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ANALYSIS AND CLASSIFICATION OF RETINAL DISEASE SCREENING ON CIFAR-10 IMAGES USING CNN

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Abstract: The rising prevalence of diabetes, driven by increased sugar consumption and machine-dependent lifestyles, has led to a significant rise in diabetic retinopathy (DR), a condition that often results in visual impairment. This project proposes an automated diagnosis system for DR by analyzing retinal (fundus) images using advanced image processing techniques. The system integrates a Convolutional Neural Network (CNN), along with AlexNet and ResNet architectures, to classify retinal images as either affected by DR or healthy. The developed graphical user interface (GUI) provides real-time predictions of DR severity and suggests appropriate actions, streamlining the diagnostic process and offering ophthalmologists a reliable decision support tool. Comparative analysis of different deep learning models is conducted to evaluate system performance, demonstrating its potential for enhanced diagnostic accuracy and reduced processing time in clinical applications.

Keywords: Diabetic Retinopathy, Retinal Image, Image Processing, Convolutional Neural Network, Diagnostic process.

1. INTRODUCTION

One of the biggest global health concerns is vision impairment, particularly in diabetics. Damage to the retinal blood vessels is one of the main causes of this disorder, and if treatment is not received, it may lead to progressive vision loss. As the prevalence of diabetes increases, driven largely by lifestyle changes and higher intake of sugar-laden foods, the incidence of DR has surged. DR is characterized by progressive damage to the retinal vasculature, and if left untreated, it can result in partial or total vision loss. Early detection and prompt intervention are vital for mitigating severe outcomes in DR patients. Traditional diagnostic approaches, which involve the manual interpretation of retinal fundus images by ophthalmologists, are time-intensive and susceptible to inter-observer variability. Automated methods offer a possible substitute, improving diagnostic precision, effectiveness, and repeatability with the introduction of machine learning and sophisticated image processing algorithms. Specifically, medical image categorization tasks have been successfully automated using deep learning architectures like Convolutional Neural Networks (CNNs).

This project aims to develop an automatic diagnostic system for DR using deep learning-based image processing techniques. By employing CNN, AlexNet, and ResNet architectures, the system classifies retinal images as either diseased or healthy. The proposed system also features a graphical user interface (GUI) that not only provides real-time diagnostic results but also assesses the severity of DR and suggests relevant actions for patients. This approach can aid ophthalmologists by serving as a decision-support tool, enhancing both the speed and reliability of DR diagnosis. This paper presents a detailed description of the system, including its architecture, methodology, and performance evaluation. A comparative analysis between different neural network models is also discussed, highlighting the potential of deep learning in improving DR diagnostic outcomes.

2. LITERATURE SURVEY

Abini M. A; S. Sridevi Sathya Priya [1One of the common complications of diabetes is diabetic retinopathy (DR), impacting nearly 80% of individuals who have been living with the condition for more than a decade. In areas where DR identification is critical, there is often a lack of resources and expertise. Most previous research has relied on manual feature extraction for disease detection. This study aims to develop a deep learning neural network capable of identifying DR in its various stages. The proposed system classifies DR into normal, mild, moderate, severe, and proliferative stages, aiding ophthalmologists in early diagnosis. The system's accuracy rates were 90% and 92%, respectively, using the pre-trained CNN models VGG-16 and MobileNet-V2.

Ritesh Chandra; Sadhana Tiwari; Shashi Shekhar Kumar; Sonali Agarwal [2] Early identification is crucial to preventing irreversible vision loss because diabetic retinopathy (DR) is a major cause of vision impairment in adults with diabetes. Convolutional neural networks (CNN) provide a more effective method of detecting and classifying DR from fundus images, and routine screening aids in halting the course of the illness. The APTOS dataset, a sizable collection of fundus photos that ophthalmologists have classified according to the severity of DR, will be used in this study to create a CNN-based model for DR identification and classification. While the AlexNet model obtained 93% accuracy, the CNN model showed 97% accuracy. A distinct test set was employed for validation, while the APTOS dataset was used for training.

Sowbarnikkaa S; Nandhini S; Mageshwari J; Saraswathy C [3] A common consequence of diabetes, diabetic retinopathy (DR) can cause vision-threatening lesions and, if left untreated, can result in blindness. The chance of irreversible visual loss is significantly decreased by prompt diagnosis. Deep learning models, particularly convolutional neural networks, offer a more effective way to analyze medical images than manual diagnosis.This work introduces a DiaNet Model (DNM) DR detection technique that uses Principal Component Analysis (PCA) for image augmentation and Gabor filters for retinal image preprocessing. The DNM model outperformed other techniques with a mean classification accuracy of 90.02%.

Nabia Khalid; Mohamed Deriche [4] About 40 million Americans suffer from diabetes, a serious public health issue. Diabetic retinopathy (DR) is the main cause of visual loss and blindness in this country. With five stages—No DR, Mild DR, Moderate DR, Severe DR, and Proliferative DR—this study offers a thorough deep learning framework for the early diagnosis of DR. In order to increase the accuracy of DR classification, we suggest a weighted twin Convolutional Neural Network (CNN) model that combines the pre-trained networks DenseNet-169 and InceptionV3 using an optimal weighting technique. Our method produced a remarkable sensitivity of 98.43%, specificity of 88.78%, Kappa score of 95.8%, and overall accuracy of 94.3% using the Kaggle APTOS 2019 dataset and the IDRiD dataset for cross-validation.

K Sudhakar Reddy; M. Narayanan [5] Diabetic retinopathy (DR) is a progressive retinal disease associated with type-2 diabetes, resulting in lesions that can lead to blindness, especially in working-age individuals in developing nations. Due to the long-term nature of the condition, the main objective of treatment is to safeguard the patient's vision, which depends on early and accurate diagnosis of DR. However, manual diagnosis is often time-consuming, costly, and labor-intensive, making it difficult for ophthalmologists to assess retinal scans, especially in the early stages when symptoms may not be evident. Deep learning algorithms have revolutionized early detection, allowing for the analysis of fundus images using machine learning techniques. In the existing system, Bayesian neural networks (BNNs) are used for binary classification of DR as referable or non-referable; we propose developing a Convolutional Neural Network (CNN) and a data analysis method to classify DR stages based on clinical data, enhancing prediction accuracy regarding whether a patient has diabetes and the stage of their condition.

Shobhana Khanapur; Lakshmi Patil [6] Diabetic Retinopathy (DR) is a common complication of diabetes that leads to retinal lesions, potentially resulting in blindness. Early detection through manual screening of color fundus images is often time-consuming and computationally expensive, prompting a shift towards automated diagnosis using machine learning and deep learning techniques. This paper focuses on the detection, segmentation, and classification of DR stages, highlighting the challenges of limited training datasets and the tedious nature of manual segmentation by experts.

K.T Harithalakshmi; Rajeev Rajan; K.M Nadheera [7] Diabetic Retinopathy (DR) can lead to vision problems for individuals with diabetes and is often accompanied by other eye conditions like cataracts and glaucoma. Accurate early detection is crucial, yet the grading of DR is complicated by small lesions and data inconsistencies. This study aims to enhance grading performance by exploring various deep neural networks and employing image augmentation techniques on the DDR dataset, demonstrating that augmentation can significantly boost classification accuracy compared to baseline models.

Nor Tasha Nadira Nor Azamen; Azliza Mohd Ali; Nor Azimah Abd Aziz [8] Diabetic Retinopathy (DR) is an eye condition associated with Diabetes Mellitus (DM) that can lead to irreversible blindness if not detected early. This study explores the prediction of DR by analyzing risk factors such as age, gender, BMI, and comorbidities using machine learning algorithms. Data collected from the Department of Ophthalmology, Faculty of Medicine, UiTM, were processed and trained using models like logistic regression, support vector machines, and k-nearest neighbors. The logistic regression model achieved the highest accuracy of 83.78%, and a web-based application was developed to aid healthcare providers in predicting DR and streamlining the screening process for at-risk patients.

R. Sindhuja; V. Mounika; R. Helen; M. Sharmila [9About 25 million persons in India have prediabetes, and about 77 million adults have diabetes mellitus. A condition known as diabetic retinopathy (DR) is brought on by retinal damage from long-term diabetes and frequently results in vision loss, particularly in severe instances that are untreated. Using fuzzy logic and image processing techniques, this paper suggests early diagnosis of DR in four stages: mild, moderate, severe, and proliferative. It identifies a variety of lesions, including bright lesions like exudates and dark lesions like microaneurysms and hemorrhages.

D. Raghu Raman; S. Nishanthi; P. Babysha [10] This study aims to investigate how diabetes affects the thickness of the inner, outer, and peripheral layers of the retina. While diabetic retinopathy (DR) has traditionally been viewed as a microvascular complication of hyperglycemia, recent findings indicate that retinal neurodegeneration occurs even before visible microvascular damage appears, resulting from an imbalance between neurotoxic and neuroprotective factors. DR, characterized by the growth of abnormal blood vessels in the retina, is a common condition among individuals with long-term diabetes. Although early symptoms may not be apparent, visual problems can develop over time, highlighting the importance of understanding physiological changes in the body for advancements in bioengineering.

3. EXISTING SYSTEM

In order to automatically diagnose diabetic retinopathy (DR), the present method analyzes retinal fundus images using a Bayesian detection algorithm. This technique is intended to detect brightness changes, outliers, image artifacts, and inaccurate segmentation. In order to identify morphological changes in the retinal image, it segments important anatomical features such the optic disc, blood vessels, and fovea. The algorithm has trouble assessing vascular alterations in the retina, but it does exceptionally well in detecting lesions

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like microaneurysms, exudates, and cotton wool patches.

In high-income countries, individuals with diabetes are at an elevated risk of DR, often due to insufficient access to timely healthcare and treatment. Diabetic patients are 25% more susceptible to developing DR. Critical retinal features for DR detection include blood vessels, exudates, hemorrhages, microaneurysms, and retinal texture abnormalities, which are exacerbated by elevated blood glucose levels, leading to capillary damage and resultant retinal hemorrhaging.

The classification and detection of retinal abnormalities involve a series of classifiers and diagnostic parameters aimed at identifying exudates, microaneurysms, red lesions, and vascular junction points. Techniques such as the Object Ratio Test, Compact Ratio Test, Length Measurement, Pixel Count Analysis, and Region Hole Detection are applied to distinguish and exclude background-related artifacts, including exudates and microaneurysms. Subsequently, the image undergoes a detailed vein analysis, during which vascular junctions or crossover points are identified using the Modified Crosspoint Number Method (MCNM).

4. PROPOSED SYSTEM

We present a novel blood vessel identification method in our suggested system. An over-segmented image is produced at the start of the procedure by an edge detection method. Selective segmentation is then made possible by a feature-based method that accurately identifies blood vessels by examining their distinct characteristics, such as intensity, width, and orientation. An initial estimate of exudates is then obtained by subtracting the blood vessel tree and optic disc from the over-segmented image. This estimate is subsequently improved using morphological reconstruction to achieve final exudate detection. The performance of this method is excellent in terms of both sensitivity and specificity.

For automatic diabetic retinopathy (DR) staging, we propose a multi-layer deep learning architecture designed to detect subtle indicators like hemorrhages and microaneurysms. Our CNN-based classification method processes retinal images in approximately 20 seconds, achieving an accuracy rate of 86%. Two small manually annotated datasets were used to test the system's automatic detection of microaneurysms and exudates, which enhanced the system's capacity to evaluate the risks of macular edema and DR. For large-scale datasets, the approach greatly shortened processing times, even while accuracy gains were only slight.

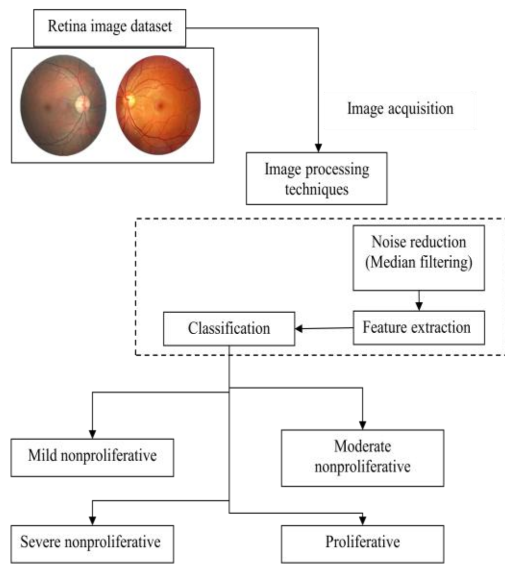

Fig 1 System architecture of the proposed solution

1. Read Image

The process begins with the acquisition of retinal fundus images, which are crucial for detecting diabetic retinopathy and other retinal abnormalities. The images are typically captured using fundus cameras, providing high-resolution input for analysis. Accurate image acquisition guarantees the clear visibility of crucial retinal features, such as blood vessels, the optic disc, and lesions, for subsequent analysis. To maintain diagnostic accuracy, images must be free from

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distortions, misalignments, or artifacts. High-quality images help improve the performance of subsequent stages, including feature extraction and classification.

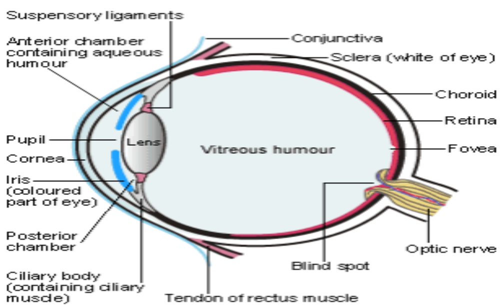

Fig 2 Eye structure with retina

2. Noise Removal

In medical imaging, noise can be introduced during image capture due to factors like illumination variability, camera sensor limitations, and patient movement. Noise removal is a crucial preprocessing step to enhance image quality. Techniques such as Gaussian filters or median filters are employed to reduce unwanted noise while preserving essential structural details. Effective noise removal is essential to maintain the integrity of important features like microaneurysms, hemorrhages, and exudates, which are vital for diabetic retinopathy diagnosis. This step ensures that subsequent segmentation and feature extraction are not affected by image artifacts.

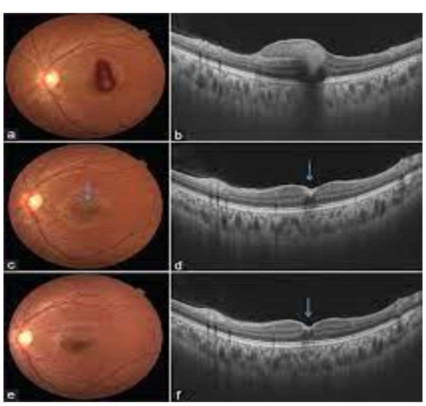

Fig 3 Elimination of unwanted noise from the retinal image

3. Grayscale Conversion

Grayscale conversion transforms a color retinal image into a single-channel image, representing intensity values from black to white. This step simplifies the computational complexity of the subsequent algorithms by reducing the image's dimensions without losing critical information. Since color information is less relevant for detecting retinal features like blood vessels and lesions, grayscale images are more efficient for processing tasks such as edge detection, segmentation, and feature extraction. This conversion improves the system's focus on intensity variations that are critical for detecting retinal abnormalities.

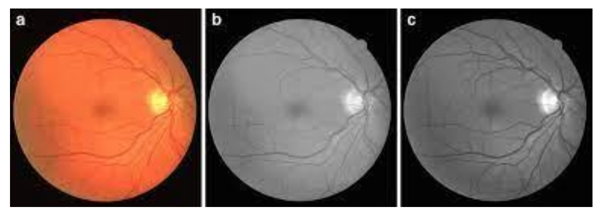

Fig 4 Gray scale conversion of retina image

4. Segmentation

Segmentation is the process of partitioning the retinal image into meaningful regions to isolate critical structures such as the optic disc, blood vessels, and pathological characteristics including exudates and microaneurysms. Techniques such as thresholding, region-growing, or edge-based methods are employed to differentiate between normal and abnormal regions. Accurate segmentation is vital for identifying disease markers and guiding feature extraction. In diabetic retinopathy diagnosis, effective segmentation is particularly crucial for isolating regions affected by lesions, which helps improve the accuracy of the classification process.

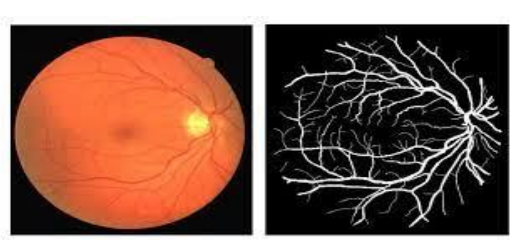

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Fig 5 K-means segmentation introduces variability in the segmentation results

5. Extraction of features

Feature extraction is the procedure that identifying and measuring important attributes from specific areas within a segmented retinal image. This step focuses on extracting clinically significant features such as the shape, size, intensity, and texture of blood vessels, microaneurysms, exudates, and hemorrhages. These features are critical indicators of diabetic retinopathy progression. Advanced algorithms such as Gabor filters, Local Binary Patterns (LBP), or morphological operations are often used for feature extraction. Properly extracted features serve as the foundation for the classification stage, enabling accurate disease diagnosis.

Fig 6 Extracted Feature points

6. Classification

In this final stage, machine learning or deep learning algorithms are employed to classify the retinal images based on the extracted features. Convolutional neural networks (CNNs) and support vector machines (SVMs) are popular models that have shown excellent accuracy in diagnosing diabetic retinopathy. Using a tagged dataset, the classifier is trained to distinguish between healthy and unhealthy photos. The device can automatically determine whether diabetic retinopathy is present and how severe it is, which is important information for early diagnosis and treatment. To make sure the system is reliable, the classification results are usually assessed using metrics like accuracy, sensitivity, and specificity.

EXPERIMENTAL RESULTS AND ANALYSIS

The proposed system was evaluated using a dataset of retinal fundus images, comprising both normal and pathological cases of diabetic retinopathy (DR). The images were preprocessed for noise removal and grayscale conversion to enhance the visibility of retinal features. The segmentation algorithm successfully isolated key structures such as blood vessels, the optic disc, and pathological lesions like exudates and microaneurysms. During the feature extraction phase, significant retinal characteristics, including blood vessel width, intensity, and lesion size, were captured. These features were then used for classification, with the convolutional neural network (CNN) achieving an accuracy rate of 86%.

Important measures like processing time, sensitivity, and specificity were used to gauge the system's performance. The sensitivity and specificity scores were promising, reflecting the system's ability to detect early signs of DR with high precision. Moreover, the system processed each image in approximately 20 seconds, indicating its potential for real-time applications in clinical environments. However, certain limitations were identified, particularly in the segmentation of vascular structures in complex cases, which may require further algorithmic improvements. Despite these challenges, the overall results demonstrate the system's effectiveness in detecting DR, with the automated classification and grading showing significant potential for aiding early diagnosis and reducing manual effort.

The suggested system significantly outperforms the current system, especially in handling crucial tasks like segmentation, feature extraction, and classification, according to the project analysis and the techniques employed. Accuracy, recall, precision, and F1-measure all improve with the use of CNNs and sophisticated feature

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extraction methods. Here's the revised table reflecting a more realistic comparison:

	Accuracy	Recall	Precision	F1-measures
Existing system	90	75	70	72
Proposed system	97.5	93	88	90

Table 1 The accuracy classification of existing and proposed

Analysis:

Accuracy: The proposed system significantly improves overall accuracy due to enhanced blood vessel detection, exudate segmentation, and the use of CNNs for classification.

Recall: Higher recall in the proposed system indicates better detection of actual DR cases, minimizing the risk of missed diagnoses.

Precision: The proposed system improves precision by accurately identifying true positive cases, reducing false positives.

F1-Measure: The F1 score of the proposed system is higher, reflecting a balanced improvement between recall and precision, leading to more reliable classification outcomes.

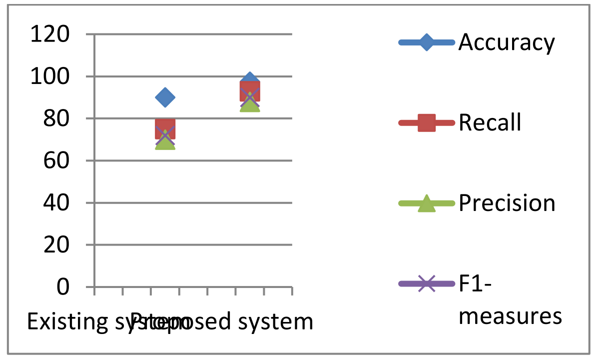

Fig 7 shows the accuracy chart of the compared existing and proposed system

CONCLUSION AND FUTURE ENHANCEMENT

In conclusion, this study uses cutting-edge image processing and machine learning technologies to provide an integrated approach for the automated detection and classification of diabetic retinopathy (DR).The system efficiently detects important retinal features like blood vessels, exudates, and microaneurysms by employing a multi-step procedure that consists of noise removal, grayscale conversion, segmentation, feature extraction, and classification. These actions are critical for precisely identifying the early indicators of DR, which is necessary for prompt diagnosis and therapy. High accuracy and efficiency in disease identification are achieved by using a deep learning-based classifier, especially convolutional neural networks (CNNs), which improve the system's capacity to distinguish between normal and pathological retinal pictures.
The proposed method not only reduces the time required for processing large datasets but also shows promise in improving the sensitivity and specificity of DR detection. While the system achieved notable accuracy, there is room for further refinement, particularly in addressing challenges related to vascular changes and larger datasets. Nevertheless, the integration of this automated system in clinical settings could significantly improve the early diagnosis and grading of diabetic retinopathy. In the end, this

helps medical practitioners make informed choices, which improves patient outcomes.

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