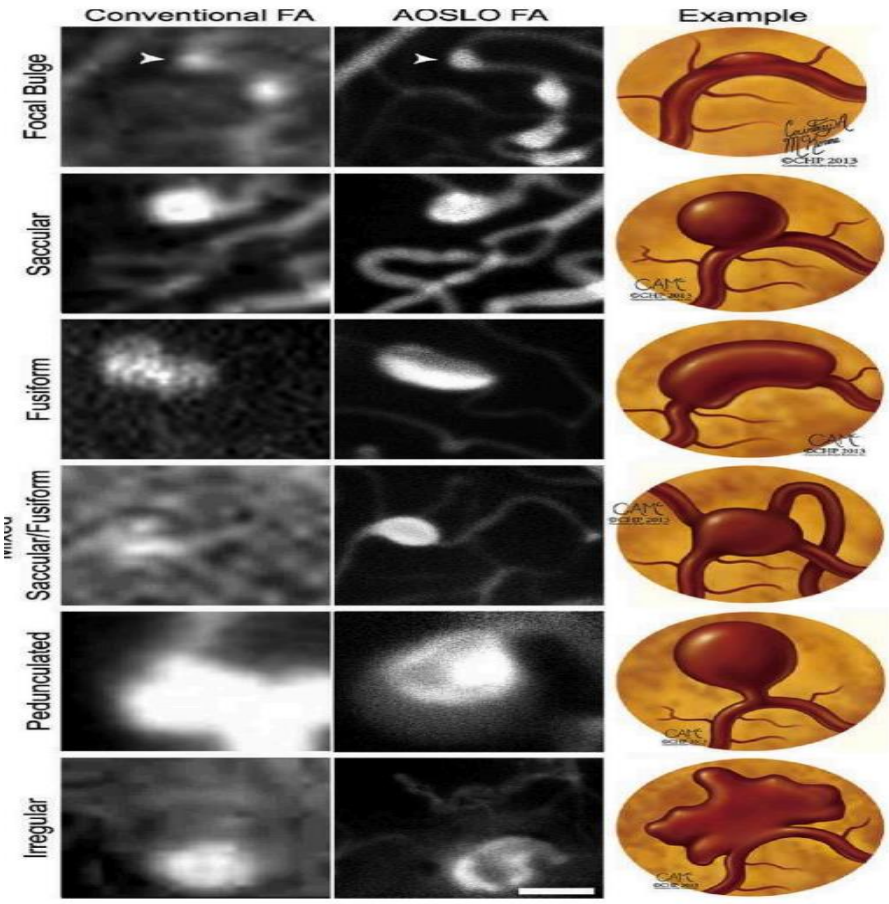

Figure 1. Types of MA [8]

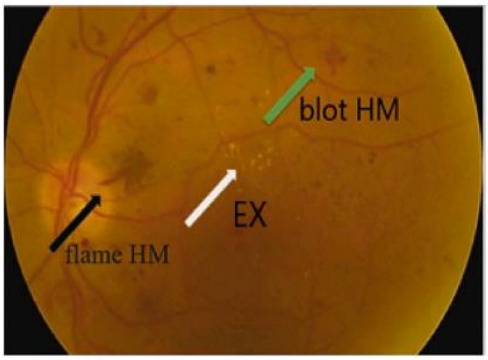

Figure 2. Types of HM [9]

The currently used advanced Machine Learning Methods for the detection and classification of DR are more economical and time saving, than traditional ML methods. This paper reviews some important works that are conducted in the area of DR detection and classification with advanced Machine learning techniques.

1.1 Machine Learning

Machine learning is a part of Artificial Intelligence (AI) that enables a system to think and act self, without being clearly programmed. System is learning through data observation or by direct instructions. ML Algorithms build a mathematical model for decision making and prediction, by using available training data. Primary aim of ML is to enable Computers to learn automatically and to act accordingly, without human involvement. To detect DR, conventional Machine Learning methods like Decision Tree, support vector machine, Random forests, logistic regression, and Gaussian Naïve Bayes are being used.

1.2 Deep Learning

Deep Learning (DL) is a kind of Machine Learning and a part of Artificial Intelligence. It is similar to human brain, where artificial neural networks learn from the available data. In Deep Learning, by using feature extraction methods, similar features can recognize and by using decision boundary methods, available feature can determine of each label as it represents. Therefore, Deep Learning methods can successfully use for DR detection and Image classification.

1.3 Federated Learning

Federated Learning is a new concept introduced by Google in 2006 as one of the most secure and robust cloud infrastructures for processing data. Federated Learning is a part of ML where many clients collaborately train a model under the control of a Central Server, without sharing the training data. FL is being worked by sharing a few megabytes sized encrypted training model by each device, centralized server will group these devices and then aggregated and updated model of data will be shared. This process will repeat till the stage where further updating is not needed. In this way Federated Learning ensures more privacy than traditional ML methods. Because of this

characteristics, patient's data collected from different areas can be used without sharing and hence privacy and security of collected data can be ensured.

The upcoming sections of this paper are arranged as, Section 2 which examines and discusses the clear-cut review on DR detection. Also, check the research methods used for the selection of the primary studies. Section 3 considers the results and discussion on the review and Section 4 concludes the paper.

2. Literature Survey

Pooja Bidwai and Shilpa Gite *et al.* [10] this paper gives a comprehensive survey of DR detection by using Artificial Intelligence and also describes all types of feature extraction methods using AI techniques like Machine Learning and Deep Learning. This Survey also describes about Diabetics and its troubles and how does it lead to Diabetic Retinopathy.

Mohammad Z. Atwany *et al.* [11] This paper analysis about different types of Deep Learning Methods and also how it can be used for DR detection and Classification. It is mentioned about the available Fundus Images dataset for this process and also about the research gap for the DR detection and classification area.

Shu-I Pao, and Hong Zin Lin, *et al.* [12] Here proposes a method that entropy images computed by using green component of Fondus photographs can be used to improve DR detection, by Deep Learning Performance. Also it states that better results can be obtained by using entropy images which are done by image enhancement by unsharp masking (UM)

Skylar Stolte and Ruogu Fang *et al.* [13] This provides concepts of novel Deep Learning pipelines and processing of images using Machine Learning. Also, discuss about all tasks of DR grading like strong, hard, moderate etc.. It has been included the clinical implementation of new technology.

Uzair Ishtiaq *et al.* [14] This paper reviews different DR detection techniques. Here Datasets and Techniques for image processing are comparing based on the efficiency of various Machine Learning and Deep Learning Methods. As the Author included the complete history of DR detection study, this shall be helpful for the Scientists those who are working in this file.

Md. Nahiduzzaman *et al.* [15] This Study proposes the methods to detect DR from the Fundus Images fast and accurate. This reduces the vision loss and thereby save the valuable time of Medical Practitioners.

Mohamed Chetoui and Moulay A. Akhloufi *et al.* [16] This study expresses the implementation of advanced texture features like LTP, LESH etc. In these techniques the bonding between the neighboring pixels is being used. Therefore, the output images are less sensitive to illumination, colour, noise etc. This helps to learn HEM signs and to differentiate DR and Non-DR.

Muhammad Mohsin Butt, and Awang Iskandaret *et al.* [17] Here new methods are told for the detection of DR from the Fundus Images. A hybrid approach is presented here by using Transfer Learning based on Google Net and Res Net-18 Architecture.

Parshva Vora and Sudhir Shrestha *et al.* [18] In this paper an algorithm is mentioned, which uses to classify healthy and DR images by using CNN and k-fold cross-validation process. Caffe and Keras models are used for Testing and Training different data models.

Erdal Özbay *et al.* [19] In this article, an Active Deep Learning Multilayer Architecture Method is mentioned, which is used for the automatic recognition of DR. Here Artificial Bee Colony algorithm is used for image segmentation and CNN algorithm for image extraction.

2.1 Review of Datasets

We have a large set of publicly available dataset to detect and classify Diabetic Retinopathy. By using this dataset, the images can be trained and tested and also the system performance measures can be compared. Such Fundus Image datasets are as follow:

Kaggle: - It has a collection of large set of high-resolution retina images, and each of these items are labelled subject wise. Such 88,702 images with a range of 433 x 289 pixels to 5184 x 3456 pixels can be used for research purposes. Here all images have been classified as Five DR Stages.

APTOS:- It contains 5593 files of size 10.22 GB, with a format of png, ccv.

Messidor /Messidor-2: - Messidor database is formed for computer assisted Diabetic Retinopathy diagnosis. 1200 color numerical fundus are arranged in this as 3 sets. This Dataset is classified as 4 DR Stages. In Mesidor-2 dataset all images are saved as pairs. Researchers can directly download this dataset to their work.

Kaggle IDRiD:- This dataset includes Kowa VX-10α digital fundus images. These images were collected from an Eye Hospital, Maharashtra in India.

Kaggle EyePacs:- This is a collection of originally available preprocessed dataset.

2.2 Review of Methodology

Different types of DR detection and classification models are constructed by using various Machine Learning and Deep Learning Algorithms. DR Classification models have been categorized into two:

(1) **Binary Classification**: - Here the data set is divided into two classes. Using binary classification method we can detects whether the Diabetic Retinopathy is having or not. Xu K, Feng D, Mi H *et al.* [9] In this work the publicly available Kaggle dataset images are classified as Normal Images and DR Images.

(2) **Multi Class Classification: -** In this DR dataset is divided as many classes. A lot of studies have been conducted in this area, out of few only are highlighted here. Skylar Stolte and Ruogu Fang *et al.* [13] and Muhammad Mohsin Butt, and Awang Iskandaret *et al.* [17] Here Images are classified as Strong, Hard, Moderate by using Deep Learning Pipeline Techniques. Md. Nahiduzzaman *et al.* [15] proposes a method to classify entropy and green component of images. Using bichannel CNN. Mohamed Chetoui and Moulay A. Akhloufi *et al.* [16] In this work Images are graded into 5, by using conventional neural network methods.

3. Results and Discussions

This study is a review about DR detection and classification by using different ML and DL Methods. A table is shown below, which is a description about the trained dataset and the algorithms used for this. Figure 3 shows a comparison between various ML methods used for DR detection and its accuracy. X axis represents different types of ML algorithms and Y axis it's accuracy. While considering all methods, it can be seen that CNN with more efficiency.

Sl.No.	ML Method	Data set Name	Description	Availability	Reference
1	CNN	Kaggle	EyePACS dataset is used for DR detection. Out of 88,702 images, 35,126 are used for training and 53,576 for testing.	Free	[10]
2	SVM	Messidor	There are 1200 color numeric images with resolution 1440x960, 2240x1488. Out of these a classification was made like, 540= Normal, 153=mild, 247 = moderate and 260 = severe.	Free	[20]
3	ADL-CNN	Kaggle EyePacs Messidor	The Kaggle EyePacs dataset containing 35,122 retinal images and Messidor data set with the resolutions of the pictures were 1440 × 960, 2240 × 1488.	Free	[19]
4	CNN, a K-fold cross-validation process	Kaggle/EyePacs database.	In these 88,000 named high-resolution images are used.	Free	[21]

			For this, publicly available sets in Kaggle are used.		
5	ANN	APTOS	3662 fundus images are used in this dataset.	Free	[20]
6	PCNN, CLAHE	Kaggle DR and APTOS 2019	Here 34,984 images from Kaggle are used as Dataset 1 and 3,662 images from APTOS, 2019 are used as Dataset 2.	Free	[17]

Table 1: The methods and datasets used for DR detection/classification.

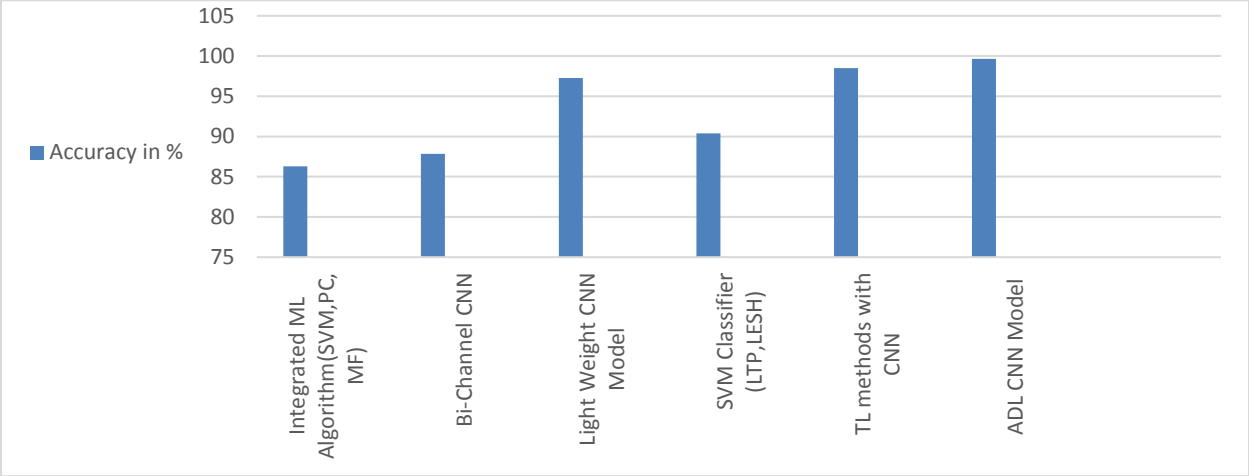

Figure 3. Accuracy of different machine learning algorithms for DR detection.

4. Conclusion

This Paper is a review on DR detection and Classification by using different Methodologies. The objective of this work is a study on DR and its early detection and classification by using available different Machine Learning methods. It is concluded that, usage of Federated Learning (FD) algorithms is better to keep the privacy and security of the dataset.

5. References

[1]. Taylor R, Batey D. Handbook of retinal screening in diabetes: diagnosis and management. second ed. John Wiley & Sons, Ltd Wiley-Blackwell; 2012.

[2]. International diabetes federation - what is diabetes [Online]. Available, https: //www.idf.org/aboutdiabetes/what-is-diabetes.html.

[3]. American academy of ophthalmology-what is diabetic retinopathy? [Online]. Available, https://www.aao.org/eye-health/diseases/what-is-diabetic-retinopathy.

[4]. Bourne RR, et al. Causes of vision loss worldwide, 1990-2010: a systematic analysis. Lancet Global Health 2013;1(6):339–49.

[5]. Harper CA, Keeffe JE. Diabetic retinopathy management guidelines. Expert Rev Ophthalmology 2012;7(5):417–39.

[6]. E. T. D. R. S. R. GROUP. Grading diabetic retinopathy from stereoscopic color fundus photographs- an extension of the modified Airlie House classification. Ophthalmology 1991;98(5):786–806.

[7]. Scanlon PH, Wilkinson CP, Aldington SJ, Matthews DR. A Practical manual of diabetic retinopathy management. first ed. Wiley-Blackwell; 2009.

[8]. Dubow M, et al. Classification of human retinal microaneurysms using adaptive optics scanning light ophthalmoscope fluorescein angiography. Investing Ophthalmology Vis Sci 2014;55(3):1299–309.

[9]. Xu K, Feng D, Mi H. Deep convolutional neural network-based early automated detection of diabetic retinopathy using fundus image. Molecules 2017;22(12): 2054.

[10]. Pooja Bidwai 1,* , Shilpa Gite 1,*, Kishore Pahuja 2 and Ketan Kotecha 1,* "A Systematic Literature Review on Diabetic Retinopathy Using an Artificial Intelligence Approach", Big Data Cogn. Comput. 2022, 6, 152. https://doi.org/10.3390/bdcc6040152.

[11]. Mohammad Z. Atwany , Abdulwahab H. Sahyoun , and Mohammad Yaqub, " Deep Learning Techniques for Diabetic Retinopathy Classification: A Survey", Received February 7, 2022, accepted March 1, 2022, date of publication March 8, 2022, date of current version March 18, 2022.

[12]. Shu-I Pao, Hong-Zin Lin, Ke-Hung Chien, Ming-Cheng Tai, Jiann-Torng Chen, and Gen-Min Lin, "Detection of Diabetic Retinopathy Using Bichannel Convolutional Neural Network", Received 10 March 2020; Accepted 18 May 2020; Published 20 June 2020.

[13]. Skylar Stolte , Ruogu Fang, "A Survey on Medical Image Analysis in Diabetic Retinopathy", S Stolte, R Fang - Medical image analysis, 2020 – Elsevier.

[14]. Uzair Ishtiaq & Sameem Abdul Kareem & Erma Rahayu Mohd Faizal Abdullah & Ghulam Mujtaba & Rashid Jahangir & Hafiz Yasir Ghafoor," Diabetic retinopathy detection through artificial intelligent techniques: a review and open issues", Multimedia Tools and Applications (2020) 79:15209–15252.

[15]. Md. Nahiduzzaman, Md. Robiul Islam, Md. Omaer Faruq Goni, Md. Shamim Anower, Mominul Ahsan, Julfikar Haider, Marcin Kowalski," Diabetic retinopathy identification using parallel convolutional neural network based feature extractor and ELM classifier", Received 15 February 2022; Received in revised form 2 December 2022; Accepted 12 January 2023.

[16]. Mohamed Chetoui, Moulay A. Akhloufi, Mustapha Kardouchi," Diabetic Retinopathy Detection Using Machine Learning and Texture Features", DOI: 10.1109/CCECE.2018.8447809.

[17]. Muhammad Mohsin Butt, D. N. F. Awang Iskandar, Sherif E. Abdelhamid, Ghazanfar Latif and Runna Alghazo," Diabetic Retinopathy Detection from Fundus Images of the Eye Using Hybrid Deep Learning Features", Diagnostics 2022, 12, 1607.

[18]. Parshva Vora and Sudhir Shrestha," Detecting Diabetic Retinopathy Using Embedded Computer Vision", Received: 4 September 2020; Accepted: 13 October 2020; Published: 17 October 2020.

[19]. Erdal Özbay," An active deep learning method for diabetic retinopathy detection in segmented fundus images using artificial bee colony algorithm", DOI: 10.1007/s10462-022-10231-3.

[20]. Mohamed Chetoui, Moulay A. Akhloufi, Mustapha Kardouchi," Diabetic Retinopathy Detection Using Machine Learning and Texture Features", DOI: 10.1109/CCECE.2018.8447809.

[21]. Parshva Vora and Sudhir Shrestha," Detecting Diabetic Retinopathy Using Embedded Computer Vision", Received: 4 September 2020; Accepted: 13 October 2020; Published: 17 October 2020.