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A study of deep learning methods to diagnose Diabetic Retinopathy

Anil Kumar[1*], Mridul Chawla[1]

Department of Electronics and Communication Engineering, DCRUST, Murthal, 131039, Sonipat, Haryana, India[1]

Abstract: Damage to the retina that impairs vision is a Diabetic Retinopathy (DR), a common side effect of diabetes mellitus and it may cause blindness if not caught in time. Regrettably, DR is irreversible, and therapy can only preserve eyesight. If DR is identified and handled right away, visual loss may be prevented. In contrast to computer-aided diagnostic techniques, it takes a lot of time, effort, money, and misdiagnosis for ophthalmologists to manually diagnose DR retina fundus photos. When it comes to medical picture analysis and classification, deep learning has quickly become among the most well-liked methods due to its improved performance. In medical image processing, convolutional neural networks (CNN) are most well-liked and successful deep learning (DL) technology. In this paper, we analyse and examine the advanced methods for applying deep learning to identify and categorise DR colour fundus images. Furthermore, an overview of the fundus retina DR colour datasets that are currently accessible has been provided. We also talk about some of the other difficult subjects that need additional research.

Keywords: Diabetic Retinopathy, Diabetes, Deep Learning, Convolutional Neural Networks, Retina.

1. INTRODUCTION

It is widely known that DR as a significant contributor to visual impairment leading to blindness. DR is distinguished by the pathological alteration of retinal blood vessels in individuals with diabetes. DR may divided into two primary categories: Non-Proliferative DR (NPDR) and Proliferative DR (PDR) [1]. In the first phases, DR is referred to as NPDR, which may be categorized into Mild, Moderate, and Severe stages. In cases when the mild stage is present, a single microaneurysm (MA) may be seen, characterized by a little red, round dot that is situated at blood vessel extremities. As the stage is moderate, the microaneurysms undergo rupture and penetrate into deeper retinal layers, resulting in the formation of an enflamed haemorrhage. The extreme phase is characterized by the presence of over 20 haemorrhages within the retina in every quadrants, accompanied by distinct bleeding in veins and notable intra retinal microvascular anomalies. PDR is the latter stage of DR distinguished by the growth of neovascularization. Neovascularization refers to the physiological process of generating new blood vessels, specifically functioning microvascular networks, which emerge along the inner retinal surface [2]. The visual representation shown in Figure 1 shows the retina's typical structure, as well as distinct phases of DR [3].

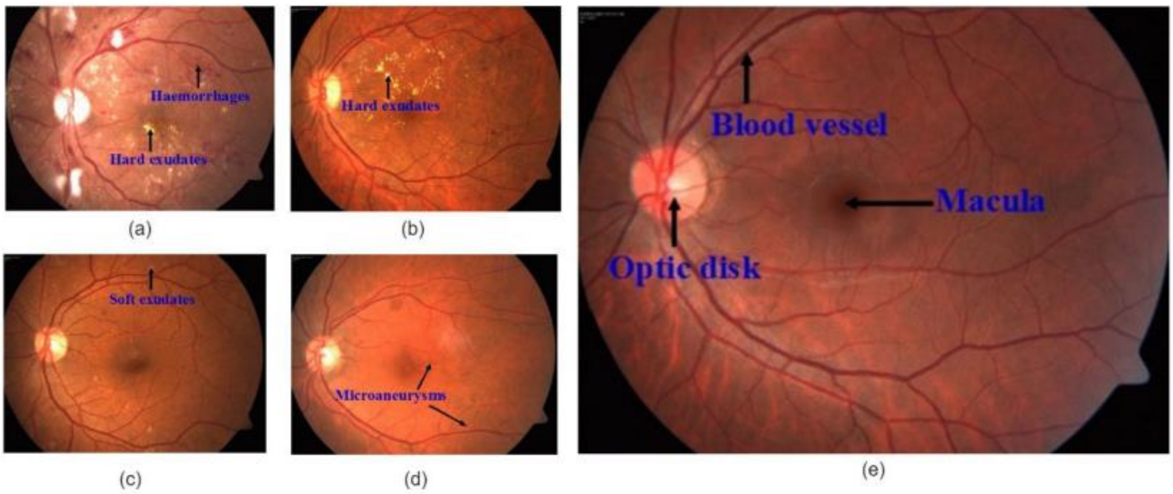

Fig. 1. (a) PDR (b) Severe NPDR (c) Moderate NPDR (d) Mild NPDR (e) Normal Retina.

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In this particular case, the prompt detection of DR may facilitate the afflicted individual in receiving timely and appropriate medical intervention. Based on the findings presented in the survey study, a significant number of specialists have said that the timely identification of DR might potentially result in the preservation of around 90% of individuals diagnosed with diabetes [4]. The identification of DR may be carried out by manual examination by ophthalmologists or through the use of an automated technology. There are some benefits and drawbacks associated with both manual and automated diagnostic approaches for DR. The only benefit of using the manual approach for detecting DR is the absence of reliance on computer aid, hence necessitating a manual procedure. However, it is crucial to emphasize things the ophthalmologist needs to possess expertise when it comes to DR identification. In many instances, the first manifestations of DR may be minuscule, to the extent that they might elude detection by ophthalmologists. Artificial intelligence (AI) in ophthalmology playing an important part in the identification of significant conditions such as DR. The automated method offers several benefits and demonstrates more utility in comparison to the manual technique. The use of an automated method in order to identify DR is characterized by enhanced authenticity, reliability, speed, efficiency, and ease in contrast to the manual method. Hence, automatically recognising DR is crucial.

2. RELATED WORK

DL has emerged as the prevailing and efficacious methodology within the field of ophthalmology in order to identify and categorise DR. According to a research done by Kwasigroch et al. [5], a computerised method for monitoring DR was proposed, using DL techniques. The efficacy of the specified methodology was assessed using a retinal dataset including 88,000 fundus pictures. During CNN's training phase, an integrated special class coding strategy was used in the given technique. The created model's performance was assessed by computing the weighted quadratic kappa score separating the dataset scores and the predicted values. In addition, Seth and Agarwal [6] introduced a hybrid DL technique to analyse DR. The used methodology utilized digital fundus pictures for the purpose of detecting and diagnosing DR. During the phase of training, EyePACS dataset was processed using Support Vector Machine (SVM) to conduct tests. The final model demonstrated superior performance compared to existing techniques, specifically about specificity and sensitivity, when applied to a heterogeneous dataset. The model exhibited a high level of robustness, as shown by its ability to achieve notable accuracy and recall scores when applied to a vast and diverse dataset.

The computer-aided system for volume measurement was created by El Tanboly et al. [7] in their study conducted in 2020. In th publication titled "Automatic Detection of Diabetic Retinopathy: A Comprehensive Review of Datasets, Methods, and Evaluation," Mateen et al. delve into the topic of automated detection of DR the authors provide an extensive overview of the datasets, methodologies, and evaluation techniques used in this field. The present study proposes a metrics diagnostic framework based on computer-aided detection (CAD) for the identification of DR using optical coherence tomography (OCT) pictures. The structure that was provided consisted of three distinct phases. The establishment of retina layers was first approached by a segmentation method utilizing the integrated joint model, which effectively combines spatial information, shape, and intensity. Additionally, the segmented layers were assessed based on three distinct characteristics, namely thickness, curvature, and reflectivity. The study included training a deep fusion classification network using a constraint autoencoder to classify normal and DR cases. Additionally, the network was used to examine the classification of mild-to-moderate or early-stage DR.

Li et al. [8] proposed a computerised diagnostic method to achieve the goal of identifying DR using deep CNN. In the study at hand, the researchers used fractional max-pooling as a means to extract more discerning characteristics for the purpose of classification, as opposed to the conventional strategy of using max-pooling. The discriminative characteristics were categorised with an SVM. The fundus pictures from the Kaggle dataset was utilised to both train and validate the DR detection algorithm. Furthermore, the researchers also devised a machine learning-driven program for detecting DR called "Deep Retina", which used an ophthalmoscope to acquire the outcomes. In their study, Sisodia et al. (2019) used preprocessing methods and feature choice in order to detect DR [9]. The preprocessing methodology was applied to unprocessed retinal data, which was then subjected to scaling, picture improvement, histogram equalization, and green channel procedures. Fourteen characteristics were extracted from fundus pictures for the purpose of quantitative analysis.

The Kaggle dataset was used in this methodology to train and validate the fundus photos, which were then categorized into three different classes: severe, moderate, and normal pictures. Li et al. [10] created a deep CNN method to achieve the goal of classifying digitized fundus images of the retina. The studies were conducted using two retinal datasets that are available to the public: DR1 and MESSIDOR. The stated technique included three distinct approaches: the CNN model's tuning, the network layers' tuning, and the use of CNN models for obtaining the features from fundus pictures. Finally, the SVM algorithm was employed in order to classify the retinal fundus pictures. The deep multiple instance

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learning (MIL) approach for DR diagnosis was presented by Zhou et al. [11]. The approach used in this study was utilized to identify DR and lesions in retinal fundus pictures using a CNN was employed to extract features, while global aggregation techniques were deployed to categorize lesions and DR in fundus pictures. This experiment was carried out utilising three publicly available datasets: Kaggle, Messidor, and DIARETDB1.

3. TRENDS AND OBSTACLES IN THE NEAR FUTURE

In contemporary times, the use of DL in image processing methods has emerged as a crucial component in computer-aided methods for detecting and diagnosing DR-related problems. There are many potential avenues that might enhance the efficacy of DL methodologies for optimal use. The existing body of literature has observed that the majority of research endeavours have focused on employing CNN models to construct intricate frameworks with several layers for diagnosing DR through the examination of digitised retinal fundus pictures. However, it is worth noting that the interpretation and elucidation of retinal photographs necessitate the expertise of ophthalmologists, resulting in a laborious and costly undertaking. Therefore, it is essential to use efficacious DL methodologies that possess the capability to acquire knowledge from a constrained retinal dataset. The elucidation of the contrast between DL methods and classical approaches is presented in a sequential manner.

i. DL applications rely on the use of shared weights in deep networks to establish their decision-making capabilities, a feature that was absent in prior models.
ii. Integrating both handmade and non-handcrafted elements to get higher generalized models.
iii. The use of a layer-based feature learning technique is justified due to the ability of each layer to acquire distinct layered features.
iv. The enhancement of the generalization capability in deep learning networks may be achieved by increasing their size, specifically by augmenting the quantity of units and stages in every layer. GoogleNet is an illustrative instance of a DL model characterized by a total of 22 layers.

4. CONCLUSION

This study conducted an extensive literature review on the identification of DR, examining many research articles. The review focused on summarizing retinal datasets, exploring various methodologies for detecting DR, and selecting appropriate metrics for performance evaluation to assess the outcomes of these methodologies. The discussion begins with addressing retinal datasets, followed by an explanation of several methodologies used for the detection of retinal abnormalities such as retinal neovascularization, hemorrhages, microaneurysms, and exudates. The commentary has provided an explanation of the authors' observations to highlight the importance of DL-based methodologies and have also outlined potential avenues for future study in addressing the issues encountered inside the DR domain.

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