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Analysis of Diabetic Retinopathy (DR) Based on the Deep Learning- A Review

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Abstract – *This review paper explores the Diabetic Retinopathy (DR) is a severe complication of diabetes that affects the retina and can lead to vision loss if not detected and treated early. an analysis of Diabetic Retinopathy based on deep learning approaches. Convolutional Neural Networks (CNNs) and other deep learning architectures are employed to automatically extract relevant features from retinal images, enabling efficient and accurate detection of DR stages. The model is trained on large datasets of annotated retinal images to learn intricate patterns associated with different DR severity levels.*

The review explores the interpretability of the deep learning models, aiming to enhance the trust and acceptance of these automated systems in clinical settings. Interpretability methods such as attention maps and saliency maps are employed to provide insights into the decision-making process of the model, aiding in understanding the features that contribute to the classification of DR.

Keywords: **Deep Learning, Classification, Diabetic Retinopathy, DR**

I. Introduction

The advances in science and technology have improved the standard of living for humans by making their lives easier, safer, and more convenient to live [1]. Machine Learning (ML) [2,3]-based automated systems these days provide a variety of services to customers, all with the goal of improving the quality of our lives. ML-based systems have become quite significant in the accurate early detection of dangerous diseases. One of the most common and debilitating conditions affecting people all over the globe is diabetic retinopathy (DR) [4,5]. It is a major contribution to the increase in the frequency of vision disorders among individuals, which is the major driving force behind the general rise in the number of people who are experiencing vision loss. People who are diagnosed with DR have an approximately 90% chance of averting the permanent loss of their vision if early diagnosis is performed correctly and effectively [6].

The clinical, blood-vascular, and optic disc features of a patient may be improved using image enhancement technologies for retinal imaging [7]. A typical visual diagnostic approach for DR diagnosis is digital fundus imaging. Recent clinical studies recommend carrying out this check on a consistent basis throughout the whole of the diabetic patient’s life. Patients who had none or a mild degree of diabetic retinopathy, for instance, were instructed to go through screening once a year, but those who had moderate retinopathy were instructed to repeat fundus examinations every six months. This retinal examination, along with the overall rise in the number of DR patients throughout the globe, represents a huge responsibility that medical professionals consider difficult to handle [8,9]. Due to various recent developments in areas such as nonmydriatic eye imaging and online data transmission, it is now feasible to use retinal fund us image analysis (RFIA) systems for the purpose of analyzing the retinal image in order to make a diagnosis of DR. The phases of the radiography sample analysis procedures may be carried out by qualified eye physicians or non-eye trained personnel, depending on the results corresponding to acquired sensitivity (SE) and specificity (SP). The usual performance of automated software for the diagnosis of diabetic retinopathy is outstanding, with sensitivity (SE) approaching 80% and specificity (SP) reaching 95% [10,11].

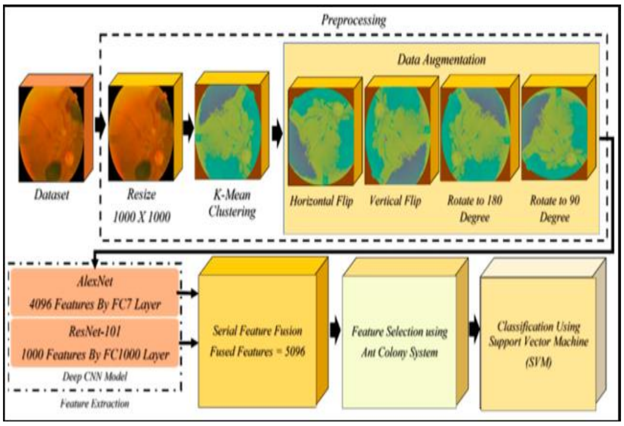

Figure 1: Analysis of Diabetic Retinopathy (DR) Based on the Deep Learning Images

The proposed international clinical diabetic retinopathy and diabetic macular edema disease scales are two examples of these severity ratings [15,16,17]. There are two distinct flavors of DR, Non-Proliferative Diabetic Retinopathy (NPDR), the less severe form, and Proliferative Diabetic Retinopathy(PDR), the more severe form [18]. The signs of a DR are the first symptoms that manifest themselves. These symptoms could include a mild illness or NPDR. Patients who have NPDR may initially have just foggy vision in the early stages of the disease; but, as the disorder advances, the retina starts to generate new blood vessels, which may result in significant visual impairment [19]. Diabetes mellitus is a condition that is caused by excessive levels of blood sugar, which results in the vessels expanding and leaking fluid [20]. In the images of the fundus retina, the lesions seem like dots of streaming blood and fluids. There are two distinct sorts of lesions, which are referred to, respectively, as bright lesions and red lesions [21]. Red lesions include micro aneurysms (MCA) and hemorrhage (HM), while bright lesions contain soft and hard exudates. Both types of exudates may be seen in bright lesions (EX). HM and MCA are represented, respectively, by the bigger and smaller dark red dots. Hard EX is displayed as vivid yellow spots, but soft EX, often known as cotton wool, manifests as fluffy, yellowish-white patches. This is because soft EX causes damage to nerve fibers, whereas hard EX does not [22,23]. Research has shown that an automated system that is based on the technology of deep learning ay be able to diagnose diabetic retinopathy successfully [24].

II. LITERATURE SURVEY

Sarra Guefrachi et.al. (2024) - The purpose of this research is to propose a new method for identifying diabetic retinopathy using retinal funds images. Currently, identifying diabetic retinopathy from computerized funds images is a challenging task in medical image processing and requires new strategies to be developed. The manual analysis of the retinal funds is time-consuming and requires a significant amount of skill. To assist clinicians, this research develops a graphical user interface that integrates imaging algorithms to assess whether the patient's fund us image is affected by diabetic retinopathy. The diagnosis is made using a deep neural network, specifically the Resnet152-V2, which has been shown to have 100% accuracy in all evaluation criteria including accuracy, recall, precision, and F1 Score. The severity of the disease is displayed on the graphical user interface and the patient's information is stored in a local database. This proposed method can also be used by ophthalmologists as a backup option to support in disease detection, reducing the necessary processing time [01].

Abdul Muiz Fayyaz et.al. (2023) - If Diabetic Retinopathy (DR) patients do not receive quick diagnosis and treatment, they may lose vision. DR, an eye disorder caused by high blood glucose, is becoming more prevalent worldwide. Once early warning signs are detected, the severity of the disease must be validated before choosing the best treatment. In this research, a deep learning network is used to automatically detect and classify DR fundus images depending on severity using AlexNet and Resnet101-based feature extraction. Interconnected layers helps to identify the critical features or characteristics; in addition, Ant Colony systems also help choose the characteristics. Passing these chosen attributes through SVM with multiple kernels yielded the final classification model with promising accuracy. The experiment based on 750 features proves that the proposed approach has achieved an accuracy of 93% [02].

Nurrahmadayenia et.al. (2022) - Diabetic retinopathy (DR) is a serious retinal disease and is considered the leading cause of blindness and is strongly associated with people with diabetes. Ophthalmologists use optical coherence tomography (OCT) and retinal fundus imagery to assess the retinal thickness, structure, and also detecting edema, bleeding, and scarring. Deep learning models are used to analyze OCT or fundus images, extract unique features for each stage of DR, then identify images and determine the stage of the disease. Our research using retinal fundus imagery is used to identify diabetic retinopathy disease, among others, using the Convolutional Neural Network (CNN) method. The methodology stage in the study was a green channel, Contrast Limited Adaptive Histogram Equalization (CLAHE), morphological close, and background exclusion. Next, a segmentation process is carried out that aims to generate binary imagery using thresholding techniques. Then the binary image is used as training data conducted epoch as much as 30 times to obtain an optimal training model. After testing, the deep learning method with the CNN algorithm obtained 95.355% accuracy in the identification of diabetic retinopathy disease based on fundus image in the retina [03].

Saif Hameed Abbood et.al. (2022) - Diabetic Retinopathy (DR) is a prevalent acute stage of diabetes mellitus that causes vision-effecting abnormalities on the retina. This will cause blindness if not identified early. Because DR not an irreversible procedure, and only vision is preserved via care. Consequently, Early diagnosis and care with DR will significantly minimize the chance of vision loss. In modern ophthalmology, retinal image analysis has become a popular approach to disease diagnosis. The ophthalmologists and computerized systems extensively employ fundus angiography to detect DR-based clinical signs for early detection of DR. fundus photographs are commonly prone to low contrast, noise, and irregular illumination issues due to the complexity of imaging environments such as imaging variety of angles and light conditions. This research presents an Algorithm for improving the quality of images to strengthen the standard of color fundus images by reducing the noise and improving the contrast. The approach includes two main stages: cropping the images to remove insignificant content, then applying the shape crop and gaussian blurring for noise reduction and contrast improvement. The experimental results are evaluated using two standard datasets EyePACS and MESSIDOR. It's clearly shown that the outcomes of feature extraction and classification of enhanced images is outperform the results without applying the enhancement approach. The improved algorithm is also tested in smart hospitals as an IoMT application [04].

Hassan Tariq et.al. (2021) - Diabetic retinopathy (DR) is a human eye disease that affects people who are suffering from diabetes. It causes damage to their eyes, including vision loss. It is treatable; however, it takes a long time to diagnose and may require many eye exams. Early detection of DR may prevent or delay the vision loss. Therefore, a robust, automatic and computer-based diagnosis of DR is essential. Currently, deep neural networks are being utilized in numerous medical areas to diagnose various diseases. Consequently, deep transfer learning is utilized in this article. We employ five convolutional-neural-network-based designs (AlexNet, GoogleNet, Inception V4, Inception ResNet V2 and ResNeXt-50). A collection of DR pictures is created. Subsequently, the created collections are labeled with an appropriate treatment approach. This automates the diagnosis and assists patients through subsequent therapies. Furthermore, in order to identify the severity of DR retina pictures, we use our own dataset to train deep convolutional neural networks (CNNs). Experimental results reveal that the pre-trained model Se-ResNeXt-50 obtains the best classification accuracy of 97.53% for our dataset out of all pre-trained models. Moreover, we perform five different experiments on each CNN architecture. As a result, a minimum accuracy of 84.01% is achieved for a five-degree classification [05].

Gazala Mushtaq et.al. (2021) - Diabetic retinopathy is a complication of diabetes that targets the eyes by damaging the retinal blood vessels. Initially it is asymptomatic or causes fluctuating vision problems. As it becomes severe, it affects both the eyes and eventually causes partial or complete vision loss. Primarily occurs when the blood sugar level is unmanageable. Therefore, the person with diabetes mellitus is always at a high risk of acquiring this disease. The early detection can deter the contingency of complete and permanent blindness. Thus, requires an efficient screening system. The present work considers a deep learning methodology specifically a Densely Connected Convolutional Network DenseNet-169, which is applied for the early detection of diabetic retinopathy. It classifies the fundus images based on its severity levels as No DR, Mild, Moderate, Severe and Proliferative DR. The datasets that are taken into consideration are Diabetic Retinopathy Detection 2015 and Aptos 2019 Blindness Detection which are both obtained from Kaggle. The proposed method is accomplished through various steps: Data Collection, Preprocessing, Augmentation and modelling. Our proposed model achieved 90% of accuracy. The Regression model was also employed, manifested up an accuracy of 78%. The main aim of this work is to develop a robust system for detecting DR automatically [06].

Lifeng Qiao et.al. (2020) - Predicting the presence of Microaneurysms in the fundus images and the identification of diabetic retinopathy in early-stage has always been a major challenge for decades. Diabetic Retinopathy (DR) is affected by prolonged high blood glucose level which leads to microvascular complications and irreversible vision loss. Microaneurysms formation and macular edema in the retinal is the initial sign of DR and diagnosis at the right time can reduce the risk of non proliferated diabetic retinopathy. The rapid improvement of deep learning makes it gradually become an efficient technique to provide an interesting solution for medical image analysis problems. The proposed system analysis the presence of microaneurysm in fundus image using convolutional neural network algorithms that embeds deep learning as a core component accelerated with GPU(Graphics Processing Unit) which will perform medical image detection and segmentation with high-performance and low-latency inference. The semantic segmentation algorithm is utilized to classify the fundus picture as normal or infected. Semantic segmentation divides the image pixels based on their common semantic to identify the feature of microaneurysm. This provides an automated system that will assist ophthalmologists to grade the fundus images as early NPDR, moderate NPDR, and severe NPDR. The Prognosis of Microaneurysm and early diagnosis system for non - proliferative diabetic retinopathy system has been proposed that is capable to train effectively a deep convolution neural network for semantic segmentation of fundus images which can increase the efficiency and accuracy of NPDR (non proliferated diabetic retinopathy) prediction [07].

III. METHOD

The analysis of diabetic retinopathy (DR) using deep learning involves the application of artificial intelligence (AI) techniques to automatically detect and classify signs of DR in retinal images. Deep learning models, particularly convolutional neural networks (CNNs), have shown great promise in this area Here's a general method for analyzing diabetic retinopathy based on deep learning.

Data Collection and Preprocessing:

Gather a large dataset of retinal images containing both normal and diabetic retinopathy cases. These images may come from various sources, such as medical databases or hospitals.

Preprocess the images by resizing, normalizing pixel values, and augmenting the dataset to increase diversity and improve model generalization.

Data Labeling:

Annotate the dataset with ground truth labels indicating the presence and severity of diabetic retinopathy. Labelsmay include categories like "no diabetic retinopathy," "mild," "moderate," "severe," and "proliferative."

Model Architecture Selection:

Choose a suitable deep learning architecture, often based on convolution neural networks (CNNs), for image classification. Popular architectures include VGG, ResNet, and Inception.

Model Training:

Split the dataset into training, validation, and testing sets.

Train the deep learning model on the training set using the labeled images. Use the validation set to fine-tune hyper parameters and prevent over fitting.

Utilize transfer learning by initializing the model with pre-trained weights on large image datasets (e.g., ImageNet) to boost performance.

Loss Function and Metrics:

Define an appropriate loss function for the classification task, such as categorical cross-entropy.

Choose evaluation metrics, such as accuracy, precision, recall, and F1-score, to assess the model's performance on the validation and test sets.

Optimization Techniques:

Apply optimization techniques like stochastic gradient descent (SGD) or adaptive optimization algorithms (e.g., Adam) to update model parameters during training.

Regularization and Dropout:

Implement regularization techniques such as dropout to prevent overfitting, especially when dealing with limited data.

Post-processing:

Post-process the model predictions to interpret the results and generate a final diagnosis. This may involve thresholding or filtering to reduce false positives or false negatives.

Validation and Testing:

Evaluate the trained model on the validation set to ensure it generalizes well to new data.

Test the model on an independent test set to assess its overall performance.

IV. CONCLUSION

In this paper has provided the application of deep learning in the analysis of Diabetic Retinopathy (DR) represents a significant stride towards more efficient and accurate diagnostics. The utilization of advanced neural networks and machine learning algorithms has demonstrated promising results in the early detection and classification of DR, which is crucial for timely intervention and treatment

Deep learning models, particularly convolution neural networks (CNNs), have showcased their ability to autonomously interpret complex patterns within retinal images, aiding in the identification of subtle abnormalities indicative of diabetic retinopathy. The integration of large datasets and sophisticated architectures has further enhanced the sensitivity and specificity of these models, offering a reliable tool for healthcare professionals.

The potential impact of deep learning in DR analysis extends beyond mere diagnosis, encompassing the prospect of personalized treatment plans and improved patient outcomes. The rapid progress in this field raises optimism for the development of cost-effective and scalable solutions, ultimately contributing to the global effort in combating diabetic retinopathy.

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