A Review On Detection Of Diabetic Retinopathy

M. Kalpanadevi, Dr. M. Mary Shanthi Rani

Abstract: Diabetic Retinopathy (DR) is a progressive micro vascular complication of diabetes that affects the eye. It is identified by the appearance of different types of lesions, which includes microaneurysms, Hemorrhages, Macular Edema and Exudates. Detection of lesion plays an important role in early detection and treatment of Diabetic Retinopathy. Machine Learning and Deep Learning are state of the art technologies that are well-suited for data analytical applications specifically in Medical Field. This paper gives a survey about the different machine learning based methods that are used in detection of Diabetic Retinopathy with the comparative analysis of their performance.

Index Terms: Deep Learning, Diabetic Retinopathy, Exudates, Machine Learning, Macular Edema, Lesion detection and Microaneurysm.

1. INTRODUCTION

Diabetic Retinopathy (DR) is a progressive micro vascular complication of diabetes that affects the eye. It is a significant growing public health problem which damages the retinal blood vessel is and one of the most common causes of blindness in the world. Computer-aided diagnosis refers the approaches usedto extract specific features associated with the disease by using image processing filters. For analyzing retinal fundus image, detection of retinal blood vessels is most common and it is more important in image analysis task. Each RGB image is used to analyze the outline of the blood vessel in the retina detection for diabetic retinopathy, hypertension and glaucoma. Many approaches have been proposed for retinal blood vessel detection. Deepa Thomas et al proposed a new method using graph cut technique to extract the vessel in a retina vascular tree. Gabor wavelet is also used for vessel segmentation. [1] DR has two different classes NPDR and PDR (i) Non-Proliferative Diabetic Retinopathy(NPDR) and (ii)Proliferative Diabetic Retinopathy(PDR). In NPDR blood vessels in the retina are damaged and start leaking fluid, which causes the retina to become wet and swollen. PDR raises when new abnormal blood vessels appear in various areas of the retina, and it is an advanced severe stage of DR. It includes microaneurysms,hemorrhages, exudates, Macular Edemaetc[1]. In the earliest stages of DR, The microaneurysms in the form of reddish, smaller and circular dots will appear . Detection of lesion plays an important role in treating DR. Computer Aided diagnosis(CAD) of Microaneurysms has inspired by the researchers due to its low cost and the screening application.[3] Hemorrhages are one of the distinctive signs of retinal diseases in diabetic patients. There are dot and blot hemorrhages that appear after the appearance of microanerysm especially flame shaped hemorrhages which occur in superficial layers of the retina[5]. Diabetic Macular Edem (DME) is one of the leading cause of blindness and a chronic eye condition that affects the central vision of the eye[6]. The central part of the retina has clear and sharp vision.Exudates are the early stages of diabetic retinopathy caused by the accumulation of lipoproteins that escape from the blood vessels in diabetic patients.Yellowish intra retinal fluid deposits that contain protein, lipid or cellular debris [9].

- *Ph.D Research Scholar, Gandhigram Rural Institute(Deemed to be University),Gandhigram, Dindigul E-mail:Kds870@gmail.com*
- *Assistant Professor, Department of Computer Applications, Gandhigram Rural Institute(Deemed to be University),Gandhigram, Dindigul E-mail:drmaryshanthi@gmail.com*

2 LITERATURE REVIEW

Jadhavet al proposed a new method for Detection of the blood vessel is an important task for identifying different diseases like glaucoma, hypertension and DR. It is based on the diameter and width of vessel used to detect whether disease is present or not. Vision loss of patients indicates a severe condition of DR. To improve the appearance of blood vessels for accurate diagnosis, several enhancement techniques are used. This involves the following steps 1. Enhancement by applying filters. 2. Feature extraction by gray–level co occurrence matrix (GLCM) and Discrete Wavelet Transform (DWT). 3. Classification using classifiers based on the future. The test images are available in DRIVE, STARE and CHASE-DB1 databases. It contains Red, Blue and Green channel. Green channel gives high sensitivity to the blood vessels and Resizing of an image extract green channel from the RGB image. This channel is also used in segmentation and detection of retinal blood vessels also. Histogram Equalization method can be used to increase the contrast of the retinal blood vessel. Adaptive Histogram Equalization eliminates the false boundaries in a fundus image. The morphological operation also used to shrink the background to highlight only the interested regions like vessels and exudates present in the retinal image[2]. Adal etal. Proposed a new method to detect the Microaneurysms(MA) using scale adapted blob analysis and semi-supervised learning. It is modeled as finding interest regions using a semi-supervised learning approach. The automated MA detection CAD system involves three fundamental steps:1)Preprocessing 2)Candidate selection and 3) MA classification. In Preprocessing, correction of non-uniform illumination in fundus images are done using global and local histogram equalization. To correct the shading effects, background estimation and subtraction methods are used. Median filter is used to remove the green channel resulting in the corrected shaded image. Contrast enhancement method can reduce the shading effect while increasing the context of fundus images and by sorting all the positive pixels values of a shaded corrected image. A Gaussian mixture model-based clustering combined with logistic classification method has been proposed [3]. This algorithm reduces the false detection rate as well as computation time. Local minima detection method also proposed to detect regions of low pixel value image, by computing the local scale of the candidate measured by local maxima of an image. The third step uses supervised classifiers like KNN, Naive Bayes, SVM classifier to get the optimal solution.ROC training image database is prepared by using MA candidate selection algorithm. Accuracy of MA detectors are measured using sensitivity and specificity Parameters[4]. Jun

Wua et al proposed methods for Hemorrhages detection using 2-D Gaussian fitting. Accurate detection of hemorrhages has great significance for automatic screening and it provides effective evolution method of detection. The methods are classified into three classes.1. Template matching method based on the size and shape of hemorrhages. 2. Classifier based method using Support Vector Machine and Local Binary pattern (LBP), K-Means algorithm and Artificial Neural Network. 3. Feature analysis based method using adaptive threshold method in Convolutional Neural Networks for detection of red lesion. Pre-processing is used to enhance the influence of non-uniform brightness. Green channel is extracted and it is compared with Red and Blue channel. Green fundus image is processed by Contrast Limited Adaptive Histogram Equalization (CLAHE) to improve the contrast between hemorrhage and background candidate hemorrhage extraction. The preprocessed image is processed by background estimation, using median filter with m* m pixel windows after estimation, dark areas are transformed into bright areas. In feature extraction, Gaussian models are used to improve the accuracy of fitting. The fitting error is calculated as the mean square value of difference image between the pre-processed candidate and fitted candidate [5]. Krishna Rao et al. proposed Age-related Macular Degeneration detection using a deep convolutional neural network. If there is macular yellow deposits, it can be characterized by four levels. There are no symptoms present in early stages. Some symptoms are blurred (or) distorted vision may appear. This is the cause of leakage fluid within the central macula from the abnormal blood vessel. Diagnosis of DME is based on the presence of exudates. It needs a clinician for identification of DME. Fourteen layer CNN has been proposed to classify the fundus images having macular edema or not. The Seven – layer CNN generates the feature map that identifies the disease. The Max – Pooling operation is used to reduce the dimensionality further. The output layer is a fully connected layer with softmax function. The input layer has the dimension of 180*180*3. This model is also trained by back propagation method. Adam algorithm also used as an optimizer. A total of 1100 fundus images are taken for training with ten iterations. Automated identification of normal fundus images were done using Amplitude Modulation and Frequency Modulation method. Random Transform technique has been used to convert the 2-dimensional image into a one- dimensional image. This model is fully automatic, as there is no handcrafted feature extraction or selection. A feature extraction model can be designed that could extract highly distinctive features to be inserted into a cluster for classification, and also it can be installed in cloud system [7]. Adem K. proposed Exudate (Ex) detection for diabetic retinopathy with circular Hough transformation and convolutional neural networks. Ex detection is challenging, when it has a small lesion similar to microaneurysm and big one can be as large as an optic disc. Exudates is the early stage of DR, and it is created by accumulation of lipoprotein that escape from the blood vessel in diabetic patients. If it is severe, may cause loss of vision. Unlike hemorrhages, it takes a little longer time to detect bright lesions of the retina. Brightness base value segmentation, statistical feature and other image processing techniques .are explored for detecting exudates. Convolutional Neural Networks (CNN) method is used for object detection and classification. Optic Disc region is detected using canny edge detection and circular Hough transform algorithms. The images taken from DiratDB0 and DiratDB1 were used for detection and classifying the exudates. Exudates segmentation algorithm is used to detect the features like shape, color and feature. The presence of many different structures in the image makes it difficult to model them manually. To overcome this, CNN is used together with the circular Hough Transform. Hough Transform provides the circular mask to the segment of the region. Each Convolutional layer has the same size as the convolution filter. When it is too small, the complexity of features pushes the hardware to limits. Confusion Matrix is used to test the accuracy of the proposed CNN model with Hough Transform and is best suited for automatic detection of exudates in color fundus images [8].

3 PROPOSED WORK

The Performance of the above mentioned algorithms are measured using the following four metrics. They are True positive (TP),False Negative(FN),True Negative(TN) and False Positive(FP)[2]. For any binary classifier, the output can be defined based on these metrics

Sensitivity: It measures the proportions of actual positives that are correctly identified.

Sensitivity (SE): $\frac{TP}{(TP+FN)}$

Where TP represents True Positive and FN represents False Negative

Specificity: It is the ability to classify the patients who are not having the disease and

Specificity (SP) : $\frac{TN}{(TN+FP)}$

Where TP represents True Positive and FN represents False Negative.

Accuracy: It is a combination of both systematic and random errors. The high value of Accuracy requires high precision values. It calculates the proportion of true positive and true negative for evaluated images.[3]

Accuracy (Acc):(TP+TN)/(TP+FN+TN+FP)

IV.RESULTS AND DISCUSSION

The performance of the three algorithms interms of performance metrics. Table 1 presents the comparative analysis of the ML learning based methods for detection of DR in terms of performance metrics. The table also lists the methods and databases used for experimentation.

Table 1: *Comparative Analysis*

S. No	TYPE	METHODS	DATABASE	MEASUREMENT
1	Detection of Blood Vessels	(i)Using GSM (Common Gaussian Model) and DWT(Discrete Wavelet ransform)[1]	DRIVE	SE:100% SP:66% ACC:92%
			CHASE-DB1	SE:100% SP: 0% ACC:92%
		(ii)Neural Network with Back Propagation[2]		ACC:93.6 %
2	Detection of Microanerysm	(i)Detecting microanerysm with different candidate extractors using Hessian operator.[3]	FROC	SE: 44.64%

		(ii) Using SVM classifier (iii)Using KNN classifier[3]	DIRATDB1	SE:80% SP:92.3% AU:72.2%
		(iv)Ensemble based MA detector[4]	MESSIDOR	SE:96% SP:98% Acc:82%
3	Detection of Hemorrhages	(i) Hu moment invariant[5]	STARE	SE:69.4% SP:99.8% Acc:97.6%
		(ii) Feature descriptors in combination with multilayered Feed Forward Neural Networks	DRIVE	SE:70.6% SP:98.01% Acc:95.88%
		(iii)Principle Component Analysis with neural network for vessel segmentation using K-NN classifier.[5]	DIRATDB1	Acc:94.6%
		(iv)2D Gaussian fitting used to extract visual features of candidate Hemorrhages.[6]	DIRATDB	SE:94.01% SP: 94.30% Acc:100%
4	Detection of Macular Edema	Age related Macular Edema using (ii) CNN with blindfold cross validation strategies.[7]	Kasturiba Medical Hospital (Manipal)	SE:92.66% SP:88.56% Acc:91.17%
		(iii) CNN with tenfold cross validation strategies.[7]	DIRETDB0	SE:96.43% SP:93.75% Acc:95.45%
5	Detection of Exudates	(i)Detecting Exudates using SVM,KNN, Naïve-Bayes and Random Forest classifier	DIRETDB1	Acc:94% SE:93%
		(ii)Using Echo state Neural Network (A special form of Recurrent Neural Networks)[8]	MESSIDOR	SP:100% Acc:93%
		(iii)Using SVM Classifier(Support Vector Machine)[8]	STARE	SE:100% SP:94% Acc:97%
		(iv)Using Gaussian Mixture Model	DIRETDB1	SE:97.39% SP:98.02% Acc:97%
		(v) Using three layered neural networks.[8]	.DIRETDB1	SE:96.3% SP:99.8% Acc:99.7%
		(vi) Using Circular Hough Transform.[9]	.DIRETDB1	Acc:99.18%

4 CONCLUSION

In this paper, a review and comparative analysis of research work for identification of DR has been presented. This work discuss on the methods and databases used for detection of levels of DR (Microaneurysm, hemorrhage, Exudate, Macular Edema).This work will serve as a great reference for research in this domain.

REFERENCES

[1] Eltanboly,A, Ghazaf, M., Khalil A., Shalaby A., Mahmoud A, Switala, A & El-Baz, A., “An integrated framework for automatic clinical assessment of diabetic retinopathy grade using spectral domain OCT images”, IEEE 15th International Symposium in Biomedical Imaging, pp. 1431-143, 2018.

[2] Jadhav, A. S. & Patil, P. B.,”Detection of blood vessels in retinal images for diagnosis of diabetics”, 2nd International Conference on Inventive Systems and Control (ICISC), pp. 888-891, 2018.

[3] Adal, K. M., Sidibé, D., Ali, S., Chaum, E., Karnowski, T. P., &Mériaudeau, F ,”Automated detection of microaneurysms using scale-adapted blob analysis and semi-supervised learning”, Computer methods and programs in biomedicine, vol.114, no.1, pp.1-10, 2018.

[4] Antal,Balint,Hajdu and Andras, “An ensemble-based system for microaneurysm detection and diabetic retinopathy grading”, IEEE transactions on biomedical engineering,Vol.59,no.6, pp.56-6, 2017.

[5] Jun Wua et.al, “Hemorrhage detection in fundus image based on 2D Gaussian fitting and human visual characteristics”, Optics& Laser Technology, Elsevier, pp.5-11, 2018.

[6] Mumtaz, R., Hussain, M., Sarwar, S., Khan, K.MumtazS.,&Mumtaz,M, ”Automatic etection of al hemorrhages by exploiting image processing techniques for screening retinal diseases in diabetic patients”, International Journal of Diabetes in Developing Countries, vol.38, no.1, 2017, pp.80-87.

[7] Tan, Jen Hong, Sulatha V. Bhandary, SobhaSivaprasad, Yuki Hagiwara, AkankshaBagchi, U. Raghavendra, A. Krishna Rao et al., "Age-related Macular Degeneration detection using deep convolutional neural network", Future Generation Computer Systems, vol. 87, pp.127-135, 2018.

[8] Fraz, M. M., Badar, M., Malik, A. W., & Barman, S. A,” Computational Methods for Exudates Detection and Macular Edema Estimation in Retinal Images: A Survey”, Archives of Computational Methods in Engineering, pp.1-28, 2018.

[9] Adem, K,”Exudate detection for diabetic retinopathy with circular Hough transformation and convolutional neural networks”, Expert Systems with Applications, vol.114, pp.289-295, 2018.

[10] Sinthanayothin, C., Boyce, J. F., Williamson, T. H., Cook, H. L., Mensah, E., Lal, S., & Usher, D,”Automated detection of diabetic retinopathy on digital fundus images”, Diabetic medicine, vol.19, no.2, pp.105-112, 2002.