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Diabetic Retinopathy Detection Through Deep Learning Techniques

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ABSTRACT

Diabetes mellitus frequently results in Diabetic Retinopathy (DR), which results in lesions on the retina that impact on vision. Blindness may result if it is not caught in time. Unfortunately, there is no cure for DR treatment merely preserves vision. Early diagnosis and treatment of DR can greatly lower the risk of visual loss. In contrast to computer-aided diagnosis technologies, the manual diagnosis of DR retina fundus images by ophthalmologists is costly, time-consuming, and prone to error. Deep learning has recently risen to prominence as one of the most popular methods for improving performance, particularly in the categorization and interpretation of medical images. Convolutional neural networks are more frequently utilized in medical picture analysis as a deep learning technique since they are extremely. The most cutting-edge ways for classifying and detecting DR colour fundus photos using deep learning techniques have been explored and examined for this paper. Additionally, the colour fundus retina DR datasets have been examined. There are also discussions on several complex subjects that demand further research.

Keywords: Diabetic Retinopathy, Detecting DR colour, Deep learning, visual loss.

I. INTRODUCTION

Diabetic retinopathy is a common complication of diabetes that affects the eyes, potentially leading to blindness if left untreated. Early detection and treatment of diabetic retinopathy are crucial in preventing vision loss. Deep learning techniques have shown promise in detecting diabetic retinopathy from medical images, such as fundus photographs. Fundus photographs capture images of the retina, which can be analysed using deep learning algorithms to identify signs of diabetic retinopathy, such as microaneurysms, haemorrhages, exudates, and neovascularization. Deep learning models can be trained on large datasets of labelled fundus images to learn patterns and features that are indicative of diabetic retinopathy [1]. One popular deep learning technique for image classification is convolutional neural networks (CNNs). CNNs use a hierarchical architecture of multiple layers to extract features from images and make predictions about their content. Transfer learning, where pre-trained CNN models are fine-tuned on specific tasks, has also shown success in diabetic retinopathy detection.

Other deep learning techniques, such as recurrent neural networks (RNNs) and generative adversarial networks (GANs), have also been applied to diabetic retinopathy detection, with promising results. Overall, the use of deep learning techniques for diabetic retinopathy detection has the potential to improve early detection and treatment of the disease, ultimately reducing the risk of vision loss for diabetic patients. However, further research and validation of these techniques are needed to ensure their effectiveness and generalizability in clinical settings [3].

To overcome these challenges, researchers have developed various deep learning models for detecting diabetic retinopathy, including transfer learning, multi-task learning, and ensembling techniques. Transfer learning has been widely used to leverage pre-trained models on large datasets to improve the performance of diabetic retinopathy detection on smaller datasets. Multi-task learning has been used to simultaneously detect diabetic retinopathy and other related diseases, such as glaucoma. Ensembling techniques have been used to combine multiple models to improve the overall performance of diabetic retinopathy detection.

Globally, diabetes mellitus (DM) is a serious health issue. The World Health Organisation (WHO) anticipates that there will be up to 285 million cases of diabetes worldwide by the year 2025, according to recent research that have shown a significant rise in the incidence and prevalence of the disease worldwide. Although type 2 diabetes (T2DM) is projected to develop the most, there has also been a recorded rise in T1DM and T2DM in children. The development of alterations related to the micro- and microcirculation in diabetes is the main cause for concern [5]. The small vessels of the retina, kidneys, and nervous system experience alterations that are clinically significant during diabetic microangiopathy. Coronary artery disease, stroke, and peripheral artery disease are all included in macroangiopathy. The medium and big arteries undergo the modifications.

II. Epidemiology of Diabetic Retinopathy

A microvascular consequence of diabetes is diabetic retinopathy (DR). In middle-aged adults, diabetes is one of the most common causes of vision impairment and lost workdays, while cataract and refractive problems continue to be the main factor in childhood blindness. Estimates of DR showed a progressive drop from 1990 to 2004 and a sharp decline in 2010: it was responsible for 4,8% of global blindness in 2002, 3,9% in 2004, and 1% in 2010.The report from the United States details the findings of an analysis of diabetic patients, which showed that although the proportion of adults with diagnosed diabetes who reported visual impairment decreased from 23.7% in 1997 to 16.7% in 2010, the number of adults with diagnosed diabetes who reported visual impairment increased. The growth of diabetes and DR is a major concern for developing countries. In addition, there is a high proportion of undiagnosed diabetes in developing countries.

III.Deep Learning

In order to acquire unsupervised features and categorise patterns, deep learning (DL), a subset of machine learning algorithms, uses hierarchical layers of non-linear processing stages. DL is one type of computer-assisted medical diagnosis. Classification, segmentation, detection, retrieval, and registration of the pictures are DL applications for medical image analysis. In recent years, DR detection and classification have made extensive use of DL [2].

Even when numerous diverse sources are combined, it may still learn the characteristics of the incoming data. Numerous DL-based techniques exist, including convolutional neural networks (CNNs), auto encoders, and sparse coding. Contrary to machine learning approaches, these methods perform better as the amount of training data increases since the number of learned features increases. Additionally, DL techniques did not need manually created feature extraction. Generally, the process used to detect and to classify DR images using DL begins by collecting the dataset and by applying the needed pre-process to improve and enhance the images.

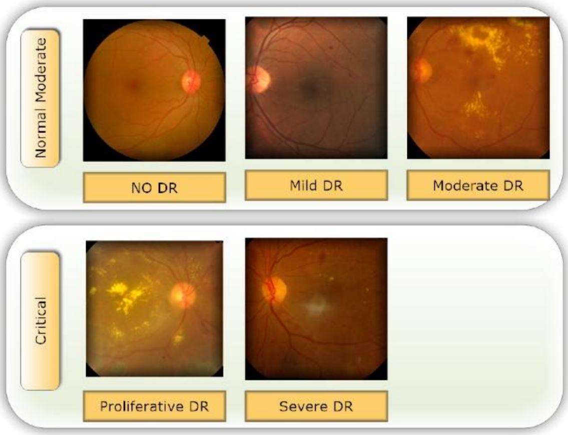

Fig 1. Prediction of Diabetic Retinopathy

IV. Risk Factors for DR

Numerous research showed that the element that determines the development of vascular. The duration of diabetes is related to problems and ocular alterations [11, 14–17]. 996 young patients with T1DM were studied in the Wisconsin Epidemiologic Study of Diabetic Retinopathy 30 years ago. After 5 or less years of T1DM duration, 17% of the population under study had DR characteristics identified, while 97.5% of those with diabetes for more than 15 years did. In a different study, Klein et al. found that among the 271 patients with T1DM diagnosed before the age of 30 who were investigated and had no DR symptoms at the beginning of this study when diabetes has been present for 4 years, up to 59% of patients have acquired no proliferative DR, and after 13 years of diabetes, PDR frequency has climbed to 14% in 11% of individuals. Additionally, 41% of patients saw a decline in their DR, whereas just 7% of diabetic individuals saw an increase in their visual acuity. Simsek et al. found that 1,4% of young patients with T1DM who were examined from 12 different centres and 1,032 patients had DR. The longer the duration of diabetes and the age of the patients tested were both associated with the existence of DR. Patients who had diabetes for more than 6 years were included in our examination. A significant risk existed for both diabetic nephropathy and DR [7]. Later in the study, we discovered that the highest discriminant value was established in predicting the development of microangiopathy in young people with T1DM for tumour necrosis factor alpha (TNF-), not for the length of diabetes.

The International Society for Paediatric and Adolescent Diabetes (ISPAD) currently recommends that young children with T1DM have their arterial blood pressure checked at least once a year. A comprehensive physical examination, the assessment of HbA1c concentration, or the detection of microalbuminuria should all be mandatory components of every visit to the paediatrician and/or diabetologist, according to the recommendations from the National High Blood Pressure Education Programme. Recent research has shown that an insufficient night-time blood pressure drops and an increase in incorrect arterial pressure levels are linked to a higher risk of diabetes problems. Systolic and diastolic pressure have been shown to be potential predictors of DR in the study by Gallego et al. Furthermore, the same authors have demonstrated that blood pressure increased the likelihood of early retinopathy in younger individuals with T1DM regardless of incipient nephropathy.

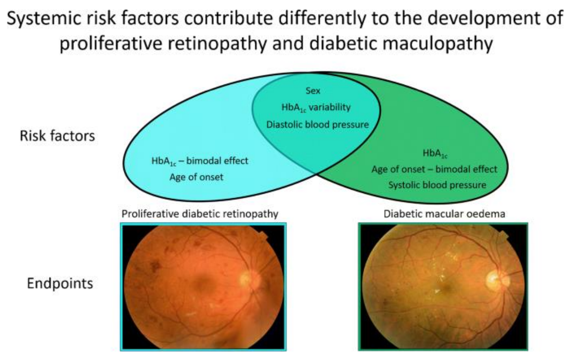

Fig 2. Risk Factor of Diabetic Retinopathy

V. Diabetic Retinopathy Screening Systems

The experiments that were done in order to divide the DR dataset into only two classes are summarised in this section. Using a CNN, K. Xu et al. automatically categorised the Kaggle dataset's photos into normal images and DR images. 1000 photos from the dataset were utilised. Before supplying the images to the CNN, data augmentation and resizing to 224*224*3 were carried out. Several transformations, including rescaling, rotation, flipping, shearing, and translation, were applied to the dataset images as part of data augmentation. Eight CONV layers, four max-pooling levels, and two FC layers made up the CNN architecture. For categorization, CNN's final layer used the SoftMax function. This technique achieved a 94.5% accuracy rate.

For the purpose of determining whether an image was referable DR, R. Pires et al. created their own CNN architecture. 16 layers make up the suggested CNN, which is comparable to the pretrained VGG-16 and team. During training, multi-image resolution and two-fold cross-validation were applied. After initialising the weights, the trained CNN on a lower picture resolution trained the CNN of the input 512 x 512 image. In order to lessen overfitting, the CNN was subjected to the drop-out and L2 regularisation approaches [6]. The Messidor-2 and DR2 datasets were used to test the CNN after it had been trained on the Kaggle dataset. Using data augmentation, the training dataset's classes were balanced. When testing the Messidor-2, the work achieved an area under the ROC curve of 98.2%.

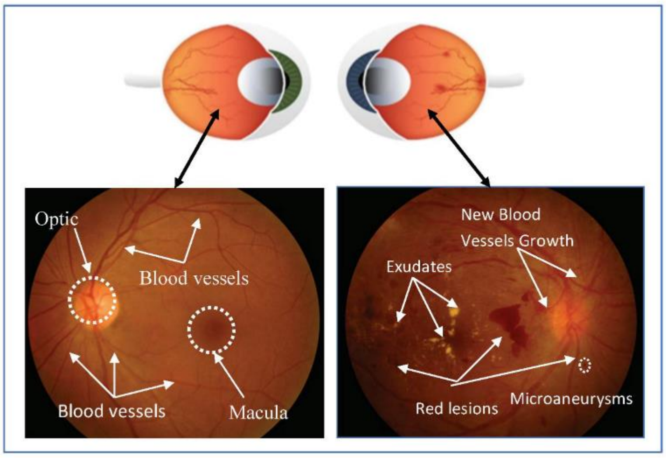

Fig 3. Diabetic Retinopathy Screening System

VI. Detection of Diabetic Retinopathy

The best correct vision acuity (BCVA) test, slit lamp biomicroscope, dilated fundus examination with ophthalmoscope, intraocular pressure measurement on patients at risk for glaucoma, and most importantly, digital fundus colour photos graded by qualified image graders and fluorescein angiography (FA) are the current standard methods to screen for DR. According to reports, the most accurate way of DR screening is retinal photography. Conversely, ophthalmoscopy has a better specificity while having a lower sensitivity. Specialists like diabetologists and ophthalmologists, particularly when employed in repeated tests. Retinal imaging for DR has long been advocated, both for disease screening and in important clinical research studies like the Early Treatment Diabetic Retinopathy Study (ETDRS). For identifying an increase in retinal thickness, stereophotography is more accurate but also more time- and labour-intensive. Mydriatic photography is the most efficient screening method, according on a systematic review of the available data.

Despite having excellent specificity (83–92%) and sensitivity (87-97%) for the identification of sight-threatening DR, it has a number of drawbacks, including the time required to get and analyse the photos, the requirement for dilating drops, and related concerns with patient compliance [8].

The main benefit of FA over fundus photography is its capacity to identify subtle DME as indicated by fluorescein leakage and macular ischemia, which is indicated by nonperfusion of the retinal capillaries via way of the capillaries. FA screening has limitations due to its invasiveness, limited time, pricey equipment, and adverse effects. It is not advised for routine use because its value as a diagnostic tool is inferior to photography. It is not necessary to diagnose clinically severe ME or PDR because both conditions can be identified with a clinical examination. The long-term follow-up of diabetic retinopathy in children showed that early alterations are not always a bad prognostic indicator in the development of DR and early FA is not particularly helpful in the management of diabetic children.

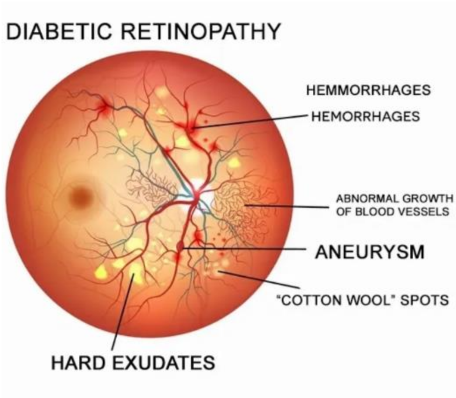

Fig 4. Detection of Diabetic Retinopathy

VII. CONCLUSION

Automated screening methods drastically cut down on the time needed to make diagnoses, saving ophthalmologists time and money, and enabling prompt patient treatment. automated DR systems detection is crucial in identifying DR at an early stage. The stages of DR are determined by the kind of lesions that develop on the retina. This article has examined the most recent deep learning-based automated methods for detecting and categorising diabetic retinopathy. We have detailed the publicly accessible common fundus DR datasets and provided a quick introduction to deep learning methods. Due to its effectiveness, CNN has been adopted by the majority of researchers for the detection and classification of DR pictures. Additionally, the effective methods that can be applied to identify and categorise DR using DL have been covered in this review.

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