Survey on Approaches used for Diabetic Retinopathy Detection

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Abstract—The retina is a very sensitive layer present at the back of the human eyeball, which is responsible for sending signals to the brain and visualizing images. Damage to the retina can cause complete vision loss. Many retinal diseases such as glaucoma, macular degeneration, diabetic retinopathy are reasons for complete blindness. Diabetic Retinopathy (DR) is a leading retinal disease which may progress through high glucose level in the blood called diabetes. Increased number of patients with diabetes, may result in increase in DR patients too. Automatic DR detection may help ophthalmologist to speed up the process of DR diagnosis. Different techniques can be used for this purpose, such as image processing, machine learning and deep learning. This paper presents survey of different approaches used for DR detection.

Index Terms—Retinal disease, Diabetic retinopathy, Image processing, Machine learning, Deep learning.

I. Introduction

An eye is the crucial organ of the human body, as it is responsible for the visualization of the world around us. Retina is part of an eye, is a thin layer present at the back of the human eyeball. Brain accepts the signals coming from the retina to recognize images. Retinal diseases such as macular degeneration, glaucoma, diabetic retinopathy can cause complete blindness if not treated at early stage. An eye aliment in diabetic patients is called diabetic retinopathy. This is when high glucose levels cause harm to veins in the retina. As per an examination which was directed by the world health organization, it demonstrates that the number of diabetic patients will increase from 130 million to 350 million throughout the following 20 years[13]. In developed countries, one of the significant reason for visual deficiency is DR. The increased number in diabetic patients may result in more number of DR patients. Detection of DR is important to know the disease at an early stage so as to save patients from getting into more severe condition.

A. Retinal Diseases

Retinal diseases are those which directly affect the retina surface and blood vessels present on the retina. The most common retinal disease are :

1) Macular Degeneration: The macula is the focal piece of the retina, a dainty layer of light touchy tissue in the back of the eye. The macula enables you to see fine subtleties unmistakably and perform exercises, for example, perusing and driving. At the point when the macula doesn't work accurately, focal vision can be influenced by haziness, dim zones or contortion. Macular degeneration influences capacity to see close and far, and can make a few exercises, such as perusing little print or threading a needle, troublesome or unthinkable[14].

2) Retinal Detachment: At the point when the retina disconnects, it is lifted or pulled from its typical position. If not expeditiously treated, retinal separation can cause changeless vision misfortune[15].

3) Glaucoma: Glaucoma is an ailment that harms eye's optic nerve. It ordinarily happens when liquid develops in the front piece of eye. That additional liquid builds the weight in eye, harming the optic nerve.

4) Diabetic Retinopathy: Diabetic retinopathy is a disorder of the retinal vessels that eventually develop to some degree in nearly all patients with long-standing diabetes mellitus. As stated in the introduction, a patient having diabetic retinopathy are increasing at a very high rate compared to another retinal disease. So automatic detection is needed to detect disease in less time compared to a manual screening of DR. DR is classified into two major classes that are Non-Proliferate Diabetic Retinopathy(NPDR) and Proliferate Diabetic Retinopathy(PDR).

NPDR is an early stage of diabetic eye disease. Tiny blood vessels leak, making the retina swell. When the macula swells, it is called macular edema. This is the most common reason why people with diabetes lose their vision. Also with NPDR, blood vessels in the retina can close off. This is called macular ischemia. When that happens, blood cannot reach the macula. Sometimes tiny particles called exudates can form in the retina. These can affect vision too. PDR is the more advanced stage of diabetic eye disease. It happens when the retina starts growing new blood vessels. This is called neovascularization. These fragile new vessels often bleed into the vitreous. If they only bleed a little, you might see a few dark floaters. If they bleed a lot, it might block all vision. These new blood vessels can form scar tissue. Scar tissue can cause problems with the macula or lead to a detached retina. PDR is very serious and can steal both central and peripheral (side) vision.

DR has primarily four stages namely, Normal, Mild, Moderate, Severe, PDR [16] :

- Mild NPDR is a beginning stage of DR in which little zones of inflatable like swelling in the retina's modest veins, called microaneurysms, happen at this most punc-

tual phase of the ailment. These microaneurysms may release liquid into the retina.

- Moderate NPDR is a stage after mild. As the sickness advances, veins that sustain the retina may swell and twist. They may likewise lose their capacity to transport blood. The two conditions cause trademark changes to the presence of the retina and may add to Diabetic Macular Edema(DME). exudates and hard exudates comes under this stage.
- Severe NPDR is a stage after moderate. In this stage a lot more veins are blocked, denying blood supply to territories of the retina. These regions discharge development factors that flag the retina to develop fresh recruits vessels.
- PDR is a last stage of DR. At this propelled stage, development factors emitted by the retina trigger the expansion of fresh recruits vessels, which develop along within surface of the retina and into the vitreous gel, the liquid that fills the eye. The fresh recruits vessels are delicate, which makes them bound to spill and drain. Going with scar tissue can contract and cause retinal separationthe pulling ceaselessly of the retina from fundamental tissue, similar to backdrop stripping far from a divider. Retinal separation can prompt changeless vision misfortune.

B. Images with DR based on severity level

Images are categories into four-part shown in figure 2 [11].

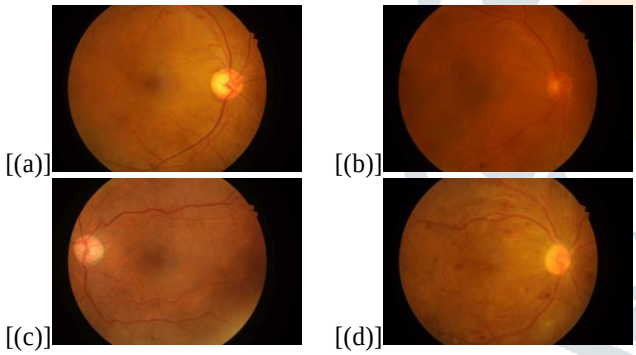

Fig. 1. (a) Mild DR, (b) Moderate DR, (c) Sever DR, (d)PDR

II. Different Approaches for DR detection

Many researchers have used different algorithms and techniques to detect DR automatically. The used techniques are categorized into three forms, image processing, machine learning, and deep learning. The following sections are explained in detail about each with their respective performance. The various approaches used to detect DR is mention in figure no.3. Image preprocessing step is a common step for all mentioned approaches.

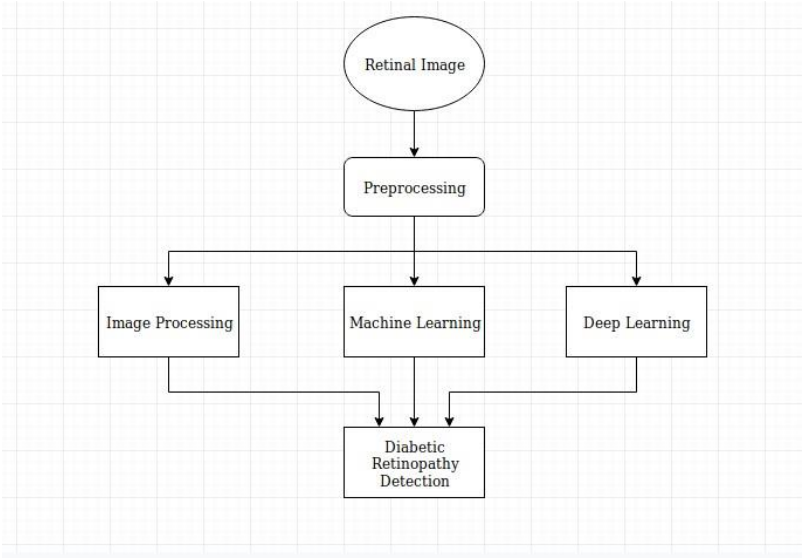

Fig. 2. Various approaches to detect DR

A. Image Preprocessing

Image preprocessing is the first step in any work where the image is input to the system. The preprocessing of the image is to convert an image into a standard form which will make system data independent. Following are the preprocessing techniques used to detect DR.

1) Re-sizing: Due to big size of the image, it is not suitable to feed into the neural network as it can increase the computation time. The image in the dataset is resized to
256x256 pixels. Resizing is accomplished by using bilinear interpolation [1][6][2].

2) Averaging: The images in the dataset contain noise such as low contrast, color variation, and uneven light reflections. To make images more consistent and smooth, a convolution filter is used [1]. To improve the image quality, contrast enhancement technique which is histogram equalization is used [2][3][6][17]. To scale data between 0-1, min-max normalization is used [6]. To remove occasional salt and paper noise, the median filter is used[17] and to remove noise, Gaussian low filter is used [3].

B. Image Processing

Many researchers solve this problem by using image processing only. Alan D. Fleming et al.[17] proposed a solution for microaneurysms(MA) which is an early sign of diabetic retinopathy. The standardization of the contrast is used to distinguish between MA and other points. Watershed transform is the best method for standardization of contrast to derive a region that does not contain vessels or other lesions. Local vessel detection technique handles dots with vessels. The MAs are detected with 84.5% sensitivity and 83% specificity. Purbi shanrma et al. [5] in their work,firstly bright disc region is removed from the image to detect bright lesions in a retinal images. The exudates are detected and then images are classified into two classes only with 98.2% of sensitivity.

C. Machine Learning

Machine learning algorithms are capable that they can learn from a large scale dataset and predict the value based on trained dataset. There are some problems such as product recommendation in which humans are not able to predict a result. To solve such problems we use machine learning techniques. Osareh et al.[2] proposed an automated system for exudates detection from retinal images using computational intelligence technique. After preprocessing, region segmentation is carried out using fuzzy c-means clustering. Segmented regions are classified based on some features such as color, size, edge length, and texture. A genetic algorithm is used to select the best subset of features and for classification of those subset multilayer neural network is used. The performance of the system is 93.5% of sensitivity. Carrera et al.[18] they used features such as blood vessels, microaneurysms, and hard exudates in the processes of DR detection. These features are extracted from the retinal image and using Support Vector Machine(SVM), the classification is carried out into four non-proliferative diabetic retinopathy.

D. Deep Learning

The deep-learning algorithm can extract a large number of features automatically. The large set of features may lead to accurate prediction. Benzamin et al.[3]In their work, they make use of patches which had the disease are extracted from retinal images and are given to 8 layers convolution neural network to detect images which are having exudates. Doshi et al.[6] they used deep convolution neural network to classify the retinal image into five stages, no DR, mild, moderate, severe, PDR. Shvav Suiyal et al.[1] proposed a system which will work on mobile without internet. the convolutional neural system show utilized in this venture is MobileNets, which is utilized for cell phones. The neural arrange has 28 convolutional layers and after each layer there is batchnorm and ReLU nonlinear capacity aside from at the last layer. The yield from last layer is a class mark either DR or no DR. The last exactness of the model is 73.3% . This model is enhanced to deal with cell phones and does not require Web association with run. Lei Zhouet al. [10] proposed a deep Multiple Instance Learning(MIL) strategy for DR discovery, which jointly learns features and classifiers from data and achieves a significant improvement on detecting DR images and their inside lesions with 86% of precision on DIARETDB1 dataset.

III. Dataset

Following are few datasets which have been used by the different authors to implement the automatic DR detection. Following table consist of the source of the dataset along with the number of images, each dataset is consist. Those datasets are namely IDRiD, DIARETDB1, DRIVE, Messidor, HRFiD, STARE as mentioned in TABLE I.

Ref.	Dataset name	No. of Images	Source
[11] [4]	IDRiD	514	IEEE Dataport Repository
[5] [10]	DIARETDB1	89	http://www.it.lut.fi/project /imageret/diaretdb1/
[5]	DRIVE	40	https://www.isi.uu.nl/Research/ Databases/DRIVE/
[10]	Messidor	1200	http://www.adcis.net/en/ third-party/messidor/
[6]	HRFiD	45	https://www5.cs.fau.de/research/ data/fundus-images/
[5]	STARE	400	http://cecas.clemson.edu/ ahoover/stare/

TABLE I
DATASET USED TO DETECT DR

IV. Discussion

The summarization of various approaches used to detect DR is shown in TABLE II. Image processing is the first technique used to detect DR. In which, using morphological operations such as erosion and thresholding techniques the retinal blood vessels and red dots are detected and separated from the input image[5][17]. The next technique was machine learning in which SVM, kNN algorithms are used to classify images into two categories that is patient with DR and with No DR[2][18]. The recent method used is deep learning techniques [1][4][6][10] in which different architectures of CNN such as standard CNN, VGG16, etc. are used to detect DR with five categories namely normal, mild, moderate, severe, PDR.

Ref.	Dataset Used	Technique Used	Performance
[17]	Fundus Retinal Image	Image Processing	84.5% Sensitivity, 83% Specificity
[5]	STARE, DRIVE, DIARETDB1	Image Processing	98.2% Sensitivity
[2]	Fundus Retinal Image	Machine Learning	93.5% Sensitivity
[18]	Fundus Retinal Image	Machine Learning	95% Sensitivity
[1]	Fundus Retinal Image	Deep Learning	73.3% Accuracy
[4]	IDRiD	Deep Learning	96.6% Accuracy
[6]	HRFiD	Deep Learning	39% Kappa score
[10]	DIARETDB1	Deep Learning	86% Precision

TABLE II
SUMMARIZED VIEW OF LITERATURE SURVEY

V. Conclusion

As detection of DR is done using various techniques, according to their performance, deep learning algorithms are quite good because of their automatic feature extraction tech- nique. A large number of features leading to probably an accurate prediction.

References

[1] Shorav Suriyal, Christopher Druzgalski, Kumar Gautam, "Mobile assisted diabetic retinopathy detection using deep neural network", 2018 Global Medical Engineering Physics Exchanges/Pan American Health Care Ex- changes (GMEPE/PAHCE), pp.19-24, 2018.

[2] Harini R, Sheela N, "Feature Extraction and Classification of Retinal Images for Automated Detection of Diabetic Retinopathy", Second Inter- national Conference on Cognitive Computing and Information Processing (CCIP), pp. 1-4, 2016.

[3] mer DEPERLOLU, Utku KSE, "Diagnosis of Diabetic Retinopathy by Using Image Processing and Convolutional Neural Network", 2nd International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT), pp. 1-5, 2018.

[4] Alireza Osareh, Bita Shadgar, and Richard Markham, "A Computational- Intelligence-Based Approach for Detection of Exudates in Diabetic Retinopathy Images", IEEE TRANSACTIONS ON INFORMATION TECHNOLOGY IN BIOMEDICINE, VOL. 13, NO. 4, pp. 535 - 545, 2009.

[5] Purabi Sharma, S. R. Nirmala, Kandarpa Kumar Sarma, "Classification of Retinal Images Using Image Processing Techniques", Journal of Medical Imaging and Health Informatics, pp.341-346, 2013.

[6] Darshit Doshi, Aniket SheQoy, Deep Sidhpura, Dr. Prachi Gharpure, "Diabetic Retinopathy Detection using Deep Convolutional Neural Net- works", pp.261-266, 2016.

[7] Yashal Shakti Kanungo, Bhargav Srinivasan, Dr. Savita Choudhary, "Detecting Diabetic Retinopathy using Deep Learning", 2017 2 nd IEEE International Conference On Recent Trends in Electronics Information Communication Technology (RTEICT), May 19-20, 2017, India, pp.801-804 , 2018.

[8] Arkadiusz Kwasigroch , Bartlomiej Jarzembinski , Micha Grochowski, "Deep CNN based decision support system for detection and assessing the stage of diabetic retinopathy", 2018 International Interdisciplinary PhD Workshop (IIPhDW), pp. 111-116, 2018.

[9] juan shan, Lin Li, "A Deep Learning Methods for Micro aneurysms Detection in Fundus Image" , IEEE First International Conference on Connected Health: Applications, Systems and Engineering Technologies (CHASE), pp.357-358 ,2016. Year: 2016

[10] Lei Zhou ,Yu Zhao, Jie Yang, Qi Yu, Xun Xu , "Deep multiple instance learning for automatic detection of diabetic retinopathy in retinal images", IET Image Processing, Vol. 12 Iss. 4, pp. 563-571, 2018.

[11] Prasanna Porwal, Samiksha Pachade, Ravi Kamble, Manesh Kokare Girish Deshmukh, Vivek Sahasrabuddhe, Fabrice Meriaudeau, "Indian Diabetic Retinopathy Image Dataset (IDRiD): A Database for Diabetic Retinopathy Screening Research", 2018.

[12] Avula Benzamin, Chandan Chakraborty, "Detection of Hard Exudates in Retinal Fundus Images Using Deep Learning", 2018 IEEE Interna- tional Conference on System, Computation, Automation and Networking (ICSCA), pp.1-5, 2018.

[13] https://www.who.int/diabetes/en/

[14] https://www.medfordretinacare.com/

[15] https://nei.nih.gov/health/retinaldetach/retinaldetach/ [16] https://nei.nih.gov/health/diabetic/retinopathy

[17] Alan D. Fleming, Sam Philip, Keith A. Goatman, John A. Olson, and Pe- ter F. Sharp, "Automated Microaneurysm Detection Using Local Contrast Normalization and Local Vessel Detection", IEEE TRANSACTIONS ON MEDICAL IMAGING, VOL. 25, NO. 9, 2006.

[18] Enrique V. Carrera, Anrez Gonzalez, Ricardo Carrera, "Automated detection of diabetic retinopathy using SVM", IEEE XXIV International Conference on Electronics, Electrical Engineering and Computing (IN- TERCON), pp.1-4, 2017.