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Diabetic Retinopathy Detection Using CNN

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ABSTRACT

Diabetic Retinopathy is a disease which gets triggered when diabetes gets uncontrolled. The disease leads to a permanent vision loss which is irreversible. So, it is very important for the patients to take proper care of their health. Diabetes is often called as a “Silent Killer”. It results in rupturing and swelling of blood vessels behind of the Retina. Until now, DR was evaluated by an ophthalmologist, which was a time-consuming process. So, it became a need to detect the presence of Diabetic Retinopathy with the help of the technology. There have been number of works and research carried out to detect the presence of Diabetic Retinopathy. Various Deep Learning and Machine Learning Algorithms are used for this purpose. One of the system’s benefit is that it can help with early detection,giving patients and medical professionals timely information.This system is an example of disruptive approach to proactive healthcare ,as it offers an easy-to-easy user interface for entering patients fundus images and receiving precise forecasts.

KEYWORDS: Diabetic Retinopathy, Deep Learning, Retinal Imaging, Medical Imaging, Fundus Photography, Machine Learning, Image Analysis, Classification, Disease Detection.

1. INTRODUCTION

Diabetic retinopathy (DR) is a form of diabetes that specifically impacts the eyes, particularly the retina. Machine learning (ML) and Deep Learning (DL) techniques play a crucial role in diagnosing this condition and creating effective systems for detecting other life-threatening illnesses. According to research, up to 80% of individuals who have had type 1 or type 2 diabetes for over 20 years are affected by diabetic retinopathy. Proper treatment and eye monitoring can reduce the progression to more severe forms of sight-threatening retinopathy in at least 90% of new cases. Symptoms of DR include microaneurysms, retinal hemorrhages, and intraretinal microvascular abnormalities on the retina. Microaneurysms are small blood vessel abnormalities, retinal hemorrhages refer to bleeding in the retina, and intraretinal microvascular abnormalities are abnormalities in the blood vessels that supply blood to the retina. This eye disease is frequently seen in individuals with diabetes and is a primary cause of blindness among working-age individuals. However, the current DR screening process is time-consuming and limited by a shortage of trained ophthalmologists. To capture an image of the retina, the eye needs to be dilated to widen the pupil. This is followed by fluorescein angiography and examination by a clinician. Unfortunately, in rural regions with an excessive wide variety of diabetic patients, the shortage of skilled clinicians is a first-rate issue. Diabetic Retinopathy occurs when the blood vessels around the eye are damaged. One of the main risks is poor blood sugar control. Early signs of this condition include blurred vision, floaters, and difficulty seeing colours. It is important to note that diabetic retinopathy is the most common cause of blindness in people between the ages of 20 and 64. Traditionally, ophthalmologists have manually diagnosed this condition, but this process is time-consuming. As a result, computer-assisted diagnosis is becoming increasingly important. “Non-proliferative diabetic retinopathy (NPDR) causes swelling of the retina and leakage of small blood vessels, which can lead to macular edema and vision loss [12].” The most significant vision loss occurs when there is swelling in the central part of the retina [14]. Diabetic retinopathy is divided into four levels: mild, moderate, non-proliferative, and progressive. In the initial stage, there is a small swelling in a specific area of the retinal vessels. In the second stage, known as mild non-proliferative retinopathy, some blood vessels in the eye may become blocked. As the retinopathy worsens in stage III, more blood vessels become blocked, resulting in insufficient blood supply to the affected area of the retina. Without proper blood supply, the retina cannot generate new blood vessels to replace damaged tissue. Grades IV and V are classified as inflammatory retinopathy. With the increasing global incidence of diabetes, there is a growing need for effective screening methods to prevent vision loss caused by diabetic retinopathy. Currently, diagnosing this condition using fundus imaging requires a time-consuming process performed by an ophthalmologist. However, an automated search for diabetic retinopathy can significantly speed up research in this field. Computers can help medical doctors in detecting and classifying diabetic retinopathy the use of diverse strategies along with CNN, KNN classifiers, and support vector machines. Number of papers have classified DR into 5 stages which are as follows- “No DR (0), Mild NPDR (1), Moderate NPDR (2), Severe NPDR (3), and PDR (4)”. “This study investigates ten research papers that employ autonomous deep learning (DL) and machine learning (ML) techniques to train models.” The subsequent sections of this paper encompass a comprehensive literature review on the subject, an exploration of the deep learning techniques utilized for retinopathy detection, an analysis of the various datasets employed in different papers, an evaluation of performance assessment measures such as accuracy, precision, sensitivity, and specificity, an examination of the methodologies employed, a discussion section, and a concluding section.

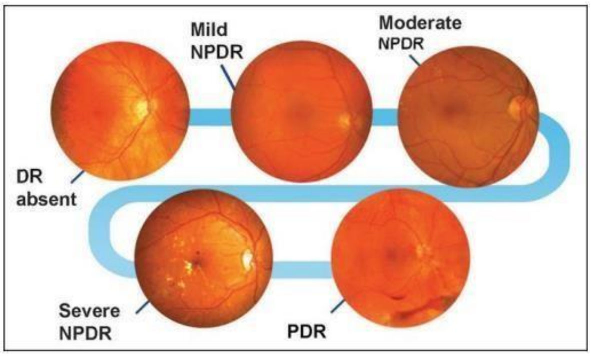

Fig. 1. Stages of Diabetic Retinopathy

2. LITERATURE SERVEY

Thorat S [1]: Thorat S addressed the class imbalance issue in the eyePACS dataset, consisting of 35,126 retinal images, by utilizing data augmentation techniques. Although achieving an accuracy of 81%, the model's trustworthiness faced challenges due to dataset imbalance and the exclusion of blacked-out images. Limited data (10%) for validation may have impacted the model's reliability.

Mishra S [2]: Using the APTOS dataset, Mishra S employed DenseNet architecture, achieving an impressive 96.11% accuracy. The comparison with VGG16 highlighted DenseNet's superiority in diabetic retinopathy classification, emphasizing the advantages of concatenating features in DenseNet over summation.

Jayakumari.C[3]:“Training on the ImageNet architecture, Jayakumari.C achieved an outstanding accuracy of 98.6%. The binary categorization (0 for No DR and 1 for others) facilitated high accuracy, with subsequent classification into specific DR categories based on probability thresholds.”

Islam K [4]: In a departure from traditional fundus images, Islam K utilized Optical Coherence Tomography (OCT) images, renowned for their high contrast. Their stepwise optimization process and feature extraction strategy led to the effective classification of diabetic retinopathy OCT images.

Imani E [5]: “Imani E employed Morphological Component Analysis (MCA) on the Messidor set of data, achieving a sensitivity of 92.01% and particularity of 95.45%. Their use of MCA, Shearlet Transform, and Contourlet Transform showcased a sophisticated approach to separating vessels and lesions in retinal images.”

Shekhar G [6]: Comparing CNN, VGG-16, and ResNet on the APTOS dataset, Shekhar G demonstrated the superior performance of ResNet with a remarkable accuracy of 98%. The choice of a deep architecture played a pivotal role in achieving high accuracy in diabetic retinopathy classification.

Arwa Gamal Eldin [7]: Using the IDRiD dataset, Arwa Gamal Eldin and team employed clustering using K-means and support vector machine. Despite achieving a commendable accuracy of 96%, the reliance on SVM and K-means clustering rather than CNN for image classification posed a limitation.

Shaban M [8]: Shaban M utilized CNN architecture comprising three fully connected layers and eighteen convolutional layers on the APTOS dataset. Their multi-class classification achieved notable results, with 5-fold and 10-fold validations reporting high accuracy, sensitivity, and specificity.

Vipparthu V [9]: Vipparthu V's dataset, gathered from diverse sources including hospitals and local patients, exhibited a noteworthy accuracy of 92.33%. However, the class imbalance problem, with almost 50% of images belonging to the No DR category, suggested a need for a more balanced representation of Mild and Moderate DR images.

Emon M [10]: Emon M adopted various machine learning algorithms on a dataset from the University of California, Irvine (UCI). Logistic Regression emerged as the most effective, achieving a 75% accuracy. Acknowledging the importance of data quality, plans for dataset improvement were emphasized to enhance diagnostic accuracy.

3. PROPOSED METHDOLOGY

The proposed methodology for Diabetic Retinopathy Detection involves a comprehensive approach that combines medical imaging, machine learning and deep learning methods. Fundus photography is usually used to get retinal pictures at the start of the procedure. The detecting system adopts these photos as its leading cause of data. Subsequently, preprocessing techniques are applied to boost image quality, rectify distortions, and normalize features. The core of the methodology lies in the application of machine learning algorithms, notoriously deep neural networks, for feature extraction and disease classification. During the training phase, the model learns intricate patterns and features indicative of diabetic retinopathy by leveraging annotated datasets. The proposed methodology evaluates the model's performance and generalization abilities through testing and validation phases as well. Continuous refinement and optimization ensure the robustness of the detection system, ultimately contributing to early and precision in identifying diabetic retinopathy from retinal pictures.

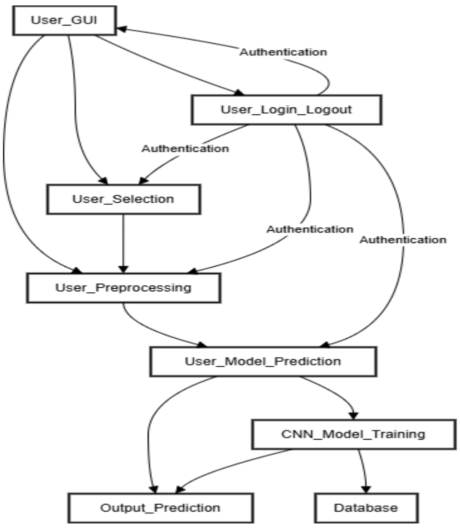

Fig 2. Proposed Methodology

3.1. APPLICATION

"The main reason why diabetics losses their vision is due to diabetic retinopathy. The use of Diabetic Retinopathy Detection holds significant promises in early detection and treatment of this condition. Healthcare practitioners can implement automated screening methods to examine retinal pictures for indications of diabetic retinopathy by utilising developments in medical imaging and machine learning technology. With the help of this programme, it is possible to identify the disease's progression in a timely manner, which allows for quick intervention and therapy to avoid blindness or vision impairment. Furthermore, Diabetic Retinopathy Detection devices expedite the screening procedure, enabling effective patient triage according to risk categories. By focusing resources and giving priority to individuals who require care the most, this focused strategy improves the way diabetes eye care is delivered".

3.1. SYSTEM ARCHITECTURE

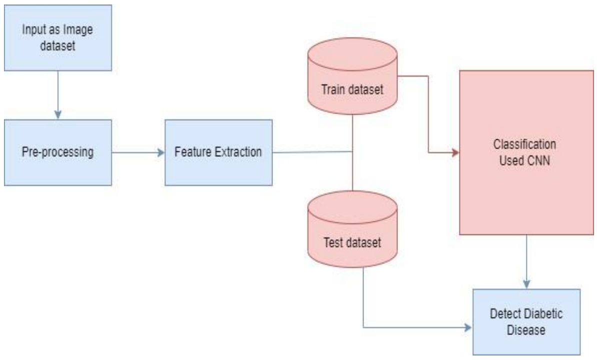

Fig 3. System Architecture

3.1. ALGORITHM

CNN:

Convolutional Neural Network is the acronym for CNN. For computer vision and image recognition applications, this kind of deep learning technique is frequently employed. In a CNN, features are automatically and hierarchically learned from input images by convolutional, pooling and fully-connected layers. CNNs are therefore well-suited for tasks like object detection, picture classification, and facial recognition because they can efficiently capture spatial and hierarchical patterns in images. CNNs have been widely used in many applications and have revolutionized the field of computer vision. CNNs are made up of multiple layers that cooperate to extract features from input images. Here's a breakdown of the different layers in a CNN:

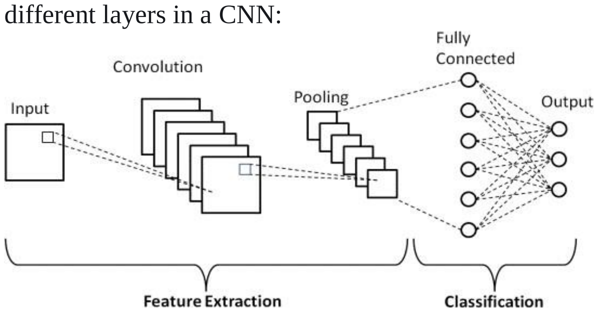

Fig 4. Convolutional Neural Network Architecture

1. Convolutional Layer: CNNs' fundamental module is the convolutional layer. It is composed of filters, often known as kernels, that move over the input picture to extract certain characteristics or patterns. Each filter performs a convolution operation, generating feature maps that reinforce specific patterns.

2. Activation Function: The activation function, also known as the Rectified Linear Unit or RELU. It is used

element-by-element to the convolutional layer's output. This gives the model non-linearity, which facilitates it pick up complex patterns.

3. Pooling Layer: The primary objective of the pooling layers is to maintain essential information while reducing the spatial dimensions of the convolved feature maps. Typical pooling operations consist of max pooling, which retains the highest value within a local region, and average pooling, which calculates the mean value.

4. Fully Connected Layer: A fully connected layer processes a flat-faced feature vector and learns global patterns and relationships in the data. These layers connect each neuron to each other, forming a dense layer.

5. Output Layer: The final prediction or classification is generated by the output layer. The task determines the number of neurons present in the layer. While many neurons with software activation are involved in multiclass classification, a neuron with sigmoid activation function can be involved in binary classification.

4. RESULT AND DISCUSSION

The proposed model of our Diabetic Retinopathy System achieved 95% of training accuracy and 90% of testing accuracy. The model was trained on 300 epochs. Increasing the number of epochs can further improve the accuracy, as the training model can improve its understanding of the training data. Furthermore, we could also add a greater number of images to the dataset to improve its quality. The loss is shown in figure no 2. The testing probability values for different classifications are as follows-

Table 1. Testing Probability Values

Classification	Accuracy
Mild	99.08%
Moderate	99.20%
Severe	98.31%
Proliferative DR	98.98%
No DR	98.98%

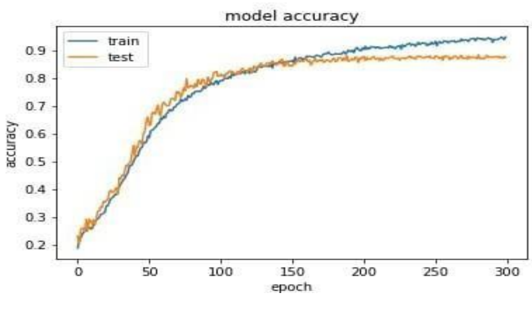

Fig 4. Model Accuracy

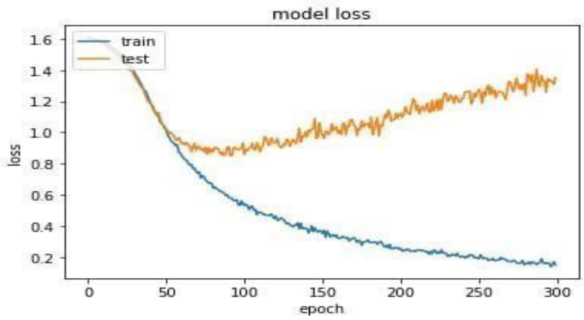

Fig 5. Model Loss

5. CONCLUSION

In this research, we showed how to quickly and efficiently separate hard exudates and Blood vessels from an image of the retina of a color fundus. The suggested technique can be used with retinal pictures and enhances the identification of blood vessels and hard exudates to reduce human error or provide service in remote locations, according to the findings of a simulation conducted on a retinal dataset. Our study offers a practical screening method for diabetic retinopathy early identification. In less time, the suggested method can automatically identify important clinical features from retinal pictures, including the optic disc, hard exudates, and blood vessels.

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