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Eye Diabetic Retinopathy Detection Using Deep Learning

KAKDE OM[1], SHIRSATHE SAKSHI[2], SAVARDEKAR SUCHITRA[3], KAUSTUBH UGALE[4]
[1, 2, 3, 4] *Member, Department of Computer Engineering AISSMS IOIT Pune, India*

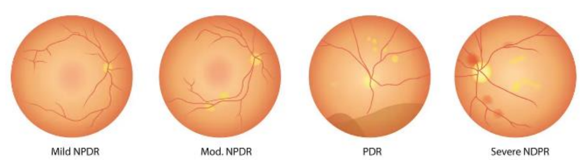
Abstract - In this paper, we address the important concerns surrounding diabetic retinopathy (DR), which is the primary cause of blindness in people with the disease. DR, resulting from long-term diabetes, requires early detection to preserve vision. Initial diabetic retinopathy has been identified using artificial intelligence-based technology. Manual diagnosis is time consuming, so machine learning, particularly deep learning, is being used to examine retinal fundus images more efficiently. Deep learning is being highlighted for its role in the early detection and classification of DR. We had implemented a deep learning model that detects different stages of diabetic retinopathy. The review focuses on retinal fundus images, discusses problems and research gaps, and suggests future directions in DR detection.

Indexed Terms - Diabetic Retinopathy, Deep Learning, CNN, VGGnet, fundus images, Microaneurysms, Hemorrhages, Exudates.

I. INTRODUCTION

Deep learning is a relatively new field of study and application. It is a prevalent and demanding field nowadays, it covers industry, business, healthcare, IoT, cybersecurity, bioinformatics, optimization, cyber-physical systems, etc. Machine learning is a subfield of artificial intelligence, while deep learning is a subfield of machine learning. It is a subset of machine learning approaches that combine artificial neural networks with representation learning. Deep learning models can be trained to identify patterns in images, text, audio, and other types of data, as well as to carry out categorization tasks. Convolutional neural networks (CNNs), recurrent neural networks (RNNs), and other deep learning algorithms are being used more and more to transform education because of their exceptional predicting powers. This model aims for minimal prediction errors, enhancing the decision-making process and operational performance within organizations, including educational, social, and government institutions.

Diabetes, often known as diabetes mellitus (DM), is a severe, systemic, and chronic illness. Where the pancreas's inability to make or secrete enough blood insulin causes blood glucose levels to tend to rise. One of the causes of vision disorder and the most common complication of diabetes mellitus is diabetic retinopathy. Diabetic Retinopathy (DR), a consequence of diabetes mellitus where glucose restricts blood vessels that supply the eye and produces swelling and leakage of blood or fluids that can cause serious eye damage, is directly caused by diabetes. Our research is looking into eye conditions like DR, glaucoma, and trachoma. These problems affect around 11.9 million people and can cause mild to severe vision problems, as stated in the World Report on Vision. Early detection is essential to prevent consequences from chronic diseases like diabetes. Side effect of DR is abnormal blood vessel growth in the retina, which can lead to retinal blindness.



Diabetes retinopathy (DR) is one of the most complex disorder affecting diabetes people, causing retinal degeneration and blindness. It damages the blood vessels in the retina, causing fluid leaks and distorting vision. There are two types of DR: proliferative (PDR) and non-proliferative (NPDR). Moreover, there are three levels of NPDR: mild, moderate, and severe.

The main causes of non-proliferative diabetic retinopathy (NPDR) include modifications to the retina's blood supply and existing blood vessels. Proliferative diabetic retinopathy (PDR), on the other hand, marks the development of abnormal new blood vessels, which significantly elevate the risk of vision-threatening complications due to their fragile nature and tendency to bleed.

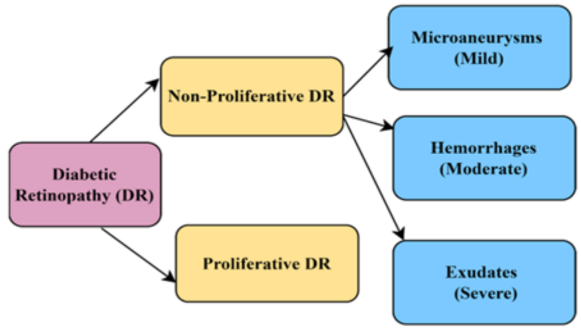
PDR develops when the illness progresses to the point where new blood vessels form on the retina's surface and in the vitreous humor, the gel-like fluid found inside the eye. This stage is characterized by these abnormal blood vessels' proliferation (growth). It's considered an advanced stage of diabetic retinopathy. In NPDR, the early stages of diabetic retinopathy, the primary changes involve weakened blood vessels, microaneurysms (small swellings in blood vessels), retinal hemorrhages (bleeding), and fluid leakage in the retina. NPDR advances in three phases, mild, moderate, and severe, according to the degree of blood vessel damage.

Let us study all these stages in detail: Microaneurysms (MA): Only microaneurysms can develop in the mild non proliferative retinopathy stage, which is the earliest stage. Early-stage DR symptoms known as microaneurysms (MA) result in retinal dysfunction because they leak fluid or blood into the retina. On the retina, it appears as little red spots. The correct way to identify MAs is by fluorescein angiography (FA). These can be categorized as focal bulge, saccular, fusiform, mixed, pedunculated, or irregular.

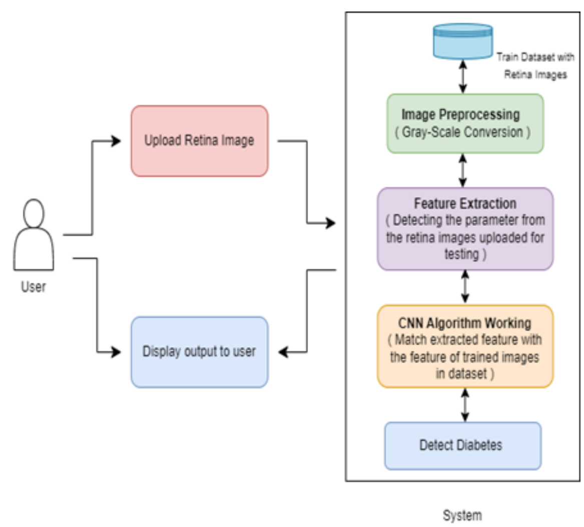
Hemorrhages (HM): Hemorrhages manifest as irregularly shaped patches on the retina, with a diameter of up to 125 m. It is separated into two groups: blots (deep HM) and flames (superficial HM). In the second stage, known as moderate non-proliferative retinopathy, when the illness worsens and the blood vessels enlarge and distort, they are unable to carry blood.

Exudates: Exudates are classified into Hard exudates and soft exudates. Hemolysis produces hard exudates, which appear as bright yellow patches on eyes. White patches on the eye called soft exudates are caused by swelling of the nerve fibers. Severe non-proliferative retinopathy is the following stage, which results in the retina receiving less blood as more blood vessels block, prompting the retina to produce new blood vessels.

Proliferative diabetic retinopathy is the final stage, in which the retina's growth factors promote the formation of new blood vessels that fill the eye by growing along the vitreous gel covered inner layer of the retina. It's considered an advanced stage of diabetic retinopathy and carries a higher risk of severe vision problems, including sudden and significant vision loss.



Each stage has its own characteristics and particular properties. However, clinicians may need to consider some of these, leading to an accurate diagnosis. This therefore raises the possibility of developing an automated DR detection system. Techniques for computerized DR detection exceed conventional diagnostics and save costs and time. Globally, DR contributes to 2.6 increases in long-term diabetic patient's symptoms. Patients with diabetes must undergo routine retinal screenings in order to detect and treat diabetic retinopathy (DR) early in order to reduce their risk of blindness.



II. PROBLEM DEFINATION

In this research, we developed a computer model to efficiently predict Diabetic Retinopathy (DR) using feature selection and classification. Section II discusses strategies for predicting diabetic retinopathy. Section III introduces method ologies for feature extraction and dataset description. Section IV presents results and performance analysis using CNN. Section V provides a conclusion and recommendations for future work.

III. METHODOLOGY

Predicting diabetes complications with accuracy and halting their course is a primary objective of diabetic retinopathy. The study implies pre-processing of images and enhances its features. Pre-processing using polynomial transformation, noise reduction with a Gaussian filter, noise avoidance with morphological procedures, and picture patching to restore candidate red lesions were the techniques employed in this research. We Implement this methodology in different phases:

A. Dataset Description

A basic model comprising three networks—small, medium, and large—using 128-, 256-, and 512-pixel images, respectively, was developed by the model utilizing 13,673 photos from the Kaggle dataset [DDR] for training and testing in a 7:3 ratio. To get the final projected regression values, the model used a Fully Convolutional Neural Network (FCNN) to the blended features.

B. Preprocessing

This is the primary step that involves preprocessing and resizing [512 × 512] of images. Here, cropped images are applied to remove the extra regions of those images, while data normalization is used to normalize the images into a similar distribution. Before the classification is done, we convert the images into greyscale. The adaptive median filter is used to remove the noise from these transformed fundus images.

C. Proposed System

In this system, users interact with the system through a user-friendly interface, initiating the process by uploading retina images. Image upload functionality should support various formats, ensuring flexibility for users. On uploading the image, the system initiates preprocessing by converting retina images to grayscale, simplifying the image and reducing the computational load for subsequent processing. A crucial preprocessing step involves resizing the images to [512 × 512]. Before classification, images are converted to grayscale. Subsequently, converted fundus images undergo filtering to eliminate noise using an adaptive median filter. The median filter is employed to smooth the image and reduce distortions caused by variations in image boundary thickness. Once the pre-processing is complete, we do feature extraction on those retinal images. Utilizing a dataset of 13,673 fundus images from the DDR, we split it into 70 percent for training and 30 percent for testing. Our goal is to identify parameters from retinal images during the testing phase. To recognize diabetic retinopathy (DR) features indicating health or disease, we employ advanced methods like edge detection and RBV analysis. Once the feature extraction is done, we pull out relevant features from retinal images to distinguish between healthy and diseased retinas. By using thresholding techniques, the model can identify important DR features such RBVs, fluid drip, EXs, HEs, and MAs.

D. Feature Extraction

The technique of transforming unprocessed data into numerical features that may be processed while keeping the original dataset's contents is known as feature extraction. This is the procedure for gathering more detailed information about an image, like its contrast, color, texture, and shape. By choosing all the necessary elements, it is utilized to increase the diagnosis system's accuracy in an efficient manner.

E. CNN

Convolutional neural networks (CNN) is a type of deep learning technique that is helpful for processing and identifying images. It is made up of multiple layers, such as fully connected, pooling, and convolutional layers. The essential part of a CNN is its convolutional layers, which has elements like edges, textures, etc. They are extracted from the input images by applying filters. After the convolutional layer, the output is processed through pooling layer. The feature maps are down-sampled to lower the spatial dimensions while keeping the most crucial data. One or more fully connected layers are then used to forecast or classify the image after the output of the pooling layers has been routed through them. The CNN model has been regarded as the VGGnet model in this work. In the VGGnet [19] model, the CONV layers do [3 × 3] convolution with stride:1 and pad:1, while the POOL layers perform [2×2] max-pooling with stride:2. CPU support is used to train the network. VGGnet works incredibly well in pictures with lots of features. Every Convolutional Layer has three sets of CNN structure that has a convoluted feature map which corresponds to every feature detector.

IV. LITERATURE SURVEY

Xu, K., Feng, D., and Mi, H. (2017). Utilizing Deep Convolutional Neural Networks for Early Automated Detection of Diabetic Retinopathy in Fundus Images. Published in Molecules, this study investigates the efficacy of deep learning in diagnosing diabetic retinopathy using retinal images.

Chennamsetty, S. S., and K.P., M. S. (2018). In their work, an ensemble of convolutional neural networks is proposed for the automatic grading of diabetic retinopathy and macular edema. The research, presented in an arXiv preprint, explores the fusion of multiple CNNs to enhance diagnostic accuracy.

Abbas, Q. (2017). This study introduces "Glaucoma-Deep," a deep learning framework for detecting glaucoma using retinal fundus images. The International Journal of Advanced Computer Science and Applications hosts this research, aiming to improve glaucoma diagnosis through advanced machine learning techniques.

Saiful, S. M., and Hasan, M. M. (2018). Published as an arXiv preprint, this study employs deep learning methods for the early detection and grading of diabetic retinopathy using retinal fundus images. The research aims to enhance diagnostic capabilities for diabetic retinopathy through the utilization of deep neural networks.

Das, D., Biswas, S. K., and Bandyopadhyay, S. (2022). This critical review explores the diagnosis of diabetic retinopathy using both machine learning and deep learning approaches. The review synthesizes existing literature to provide insights into the current state and future prospects of diabetic retinopathy diagnosis methodologies.

Atwany, M. Z. (2022). Conducted on March 8, 2022, this survey explores various deep learning techniques employed in the classification of diabetic retinopathy. The survey aims to provide a comprehensive overview of the state-of-the-art methods for diabetic retinopathy classification.

Sarki, R., Michalska, S., Ahmed, K., Wang, H., and Zhang, Y. (2019). This experimental study investigates the use of convolutional neural networks for detecting mild diabetic retinopathy. Hosted on bioRxiv, the research aims to enhance the early detection of diabetic retinopathy through advanced machine learning algorithms.

Dutta, S., Manideep, B. C. S., Basha, S. M., Caytiles, R. D., and Iyengar, N. C. S. N. (2018). Published in the International Journal of Grid and Distributed Computing, this study proposes deep learning models for the classification of diabetic retinopathy images. The research aims to improve the accuracy and efficiency of diabetic retinopathy diagnosis through the utilization of deep neural networks.

Islam, S. M. S., Hasan, M. M., and Abdullah, S. (2018). Presented as an arXiv preprint, this research focuses on the early detection and grading of diabetic retinopathy using retinal fundus images. The study aims to leverage deep learning techniques to enhance the efficiency and accuracy of diabetic retinopathy diagnosis.

The study highlighted in this reference discusses diabetic retinopathy detection using deep learning techniques. The research is featured in the International Conference on Smart Technologies in Computing, Electrical, and Electronics (ICSTCEE 2020), with a focus on advancing diagnostic capabilities through machine learning.

Adriman, R., Muchtar, K., and Maulina, N. (2019). This study evaluates the performance of deep learning techniques in binary classification of diabetic retinopathy. The research, featured in a scholarly article, explores the utilization of texture features in enhancing diabetic retinopathy diagnosis.

Oh, K., Kang, H. M., Leem, D., and Lee, H. (2021). Presented in a scholarly article, this study proposes an early detection method for diabetic retinopathy based on deep learning algorithms and ultra-wide-field fundus images. The research aims to enhance the efficiency and accuracy of diabetic retinopathy diagnosis through advanced machine learning techniques.

Arcadu, F., Benmansour, F., Maunz, A., Willis, J., Haskova, Z., and Prunotto, M. (2019). This research presents a deep learning algorithm capable of predicting diabetic retinopathy progression in individual patients. The study, published in a scholarly article, aims to provide personalized predictions for diabetic retinopathy progression using advanced machine learning techniques.

Bajwa, A., Nosheen, N., Talpur, K. I., and Akram, S. (Year). Conducted at the Sindh Institute of Ophthalmology and Visual Sciences, this prospective study investigates the detection of diabetic retinopathy using a modified convolutional neural network. The research aims to enhance diagnostic accuracy through the application of advanced deep learning methodologies.

Chellaswamy, C., Geetha, T. S., Ramasubramanian, B., Abirami, R., and Bharathi, A. (2022). Presented in an IEEE conference, this study proposes an optimized convolutional neural network for the detection of multiple eye diseases and information sharing. The research aims to develop an efficient system for early diagnosis and information dissemination in ophthalmology.

Tymchenko, B., Marchenko, P., and Spodarets, D. (2020). This study introduces a deep learning approach to diabetic retinopathy detection. The research explores the application of advanced neural network architectures to enhance the accuracy and efficiency of diabetic retinopathy diagnosis.

Alyoubi, W. L., Shalash, W. M., and Abulkhair, M. F. (2020). Published in a reputable journal, this review examines diabetic retinopathy detection using deep learning techniques. The review synthesizes existing literature to provide insights into the current state and future prospects of diabetic retinopathy diagnosis methodologies.

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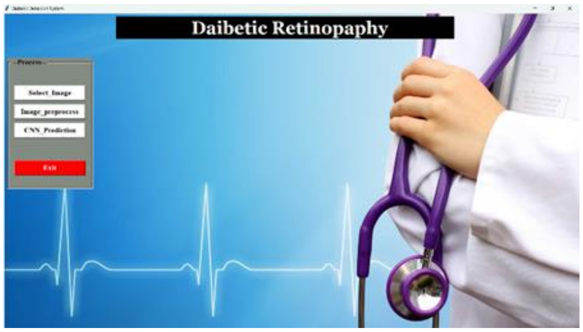
Das, D., Biswas, S. K., and Bandyopadhyay, S. (Year). This critical review evaluates the diagnosis of diabetic retinopathy using machine learning and deep learning methodologies. Published in a scholarly journal, the review provides insights into the current challenges and future directions of diabetic retinopathy diagnosis.

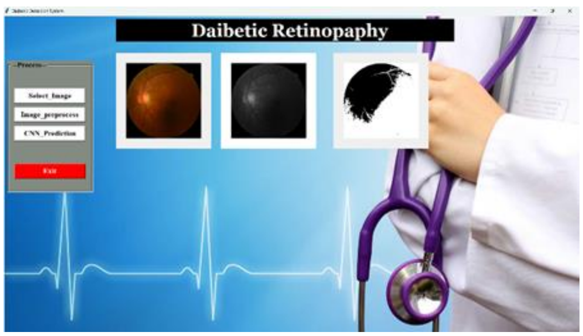
V. RESULT AND DISCUSSION

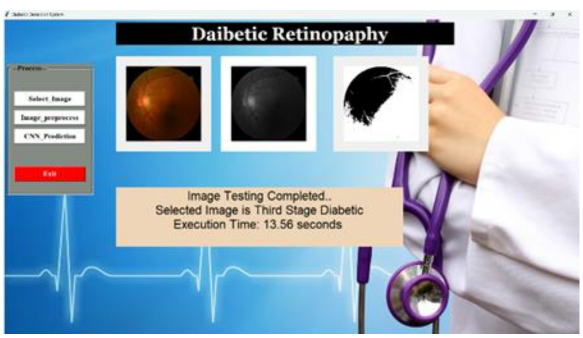
We trained our model using CNN with dataset from the kaggle(DDR). There was a lot of noise associated with the images provided by the dataset therefore, preprocessing was needed. For preprocessing, we first removed the black border of the images to focus more on the fundus image only, and then the images were resized to a standard format of 256*256 in width and height. At last, a Gaussian blur was applied to the

Classifier	Dataset	Accuracy	DR Classes
SVM	Messidor Diabeticret DB1.	85.6%	Normal, Non PDR, PDR
KNN	Messidor Diabeticret DB1.	55.1%	Normal, Non PDR, PDR
Regression	Diabetic Retinopathy Detection 2015 and APTOS 2019 from kaggle	78%	No DR, Mild, Moderate, Serve, Proliferative DR
CNN	Diabetic Retinopathy Detection 2015 and APTOS 2019 from kaggle	99.51%	No DR, Mild, Moderate, Serve, Proliferative DR

images to remove the noise. After preprocessing we analyzed that the data is highly unbalanced among the severity classes, the majority of data belonged to the class '0'i.e. No DR.







To address this issue, we used data augmentation, which gave us 7000 images from each severity class and balanced the data. After preprocessing and augmentation of images, data was finally fed to the CNN model for training the model. After evaluating our model a training accuracy of 0.953 was obtained, while a validation accuracy of 0.9034 was achieved. We also calculated the Cohen Kappa score which comes out to be 0.804. We tested with VGG-16 and VGG-19 CNN models and observed that the accuracy always ranges from 71 to 73 percent. We then tested with Keras sequential CNN models by adding a customized convolutional layer, optimizer, dense, merge, etc., obtained improved accuracy ranging from 80 to 83 percent. We can extend our work by including models built using other deep-learning architectures.

CONCLUSION

The entire project is focused on creating a system that identifies different stages for diabetic retinopathy detection using deep learning models. A key factor in the recovery from DR is early disease identification. Clinical diagnosis procedures are usually expensive and time-consuming. Deep learning approaches for medical image analysis can process the images quickly and produce more accurate predictions. We are going to create a computer model to forecast diabetic retinopathy (DR). It is essential that accurate predictions and other performance measures are good when it comes to clinical diagnosis. However, the performance of a classification model is highly dependent on both the feature extraction approach and the dataset preprocessing.

FUTURE SCOPE

In the future, scope of diabetic retinopathy research extends beyond detection and treatment. It involves a deeper understanding of the underlying mechanisms of disease, exploring personalized medicine approaches, and developing targeted therapies. One exciting thing in this is exploring the role of genetics and molecular pathways in diabetic retinopathy. Investigating how specific genes or cellular processes contribute to the development and progression of retinopathy. It provides a way for the treatment that address individual variations and disease mechanisms. The future of diabetic retinopathy detection is likely to be marked by increased accessibility, personalization, and more efficient healthcare delivery. Continued research and development in deep learning and computer vision will likely lead to even higher accuracy in diabetic retinopathy detection. We have mostly concentrated on the preprocessing and feature extraction approach in this research project. The findings of several investigations show a promising overall performance in terms of categorization, with an average accuracy of about 99 percent. Our goal is to create a categorization model based on deep convolutional neural networks in the future.

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