Prediction Of Diabetic Retinopathy Through Retinal Images Using Deep Learning

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Abstract— Diabetic retinopathy (DR) is a significant cause of vision impairment among individuals with diabetes. Early detection and timely intervention are crucial for preventing vision loss. This study presents a deep learning-based approach for the prediction of diabetic retinopathy using retinal images. We employed a convolutional neural network (CNN) architecture to extract meaningful features from a large dataset of retinal images. The dataset consisted of both normal and diabetic retinopathy-affected images, with gradings for the severity of DR. Our model achieved promising results in classifying retinal images into different stages of diabetic retinopathy, with high accuracy and sensitivity.

Keywords: DR grading, DR detection, deep learning, convolutional neural network, retinal fundus images.

INTRODUCTION

Diabetic retinopathy (DR) is a chronic complication of diabetes that damages the retina. Diabetic retinopathy (DR) is a severe and progressive eye disease that affects individuals with diabetes. The blindness caused by DR can be prevented through regular fundus examinations Researchers have explored various methodologies, including convolutional neural networks (CNNs), transfer learning, and the integration of diverse datasets, to enhance the predictive capabilities of these models. Moreover, efforts have been made to incorporate not only imaging data but also relevant clinical information, such as patient demographics and medical history, to improve the overall accuracy and clinical relevance of predictive systems.

This project focuses on developing an advanced deep learning model for predicting diabetic retinopathy through the analysis of retinal images. Leveraging state-of-the-art machine learning techniques, the project encompasses diverse stages, starting with the collection and preprocessing of a comprehensive retinal image dataset. The model architecture, rooted in Convolutional Neural Networks (CNNs), undergoes fine-tuning and transfer learning to adapt to the unique features of diabetic retinopathy.

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DENSENET

The term "Densely Connected Convolutional Network" (DenseNet) refers to a type of neural network architecture that is particularly effective for image classification tasks. DenseNet introduces a unique connectivity pattern among layers compared to traditional convolutional neural networks (CNNs). Let's elaborate on the key aspects of DenseNet. Parameter Efficiency-Dense connectivity encourages feature reuse, reducing the number of parameters compared to traditional architectures. Mitigating Vanishing Gradient-The dense connections help alleviate the vanishing gradient problem by providing shorter paths for gradients to propagate during training.

Dense Connectivity: In a DenseNet, each layer is connected to every other layer in a feed-forward fashion. This is in contrast to traditional architectures where layers are typically connected sequentially.

Dense Blocks: The building block of DenseNet is the "Dense Block." A dense block comprises several densely connected layers. Each layer receives feature maps from all preceding layers as inputs, and its own feature maps are used as inputs by all subsequent layers within the block.

Bottleneck Layers: Within a dense block, bottleneck layers (1x1 convolutions) are often used to reduce the number of input feature maps before passing them to the subsequent layers. This helps in reducing computational complexity.

Transition Layers: Between dense blocks, transition layers are used to downsample the spatial dimensions (width and height) of the feature maps. This is typically done using pooling layers. Additionally, 1x1 convolutions may be employed to adjust the number of feature maps.

TECHNOLOGIES USED

MATLAB serves as the primary programming language for implementing the proposed methodology. Its syntax facilitates mathematical computations, image processing, and algorithm development. Enables efficient and streamlined implementation of the entire diabetic retinopathy detection process, from preprocessing to image detection.

SCOPE OF THE PROJECT

The prediction of diabetic retinopathy through deep learning on retinal images offers a transformative scope in advancing early diagnosis, personalized treatment, and population wide screening. This technology not only reduces the burden on healthcare systems but also facilitates telemedicine integration, continuous monitoring, and global public health impact. Collaboration with healthcare professionals, ongoing research, and ethical considerations are central to realizing the full potential of this approach, promising improved outcomes for diabetic patients worldwide. In the pursuit of diagnosing diabetic retinopathy through deep learning, diverse approaches harness the capabilities of neural networks to interpret retinal images.

Convolutional Neural Networks (CNNs) serve as the backbone, extracting intricate features essential for precise classification. Transfer learning, a prevalent strategy, capitalizes on pretrained models' knowledge, fine-tuning them to discern diabetic retinopathy markers from retinal scans. Ensemble methods fortify predictions by amalgamating insights from multiple models, fostering heightened accuracy and resilience.

OBJECTIVE

Develop an accurate and robust deep learning model for the prediction of diabetic retinopathy (DR) through analysis of retinal images, aiming to enhance early diagnosis and intervention. The primary goal is to achieve high sensitivity and specificity in identifying different stages of DR, ultimately contributing to the improvement of patient outcomes and reducing the burden on healthcare resources." our primary objective is to develop an advanced deep learning model for predicting diabetic retinopathy through the analysis of retinal images. The foundation of this project lies in the comprehensive collection and preprocessing of a diverse dataset, encompassing various stages of diabetic retinopathy. Leveraging state-of-theart deep learning architectures, particularly Convolutional Neural Networks (CNNs), we aim to design a model that not only achieves high accuracy but is also interpretable and scalable. Through comprehensive documentation, knowledge transfer initiatives, and collaboration with healthcare practitioners, we aim to empower the medical community with a tool that significantly enhances the early diagnosis and management of diabetic retinopathy, ultimately improving patient outcomes.

LITERATURE SURVEY

A degenerative condition that affects the eyes, diabetic retinopathy (DR) is a result of diabetes mellitus, a condition in which elevated blood glucose levels cause lesions on the retina of the eyes. For diabetic patients, especially those in underdeveloped countries who are of working age, diabetic retinopathy is thought to be the primary cause of blindness. Because the illness is permanent, the goal of treatment is to maintain the patient's existing level of eyesight. Effective management of diabetic retinopathy requires early identification in order to preserve the patient's vision. The primary problem with DR detection is that it requires a lot of time, money, and effort to manually diagnose, which entails having an ophthalmologist examine retinal fundus photographs.[1].

The realm of diabetic retinopathy detection through deep learning methods has witnessed remarkable advancements. Introducing a highly accurate deep learning algorithm for detecting diabetic retinopathy from retinal fundus photographs. Additionally, proposed a system focusing on automated detection of diabetic retinopathy and macular edema. DR with a deep neural network-based algorithm to classify severity levels of diabetic retinopathy from fundus images. This model presented a model for automated grading of diabetic retinopathy using extensive retinal image datasets.[2].

Recent literature on diabetic retinopathy classification using multipath CNNs and machine learning classifiers demonstrates a concerted effort towards enhancing accuracy and efficiency. Studies have extensively explored multipath CNN architectures to extract intricate features from retinal images, leveraging the network's ability to capture nuanced details.[3].

Automatic detection using new technologies for early detection can help avoid complications such as the loss of vision. Currently, with the development of Artificial Intelligence (AI) techniques, especially Deep Learning (DL), DL-based methods are widely preferred for developing DR detection systems. For this purpose, this study surveyed the existing literature on diabetic retinopathy diagnoses from fundus images using deep learning.[4]

The research on automatic detection of blood vessels and classification in retinal images for diabetic retinopathy diagnosis using Convolutional Neural Networks (CNNs) has been an area of active exploration. Various studies have delved into this topic, aiming to enhance the accuracy and efficiency of diabetic retinopathy diagnosis. Research often focuses on leveraging CNNs for feature extraction, segmentation of blood vessels, and classification of retinal images to aid in early detection and management of diabetic retinopathy. Several approaches have been proposed, including different CNN architectures, pre-processing techniques, and optimization strategies to achieve more precise results. Some studies also incorporate machine learning algorithms to improve the overall performance of the system.[5].

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Prevention of DR is the early detection of a violation of morphology and a deterioration in the light sensitivity of the retina associated with this disease. To do this, highly informative methods of non-invasive retinal research are needed, with predictive capabilities. In this article, we propose an autonomous algorithm for such diagnostics, based on the training of the Artificial Neural Network (ANN) and the preprocessing of the image by an anisotropic diffusion filter. It allows not only to detect pathologies moreover to provide them with probabilistic evaluation of a possible variant of the disease.[7].

The epidemic nature of diabetes mellitus in different regions is reviewed. The Middle East and North Africa region has the highest prevalence of diabetes in adults (10.9%) whereas, the Western Pacific region has the highest number of adults diagnosed with diabetes and has countries with the highest prevalence of diabetes (37.5%). Different classes of diabetes mellitus, type 1, type 2, gestational diabetes and other types of diabetes mellitus are compared in terms of diagnostic criteria, etiology and genetics. The molecular genetics of diabetes received extensive attention in recent years by many prominent investigators and research groups in the biomedical field.[8].

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The objective of this study is to provide an optical coherence tomography (OCT) image based diagnostic technology for automated early DR diagnosis, including at both grades 0 and 1.[10]

In this paper, we propose a new strategy, which applies multiple weighted paths into convolutional neural network, called the WP-CNN, motivated by the ensemble learning.[11]

PROPOSED SYSTEM

The main objective of this work is to build a stable and noise compatible system for detection of diabetic retinopathy. This work employs the deep learning methodology for detecting the diabetic retinopathy based on severity level (No DR, Mild, Moderate, Severe and Proliferative DR). Many processes were carried out before feeding the images to the network. We use CNN Densenet architecture for DR classification and Expectation maximisation for segment the Diseased This work employs the deep learning methodology for detecting the diabetic retinopathy based on severity level (No DR, Mild, Moderate, Severe and Proliferative DR). In this proposed method, the datasets from both diabetic and non-diabetic patients are used to train the DL model. "Densely Connected Convolutional Network" (Dense Net) refers to a type of neural network architecture that is particularly used for DR image classification tasks. The proposed deep learning model shows promising results in classifying the DR images. Deep learning models can detect signs of diabetic retinopathy in its early stages, allowing for timely intervention and treatment, potentially preventing vision loss. These models can analyze retinal images with high accuracy and precision. These models can be integrated into existing healthcare systems, potentially reaching underserved populations or remote areas. Early detection and intervention through these predictive models can potentially reduce healthcare costs associated with advanced-stage diabetic retinopathy treatments or vision loss. The use of deep learning in predicting diabetic retinopathy fosters ongoing research and development in the field of ophthalmologist

Early detection of diabetic retinopathy symptoms by deep learning models enables prompt diagnosis and therapy, perhaps averting visual loss. These models are highly accurate and precise in their analysis of retinal pictures. These approaches have the ability to reach disadvantaged groups or rural places by being incorporated into current healthcare systems. These predictive algorithms have the potential to lower healthcare expenses related to advanced-stage diabetic retinopathy treatments or vision loss by facilitating early detection and intervention. The application of deep learning to the prediction of diabetic retinopathy promotes further ophthalmology research and development.

In diabetic retinopathy, image acquisition plays a crucial role in diagnosis and monitoring. Fundus photography is a common method where specialized cameras capture detailed images of the retina. These images help detect and assess the progression of diabetic retinopathy by revealing abnormalities like microaneurysms, hemorrhages, and vessel changes. The acquired images are then often analyzed using computer-based systems to identify and quantify specific features indicative of diabetic retinopathy severity. Regular imaging is essential for early detection and timely intervention, contributing to effective management of diabetic retinopathy in patients. Severity analysis in diabetic retinopathy involves assessing the degree or extent of damage to the retina caused by diabetes. It's crucial for determining appropriate treatment plans and predicting the progression of the disease.

WORKING OF PROPOSED SYSTEM

Diabetic Retinopathy Detection on Kaggle provided the data for this investigation. Thousands of retinal photos taken under various settings are included in both datasets. Since the pictures are from many sources, such as various cameras, models, etc. There seems to be a lot of noise attached to it that needs to be eliminated, necessitating several preprocessing stages. Each picture's related diabetic retinopathy has been given a rating between 0 and No DR, 1 and Mild, 2 and Moderate, 3 and Severe, and 4 and Proliferative DR.

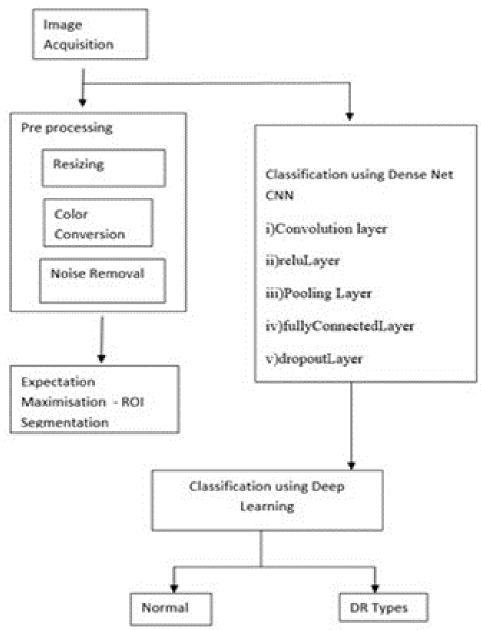

Fig. 1. Block Diagram

We use CNN Densenet architecture for DR classification and Expectation maximisation for segment the Diseased Area. The Convolutional Neural Networks (CNN) are used in a number of tasks which have a great performance in different applications. Recognition of handwritten digits was one of the first application where CNN architecture was successfully implemented. Since the creation of CNN, there has been continuous improvement in networks with the innovation of new layers and involvement of different computer vision techniques. CNNs have shown promising results in accurately detecting diabetic retinopathy, sometimes even outperforming human experts. Their ability to analyze large amounts of data quickly and efficiently makes them a valuable tool in assisting ophthalmologists. Here are some specific uses of CNNs in diabetic retinopathy: DR detection, DR grading, DR segmentation, DR prediction.

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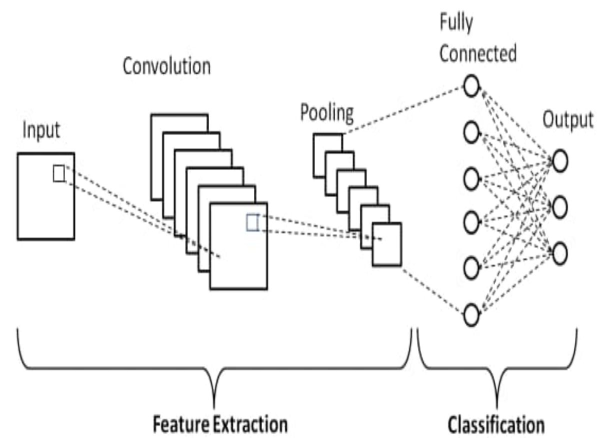

Fig. 2. CNN layers

Convolutional neural networks (CNNs) have emerged as powerful tools for medical image analysis, including the detection and diagnosis of diabetic retinopathy (DR). DR is a leading cause of vision loss worldwide, and early detection and treatment are crucial for preventing blindness. CNNs can analyze retinal fundus images to identify subtle changes in the retinal vasculature and other features that are indicative of DR. Overall, CNNs have the potential to revolutionize the diagnosis and management of DR. They can provide accurate and efficient detection, grading, and segmentation of DR lesions, leading to earlier intervention and improved patient outcomes.

RESULT

By employing deep learning methods, specifically the CNN Densenet architecture, you've structured a multi-step process: Initially, the process begins with image acquisition followed by a series of preprocessing steps. These include resizing images, converting colors to a standardized format, and removing any noise that might affect the analysis. An important stage involves ROI segmentation using the Expectation Maximization algorithm, which helps in isolating the Regions of Interest (ROIs) containing diseased areas. The heart of the system lies in the classification phase, where the CNN Densenet architecture is utilized. This step aims to categorize diabetic retinopathy based on various severity levels, ranging from No DR to Proliferative DR. Lastly, the system distinguishes between normal and DR cases while conducting a comprehensive severity analysis to determine the extent and severity of diabetic retinopathy detected. Your approach is well-structured, focusing on each crucial stage of analysis to achieve accurate detection and severity assessment of diabetic retinopathy.

Non-proliferative diabetic retinopathy (NPDR) refers to the early stage of diabetic retinopathy, a condition that affects the eyes of individuals with diabetes. "No DR" typically stands for "no diabetic retinopathy," indicating the absence of any visible signs of retinopathy in an eye examination of a person with diabetes. In NPDR, the blood vessels in the retina weaken, causing microaneurysms, hemorrhages, and other abnormalities. When there's "no DR," it suggests that these abnormalities haven't yet developed or aren't visible during the examination. It's a positive sign, indicating that the retinopathy hasn't progressed to a stage where it's causing observable damage to the retina. Predicting the likelihood of achieving or maintaining a state of No DR involves analyzing various factors, including the duration of diabetes, blood glucose control, blood pressure levels, lipid profiles, genetic predisposition, and lifestyle habits.

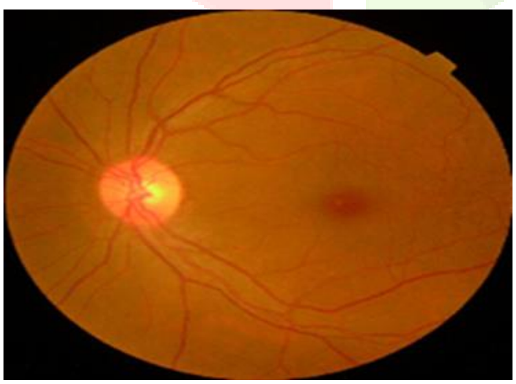

Fig.3.No DR

In diabetic retinopathy, the term "mild" typically refers to the early stages of the condition. Diabetic retinopathy has different stages, and the severity is often categorized as mild, moderate, or severe based on the changes observed in the retina. In the early stages, known as non-proliferative diabetic retinopathy (NPDR), the blood vessels in the retina weaken, leading to various changes such as Microaneurysms: Small bulges in the blood vessels of the retina, Dot and blot hemorrhages: Minor bleeding from these weakened vessels. Hard exudates: Fatty deposits that leak from damaged blood vessels and accumulate in the retina. When a diagnosis mentions "mild" diabetic retinopathy, it typically means that these early signs of damage are present, but they're not extensive or severe enough to significantly impact vision. Regular eye exams are crucial to monitor the progression of the condition because mild diabetic retinopathy can progress to more severe stages if blood sugar levels remain uncontrolled or if other factors exacerbate the condition.

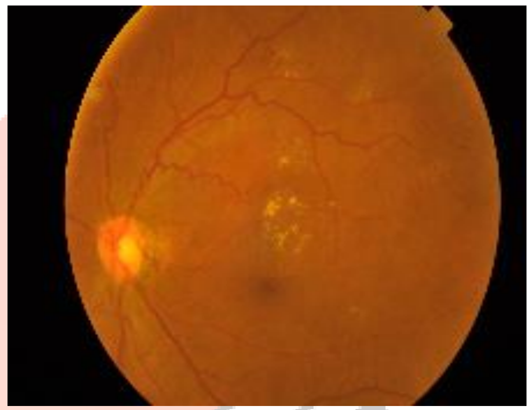

Fig.4.Mild DR

Moderate diabetic retinopathy marks a stage where the effects on the retina become more noticeable in individuals with diabetes. At this phase, changes in blood vessels within the retina intensify, showing a greater number of microaneurysms, increased hemorrhages, and visible abnormalities in vessel structure such as venous beading and intraretinal microvascular abnormalities (IRMAs). These alterations can impact vision to a greater extent compared to earlier stages, although significant vision impairment might not yet be present. However, this stage signifies a higher risk of progression to more severe forms of retinopathy that can lead to vision loss if left untreated. Effective management involves meticulous control of blood sugar, blood pressure, and cholesterol levels, along with regular eye examinations to closely monitor any advancements. Interventions such as laser therapy or injections may be employed to prevent further damage and preserve vision. The focus at this stage is on preventing deterioration and preserving eye health through vigilant monitoring and comprehensive diabetic care.

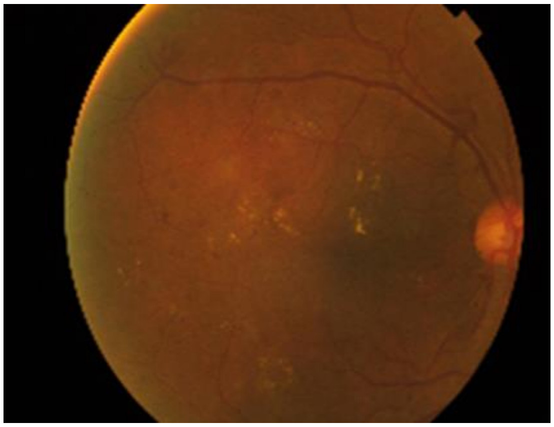

Fig. 5. Moderate DR

Severe diabetic retinopathy represents an advanced stage of retinal damage seen in individuals with diabetes. At this critical phase, the damage to the tiny blood vessels in the retina becomes extensive and pronounced. This often includes widespread bleeding into the retina, blockages in blood vessels leading to reduced oxygen supply (ischemia), and the growth of fragile, abnormal blood vessels on or within the retina. This stage poses a high risk of significant vision impairment or even blindness if not promptly managed. Complications such as retinal detachment or glaucoma may arise due to bleeding, swelling, or the formation of scar tissue. Treatment strategies at this stage typically involve laser surgery, intraocular injections, or in some cases, vitrectomy—a surgical procedure to remove blood and scar tissue from the eye. Early detection through regular eye examinations and immediate intervention are crucial to prevent further damage and preserve vision. Alongside targeted treatments, strict control of blood sugar levels, blood pressure, and cholesterol remains paramount in managing severe diabetic retinopathy. Seeking prompt care from eye care specialists is essential for tailored treatments and to mitigate the risks associated with this advanced stage of diabetic retinopathy, aiming to safeguard the individual's vision and eye health.

Fig.6.Severe DR

Proliferative diabetic retinopathy (PDR) is an advanced stage of diabetic retinopathy, characterized by the growth of abnormal blood vessels in the retina. These new blood vessels are fragile and prone to bleeding, leading to various complications and severe vision problems.

Key features of proliferative diabetic retinopathy include:

Neovascularization: The growth of new blood vessels in the retina. These vessels are abnormal, fragile, and prone to leakage and bleeding

Vitreous hemorrhage: Bleeding into the vitreous, the gel-like substance that fills the center of the eye. This bleeding can cause sudden vision loss or floating spots or cobwebs in the vision.

Retinal detachment: Abnormal blood vessel growth can cause the retina to pull away from the back of the eye, leading to severe vision loss if not treated promptly.

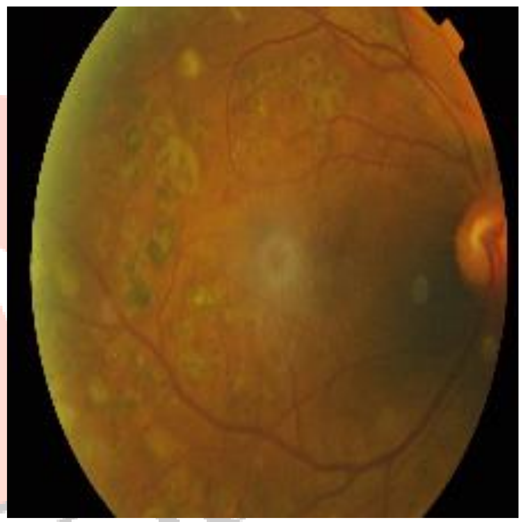

Fig. 7. Proliferative DR

CONCLUSION

An advanced form of diabetic retinopathy known as proliferative diabetic retinopathy (PDR) is defined by the development of aberrant blood vessels in the retina. These new blood vessels are brittle and prone to bleeding, which can cause a number of issues including serious visual impairments. Early DR detection is facilitated by the use of automated DR detection systems. The types of lesions that manifest on the retina determine the DR phases. In this work, we sought to offer our own deep learning methodology for the early detection of diabetic retinopathy by employing a DenseNet (a new CNN architecture, containing several deep layers). We also presented a thorough evaluation of numerous methodologies for identifying diabetic retinopathy automatically.

A lot of preprocessing and augmentation was done to standardize the data in a desired format and to remove the unwanted noise. Where the best accuracy among all was obtained by the proposed model and it also classifies the images into more no of classes. Our proposed model performed better than the regression model by achieving the accuracy yielded by the other model. Automated screening systems significantly reduce the time required to determine diagnoses, saving effort and costs for ophthalmologists and result in the timely treatment of patients.

FUTURE WORK

Improve preprocessing techniques to enhance the quality of retinal images. This includes noise reduction, image enhancement, and artifact removal to provide cleaner input to the deep learning model. Develop real-time or near-real-time systems for the early detection of diabetic retinopathy in clinical settings. Extend the capabilities of AI systems to support long-term monitoring of diabetic retinopathy progression and treatment effectiveness. Advancements in this field are poised to revolutionize how we detect and manage this sight-threatening condition. With ongoing developments, we anticipate more accurate and precise diagnostic models, capable of not only identifying diabetic retinopathy but also predicting its progression on an individual level. These innovations might lead to the creation of portable devices or smartphone applications, enabling real-time analysis of retinal images for early detection, especially in underserved areas. However, alongside these advancements, there will be ongoing discussions regarding ethics, patient privacy, and equitable access to these technologies. Collaborative efforts among researchers, clinicians, and technologists will be instrumental in driving these innovations forward, ultimately improving patient outcomes and reshaping the landscape of diabetic retinopathy diagnosis and management.

REFERENCES

[1] Mohammad Z.Atwany,AbdulwahabH.Sahyoun,and Mohammad Yaqub,Deep Learning Techniques for Diabetic Retinopathy Classification: A Survey,IEEE Access,(2022).Anoop.B, "Binary Classification of DR-Diabetic Retinopathy using CNN with Fundus Colour Images", Mater.Today Proc; 58, pp. 212–216, (2022).

[2] Amin, M. Sharif, and M. Yasmin, ‘‘A review on recent developments for detection of diabetic retinopathy,’’ Scientifica, vol. 2016, pp. 1–20, Sep. 2016.

[3] Chakrabarty.N, "A deep learning method for the detection of diabetic retinopathy.", In Proceedings of the 2018 5th IEEE Uttar Pradesh Section International Conference on Electrical, Electronics and Computer Engineering (UPCON), Gorakhpur, India; pp. 1–5, (2018).

[4] M. Dubow, A. Pinhas, N. Shah, F. R. Cooper, A. Gan, C. R. Gentile, V. Hendrix, N. Y. Sulai, J. Carroll, Y. P. T. Chui, B. J. Walsh, R. Weitz, A. Dubra, and B. R. Rosen, ‘‘Classification of human retinal microa- neurysms using adaptive optics scanning light ophthalmoscope fluores- cein angiography,’’ Investigative Ophthalmol. Visual Sci., vol. 55, no. 3,pp. 1299–1309, Mar. 2014.

[5] Gayathri.S, Gopi.V.P, Palanisamy.P, "Diabetic retinopathy classification based on multipath CNN and machine learning classifiers.", Phys. Eng. Sci. Med; 44, pp. 639–653, (2021).

[6] Jiang.Y, Wu.H, Dong.J, "Automatic screening of diabetic retinopathy images with convolution neural network based on caffe framework.", In Proceedings of the 1st International Conference on Medical and Health Informatics 2017, Taichung city, Taiwan; pp. 90–94, (2017)

[7] Kazakh-British.N.P, Pak.A, Abdullina.D, "Automatic detection of blood vessels and classification in retinal images for diabetic retinopathy diagnosis with application of convolution neural network.", In Proceedings of the 2018 International Conference on Sensors, Signal and Image Processing, Prague, Czech Republic; pp. 60–63, (2018).

[8] A.T.KharroubiandH.M.Darwish,‘‘Diabetesmel litus:Theepidemicof the century,’’ World J. Diabetes, vol. 6, no. 6, pp. 850–867, Jun. 2015.

[9] Kolla.M, Venugopal.T, "Efficient Classification of Diabetic Retinopathy using Binary CNN.", In Proceedings of the 2021 International Conference on Computational Intelligence and Knowledge Economy (ICCIKE), Dubai, United Arab Emirates; pp. 244– 247, (2021).

[10] Li.X, Shen.L, Shen.M, Tan.F, Qiu.C.S, "Deep learning based early stage diabetic retinopathy detection using optical coherence tomography.", Neurocomputing; 369, pp. 134–144, (2019).

[11] Liu YP, Li Z, Xu C, Li J, Liang R(2019).Referable diabetic retinopathy identification from eye fundus images with weighted path for convolutional neural network,National Library of Medicine(2019).

[12] Mahmoud Ragab ,Abdullah S. AL-Malaise AL-Ghamdi ,Bahjat Fakieh ,Hani Choudhry,Romany F. Mansour , and Deepika Koundal."Prediction of Diabetes through Retinal Images Using Deep Neural Network,Hindawi 6(2), 2641-0419(2022).

[13] S. Mamtora, Y. Wong, D. Bell, and T. Sandinha, ''Bilateral birdshot retinochoroiditis and retinal astrocytoma,'' Case Rep. Ophthalmolog.Med., vol. 2017, pp. 1–4, Feb. 2017

[14] Nasir.N, Oswald.P, Alshaltone.O, Barneih.F, Al Shabi.M, Al-Shammaa.A, "Deep DR: Detection of Diabetic Retinopathy using a Convolutional Neural Network.", In Proceedings of the 2022 Advances in Science and Engineering Technology International Conferences (ASET), Dubai, United Arab Emirates; pp. 1–5, (2022).

[15] Nazir.T, Irtaza.A, Shabbir.Z, Javed.A, Akram.U, Mahmood.M.T, "Diabetic retinopathy detection through novel tetragonal local octa patterns and extreme learning machines.", Artif. Intell. Med; 99,101695,(2019).

[16] Nijalingappa.P, Sandeep.B, "Machine learning approach for the identification of diabetes retinopathy and its stages.", In Proceedings of the 2015 International Conference on Applied and Theoretical Computing and Communication Technology (iCATccT), Davangere, Karnataka, India; pp. 653–658, (2015).

[17] Niranjana.R,Narayanan.K.L,Rani.E.F.I,Agalya .A,Chandraleka.C, Indhumathi.K, "Resourceful Retinal Vessel segmentation for Early Exposure of Vision Threatening Diseases.",In Proceedings of the 2022 International Conference on Advanced Computing Technologies and Applications (ICACTA), pp. 1–6,(2022).

[18] Pamadi.A.M, Ravishankar.A, Nithya.P.A, Jahnavi.G, Kathavate.S, "Diabetic Retinopathy Detection using MobileNetV2 Architecture.", In Proceedings of the 2022 International Conference on Smart Technologies and Systems for Next Generation Computing (ICSTSN), Villupuram, India; pp. 1–5, (2022).

[19] Raja.C, Balaji.L, "An automatic detection of blood vessel in retinal images using convolution neural network for diabetic retinopathy detection", Pattern Recognit. Image Anal; pp. 533–545, (2019).

[20] Rêgo.S, Dutra-Medeiros.M, Soares.F, Monteiro-Soares.M, "Screening for Diabetic Retinopathy Using an Automated Diagnostic System Based on Deep Learning: Diagnostic Accuracy Assessment.", Ophthalmologica; 244, pp. 250–257, (2021).

[21] Saranya.P, Devi.S.K, Bharanidharan.B, "Detection of Diabetic Retinopathy in Retinal Fundus Images using DenseNet based Deep Learning Model.", In Proceedings of the 2022 International Mobile and Embedded Technology Conference (MECON), Noida, India; pp. 268–272, (2022).

[22] P.Voraand S.Shrestha, ''Detecting diabetic retinopathy using embedded computer vision,'' Appl. Sci., vol. 10, no. 20, p. 7274, Oct. 2020.

[23] Washburn.P.S, "Investigation of severity level of diabetic retinopathy using adaboost classifier algorithm.", Mater.Today Proc; 33, pp. 3037–3042, (2020).

[24] J. W. Yau et al., ''Global prevalence and major risk factors of diabetic retinopathy,'' Diabetes Care, vol. 35, no. 3, pp. 556–564, 2012.

[25] Wahid.M.F, Hossain.A.A, "Classification of Diabetic Retinopathy from OCT Images using Deep Convolutional Neural Network with BiLSTM and SVM.", In Proceedings of the 2021 12th

International Conference on Computing Communication and Networking Technologies (ICCCNT), Kharagpur, India; pp. 1–5, (2021).