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A Systematic Review of Detection of Diabetic Retinopathy using Machine Learning Approach

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Abstract –
Diabetes Mellitus causes diabetic retinopathy (DR). It can cause blindness if not diagnosed early. Disease diagnosis is an essential and highly scrutinized biomedical field in which machine learning has been significantly used. Recently, machine learning has emerged as one of the most widely used approaches for improving performance in various areas, including medical image analysis and classification. This research compares several machine learning experiments based on the accuracy and sensitivity of retinal fundus pictures acquired by the fundus camera to assess several strategies for identifying Diabetic retinopathy. Inflammatory illnesses in the posterior portion of fundus photography are followed by retinal imaging. In particular, machine learning and deep learning are cutting-edge technologies well-suited for data analytics applications in the medical field. The results were compared to those of other approaches such as deep neural networks and other best practices. This work will be beneficial to researchers who want to apply their research in this field. During this research, we have gone through several research papers. This paper includes findings from other researcher's studies, which have been summarized to present their pros and cons for disease diagnosis.
Keywords: Diabetes Retinopathy, Image Processing, Matlab, Blood Vessel, Machine Learning, Deep Learning

Introduction

Diabetes has become a big health concern for individuals of all ages in today's globe. Diabetes is a condition in which the body's capacity to turn glucose (sugar) into energy is impaired. When the pancrease produces insufficient amounts of insulin, diabetes develops. Diabetes is a chronic condition that affects the retina and other organs in the human body [6]. The eye is an essential organ of the human body; without it the whole world would be dark.

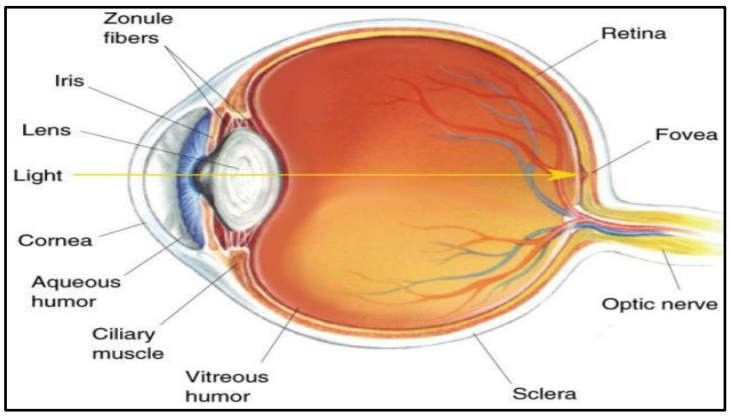

Fig. 1 Structure of Human Eye (source-[21])

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Diabetes can damage the blood vessels of the retina, which can result in blindness. It happens when the blood vessels in the retina are damaged by high blood sugar levels[12] [16]. These blood vessels can grow in size and leak. They can close, preventing blood from passing through. The review provided [11]explains that Diabetic retinopathy refers to the collection of disorders caused by the damage to the retina's blood vessel. The early stages of diabetic retinopathy are called Non-proliferative DR (NPDR), affecting the nutrition supply for the sensitive-light layer to the retina. NPDR itself did not cause blindness, but if not cared enough and got quick treatment, the NPDR comes to the next stage, called Proliferative DR (PDR), which caused blindness, and the effect is not reversible. NPDR itself contains several stages, such as mild, moderate, and severe. When NPDR becomes severe, the retinal sensory layers will ask the brain to create new blood vessels called neovascularization. Most of the patients develop changes in the blood vessel in the optic disk.

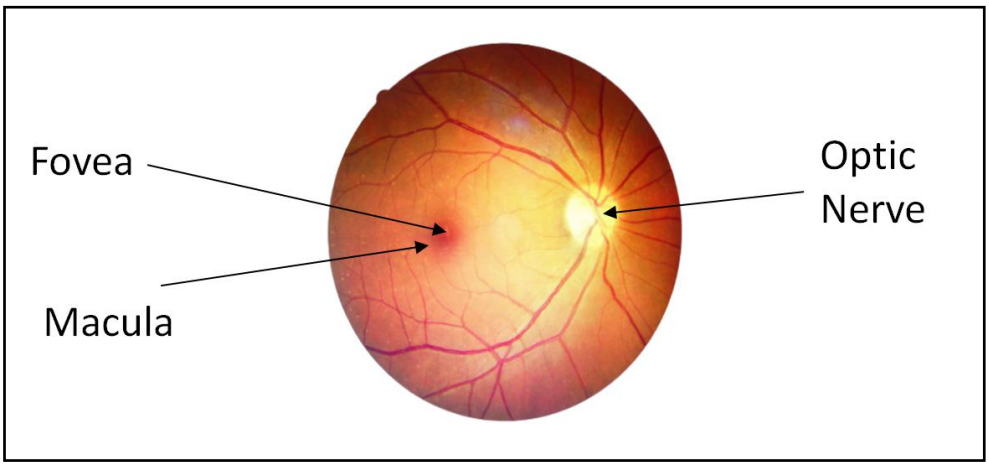

Fig 2.Healthy Retina

Traditionally, medical experts have diagnosed a diabetes disease with experience, clinical data, and adequate knowledge in identifying the disease. Such a way of diagnosis is found to be approximate and time-consuming. More appropriate methods such as Smart apps, online therapy, and healthcare are all on the rise in recent years. Many people have found it to be a convenient way to deal with medical issues.

Diabetic retinopathy can be detected by several characteristics, such as microaneurysms, Vitreous hemorrhages, hard exudates, cotton wool patches, and glaucoma [11]. These are some of the visual abnormalities caused by abnormal new blood vessels growing on the retina. Microaneurysms are the most common type of ocular abnormalities caused by diabetes. These are distinguished by tiny, dark crimson patches or hemorrhages that occur alone or in groups and are light sensitive. Hemorrhages are spherical and are located in the retina's deep layer. There are two types of exudates: hard exudates and soft exudates. Fat and protein leaking from the blood vessels produce hard exudates, which prevent light from reaching the retina and cause vision impairment. Cotton wool patches appear in the advanced stages of diabetic retinopathy and are referred to as soft exudates. These are caused by a blockage of the nerve fiber layer, which causes the nearby nerve fiber axons to swell [10]. Diabetic Macular Edema (DME) is one of the leading causes of blindness

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and a chronic eye condition that affects the eye's central vision. The main part of the retina has a clear and sharp vision[3].

This research examines the many methods for identifying DR based on features such as blood vessels, microaneurysms, and hemorrhages, among others. Fig. 3 shows a human retina affected with diabetic retinopathy

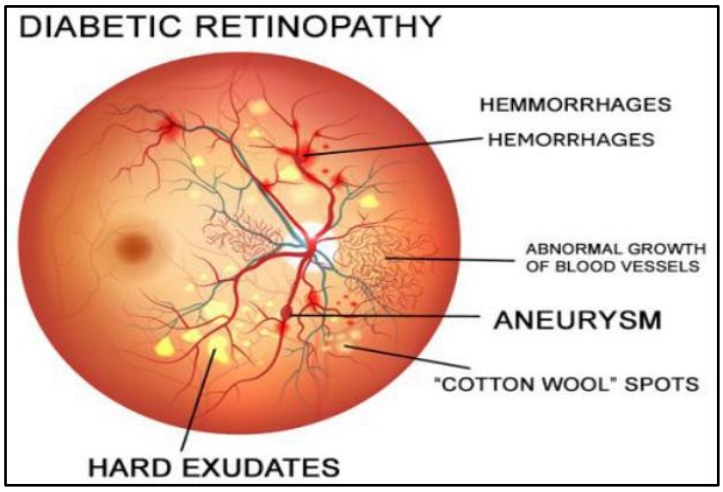

Fig 3:Various Lesions of Retina (source-[21])

Many types of research in recent years have demonstrated the significance of the machine learning approach for importance and efficiency in Disease prediction and diagnosis in the disciplines of medication as the results the researchers; medical expert systems can be used as a scientific source by medical students. Expert system is one of the tools used in the medical field for the diagnosis of diabetes. A computer program provides expert advice or solution as if a real person has been consulted [6]. It can also help users as an auxiliary diagnostic system to diagnose and treat retinopathy complication of diabetes diseases

Machine learning is a set of tools that, in general, allow us to "teach" computers how to accomplish tasks by giving them samples of how things should be done so that we may receive a speedy result. Machine learning is being used in healthcare to develop algorithms that can assist doctors in getting a more accurate or effective diagnosis for various ailments. Often, machine learning methods are broken into two phases:

a) Training: A model is learned from a collection of training data.
b) Application: The model is used to make decisions about some new test data

Several machine learning techniques have been utilized in the literature to detect DR, which requires two steps: feature extraction and classification.

Retinal fundus imaging, pictures of the retina recorded by a fundus camera, was utilized in most of the research. This Fundus camera may be used for both lighting the retina and photographing it at the same time. It has been designed to imagine the eye's interior, mainly the retina, optic disc, macula, and posterior pole. In terms of machine learning, every image pixel is either a part of the vessel or non-vessel decision class. Deep Learning (DL) has evolved into a reliable tool that enhances machine learning and is a superior technique that can replace machine learning in most cases.

Convolution Neural Networks (CNNs), a branch of deep learning, have an impressive record for image analysis and interpretation applications, including medical imaging. Network architectures designed to work with image data were routinely built already in the

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1970s [18]. In machine learning the Artificial Neural Networks have already been applied widely in medical imaging. Still, particular kinds of neural networks known as Deep Networks, especially CNN We performed various image preprocessing techniques; However, deep networks can work well on raw image data. They can work more efficiently on preprocessed images [20]. Artificial Neural Networks are some factual learning algorithms inspired by biological neural nets (people) or biological neurons (humans' central focal frameworks)[21].

LITERATURE REVIEW

Morium Akter et al. [1] proposed an automated diagnosis of diabetic retinopathy with the help of an imaging system. The authors divided the task into three sections: first, they calculated background illumination; second, they reviewed the existing method and discussed it; and finally, they concluded exudates detection and future directions. However, as an author, he analyzed that imaging technology of the fundus camera must be designed in an efficient and high-resolution manner so that diabetic retinopathy can be detected.

Basha et al. [2] expressed that morphology segmentation and fuzzy logic were used and suggest a method for automatically detecting hard exudates in diabetic retinopathy from color fundus pictures. However, due to color similarities between exudates, the optic disc, and the edge blood vessel, their system still makes some inaccurate detection.

M. Kalpanadevi et al.[3] studied that by reviewing various research work discuss the methods and databases used to detect levels of DR (Microaneurysm, hemorrhage, Exudate, Macular Edema) by machine learning technique. After evaluating many research papers, she found the high value of accuracy requires a high precision value which is a combination of both systematic and random errors

Morales et al. [4], Using the Gabor transform methodology, developed a digital tool for detecting DR in retinal images. As a result, the ophthalmologist can deliver a more accurate diagnosis of DR. Because the symptoms of DR are asymptotic, recognizing it at an early stage is challenging. Even though retinography is commonly performed, the quality of the results has been lacking. This tool provides a more excellent grade of retinography by using an algorithm based on the Gabor transform in MATLAB.

Another attempt at diabetes diagnosis was made by Hamood Ali et al.[5] Using a MATLAB-based method, the fundus image taken using a Peek retina connected to a smartphone camera lens was analyzed. They reached the PDR and NPDR stages of DR by performing morphological operations on four eye abnormalities and achieving a 98 percent accuracy rate, allowing them to assess PDR and NPDR in about 39 seconds. Furthermore, an ANOVA analysis was performed using a p-value of 0.5 (lower probability error).

R. P. Ambilwade et al.[6] reviewed several expert systems for both diagnosing and treatment of diabetes. Various expert systems have been created for use in the diagnosis or management of diabetes. For diagnosis, the majority of expert systems use the Pima Indian pregnant women dataset.

Revathy R et al.[7] focuses on using a machine learning hybrid model to automate the detection of diabetic retinopathy by extracting the features haemorrhage, microaneurysms, and exudates. As a classifier in this proposed model, a mix of SVM and KNN is used. They also depict that the disease grade as normal or abnormal also the maximum level of accuracy is 82 percent. A precision score of 0.8119, a recall score of 0.8116, and a measure score of 0.8028 were obtained using a hybrid technique.

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COMPARATIVE STUDY OF REVIEWED WORK

Author and System Name	Dataset/ Knowledge base Used	Machine Learning Methodology	Development Methodology	Usability
Alzami, F., Abdussalam, Megantara, R. A., Fanani, A. Z., & Purwanto. (2019). Diabetic Retinopathy Grade Classification based on Fractal Analysis and Random Forest.	MESSIDOR dataset for fractal analysis	Not Mentioned	fractal analysis & random forest	User friendly to detect healthy eyes and diseased pathologies eyes
Qomariah, D. U. N., Tjandrasa, H., & Fatichah, C. (2019). Classification of Diabetic Retinopathy and Normal Retinal Images using CNN and SVM	77 and 70 retinal images from Messidor database of base 12 and base 13, respectively	ANN & SVM	Not Mentioned	They gave the highest accuracy of 95.83% for base 12 and inception v3 and VGG Nettype 19 gave the accuracy of 95.24% for base 13
Kumar, S., & Kumar, B. (2018). Diabetic Retinopathy Detection by Extracting Area and Number of Microaneurysm from Colour Fundus Image	One hundred ten images (normal images and abnormal images) have been taken from DIABETDB1 database.	linear SVM	green channel extraction, histogram equalization, and morphological process	proposed a system for enhanced NPDR diabetic retinopathy detection by extracting the area and number of microaneurysms from DIARETDB1 colour fundus pictures. Fundus picture preprocessing
Choudhury, S., Bandyopadhyay, S., Latib, S., Kole, D., & Puri, J. (2016). Fuzzy C means based feature extraction and classification of diabetic retinopathy using support vector machines	fundus images:150	FuzzyC Means & Support Vector Machines	mathematical morphological segmentation techniques	suggested a system for dealing with fuzzy C means-based feature extraction and classification of diabetic retinopathy utilizing SVM to optimally categorize the images into their respective classes, achieving an overall accuracy of 97.6 percent

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Chetoui, M., Akhloufi, M., & Kardouchi, M. (2018). Diabetic Retinopathy Detection Using Machine Learning and Texture Features	1200 images in color from the MESSIDOR database	SVM	DR texture elements such as a local ternary pattern (LTP) and a shape histogram based on local energy (LESH).	the proposed method that uses several textural features and a machine learning classification algorithm to identify diabetic retinopathy
Basha, S. S., & Prasad, K. S. (2008). Automatic Detection of Hard Exudates in Diabetic Retinopathy Using Morphological Segmentation and Fuzzy Logic	dataset DIARETDB0	fuzzy logic	morphological operations for the segmentation and	suggest a method for automatically detecting hard exudates in diabetic retinopathy from color fundus pictures
Balakrishnan, V., Saravanan, V., & Niveditha, G. (2011). Graphical user interface for enhanced retinal image analysis for diagnosing diabetic retinopathy	DRIVE and DIARETDB0 datasets provide 130-color retinal images.	Not Mentioned	used MATLAB 7.8 for graphical user interface (GUI).	Color-based classification, sharp edge recognition, and extraction of the optic disc were used in the detection process.

CONCLUSION

In this paper, a review and comparative analysis of research work for the identification of DR has been presented. In addition, this work discusses the methods and databases used to detect levels of DR. This work will serve as an excellent reference for research in this domain. In the form of a complete literature study, many researchers who had investigated this subject and made significant contributions concerning diabetic retinopathy were listed, along with their benefits, disadvantages, or drawbacks.

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