

Artificial Intelligence–Enhanced Diabetic Retinopathy Classification using Neural Networks

¹Dr. DVN Sukanya, ² Guddanti Meghana, ³Lavanya Yarravarapu, ⁴Gopathoti Lasya,
⁵ Savanam Pavani

¹Associate Professor, Dept Electronics and Communication Engineering, St. Ann's College of Engineering and Technology, Nayunipalli (V), Vetapalem (M), Chirala, Bapatla Dist, Andhra Pradesh – 523187, India

^{2,3,4,5}U. G Student, Dept Electronics and Communication Engineering, St. Ann's College of Engineering and Technology, Nayunipalli (V), Vetapalem (M), Chirala, Bapatla Dist, Andhra Pradesh – 523187, India

ABSTRACT

Diabetic Retinopathy (DR) is a leading cause of blindness among diabetic patients, necessitating early detection for effective treatment. In the existing systems of Machine Learning (ML) approaches like Support Vector Machine (SVM) is employed for DR classification using handcrafted features such as Blood vessels overcomes the drawbacks of SVM and offers the improved classification, accuracy and better generalization for large-scale datasets. This concludes that contribution to early DR detection and improved patient's care at remote areas also extracted from preprocessed retinal images due to this the SVM is struggled with non-linear patterns in medical imaging. To overcome these challenges, the novelty of proposed Deep Learning (DL) algorithm such as Deep Neural Network (DNN) model which automatically learns hierarchical features, enabling more accuracy and better classification. The performance of both

models is evaluated by using the performance Metrics like Accuracy, Precision and Recall. The experimental results states that DNN

INTRODUCTION

Diabetic Retinopathy (DR) is a serious eye condition that can lead to blindness, especially in individuals with diabetes. Early diagnosis and accurate detection are crucial to preventing vision loss in diabetic patients. DNN is a type of deep learning model and are widely used in the detection of DR. These models analyse retinal images by distinguishing blood vessel pixels from other parts of the retina, significantly improving the accuracy and efficiency of diagnosis. One of the main advantages of using deep learning in DR detection is its ability to identify subtle retinal changes that may indicate early stages of the disease. Detecting DR in its early stages allows for timely medical intervention and better

disease management, reducing the risk of permanent vision impairment.

High blood glucose levels brought on by diabetes harm the retina's tiny blood vessels over time. After living with diabetes for over a decade, many patients develop DR. Globally, diabetes is a growing health crisis—especially in countries like India, where the disease is spreading rapidly. India ranks among the top three countries with the highest number of diabetic individuals. Worldwide, the diabetic population has increased from 108 million to 422 million in recent years, with half of these cases concentrated in India, China, the USA, Brazil, and Indonesia [2]. Because of this widespread prevalence, there is an urgent need to develop automated diagnostic systems to support ophthalmologists and reduce patient morbidity. Diabetic Retinopathy is a progressive condition that results from long-term uncontrolled blood sugar levels. Impaired vision and, if left untreated, blindness result from damage to the retina, the light-sensitive tissue in the back of the eye. Regular eye examinations, maintaining a healthy lifestyle and timely medical care are essential to managing the risk of DR and preserving vision in diabetic patients. The below figure 1 shows the normal eye and eye affected with DR.

LITERATURE SURVEY

This section provides an overview of existing research on the classification of Diabetic Retinopathy (DR) using Deep Learning (DL) techniques, specifically aimed at monitoring blood vessels in diabetic patients. It also highlights several notable studies that utilize big data approaches to achieve high-accuracy predictions of potential fluctuations in blood vessel conditions. The focus remains on leveraging DL methods to enhance the detection and classification of DR. In [3], CNN-based P-EDR outperformed SVM, RF, and GBM in DR diagnosis but faced challenges in dataset diversity and real-world validation. In [4], The authors implemented a CGSX ensemble method combining machine learning and deep learning for diabetic retinopathy classification, using techniques like GLLM, GLRLM, and deep CNN (ResNet, VGG).

RELATED WORK

Diabetic Retinopathy (DR) is a major cause of vision loss among diabetic patients, making early detection essential for effective treatment. Traditional machine learning approaches, such as Support Vector Machines (SVM), have been widely used for DR classification using handcrafted features extracted from retinal images. These features mainly focus on

blood vessel patterns and other manually engineered image characteristics. However, SVM-based methods often struggle to capture complex non-linear patterns present in medical imaging data. This limitation reduces their classification performance, especially when handling large-scale and diverse datasets. To address these challenges, deep learning techniques have been increasingly explored in recent studies.

EXISTING SYSTEM

Support Vector Machine (SVM) is a powerful machine learning algorithm widely used for medical image classification, including Diabetic Retinopathy (DR) detection. It works by finding an optimal hyper plane that maximizes the margin between different classes, ensuring accurate classification. In DR classification, retinal images undergo pre-processing techniques like noise removal, contrast enhancement, and segmentation to improve feature extraction. Key features such as texture, color, and shape are extracted using methods like Gray-Level Co-occurrence Matrix (GLCM) and Discrete Wavelet Transform (DWT). Dimensionality reduction techniques such as Principal Component Analysis (PCA) help optimize computational efficiency. The below figure 3 explains about the Support Vector

Machines (SVM), Lagrange multipliers (α_1 to α_n) assign weights to training samples. The decision boundary is defined by support vectors, which only correspond to non-zero α values. These support vectors act as hidden nodes, contributing to accurate classification by maximizing the margin between classes in the feature space.

PROPOSED SYSTEM

The proposed system focuses on early detection of Diabetic Retinopathy (DR) using an advanced deep learning approach. Retinal fundus images are first preprocessed to enhance image quality and remove noise. Unlike traditional machine learning methods that rely on handcrafted features, the proposed model employs a Deep Neural Network (DNN) for automatic feature extraction. The DNN effectively learns hierarchical and discriminative features from retinal images. This approach overcomes the limitations of Support Vector Machine (SVM) models in handling non-linear patterns. The system improves classification accuracy and generalization capability on large-scale datasets. The trained DNN model classifies retinal images into different DR severity levels. Performance evaluation is carried out using accuracy, precision, and recall metrics. Experimental results demonstrate superior performance of the proposed DNN-based system. The system contributes to early DR

diagnosis and improved patient care, especially in remote and resource-limited areas.

SYSTEM ARCHITECTURE

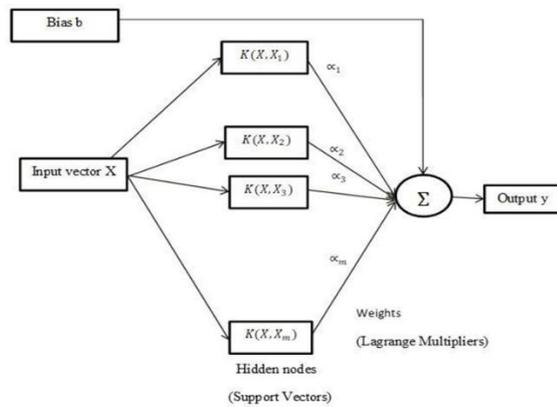


Fig:1 Diabetic Retinopathy Classification using Neural Networks

METHODOLOGY DESCRIPTION

The proposed methodology begins with the collection of retinal fundus images from a standard dataset. Preprocessing techniques such as resizing, normalization, and noise removal are applied to enhance image quality. Data augmentation is performed to increase dataset diversity and reduce overfitting. The preprocessed images are then divided into training and testing sets. A Deep Neural Network (DNN) architecture is designed for automatic feature extraction and classification. The network is trained using labeled retinal images to learn hierarchical features. During training, optimization techniques are applied to minimize classification error. The trained model is validated using unseen test data. Performance is evaluated using accuracy, precision, and recall metrics. The final model

predicts the presence and severity of Diabetic Retinopathy effectively.

RESULTS AND DISCUSSION

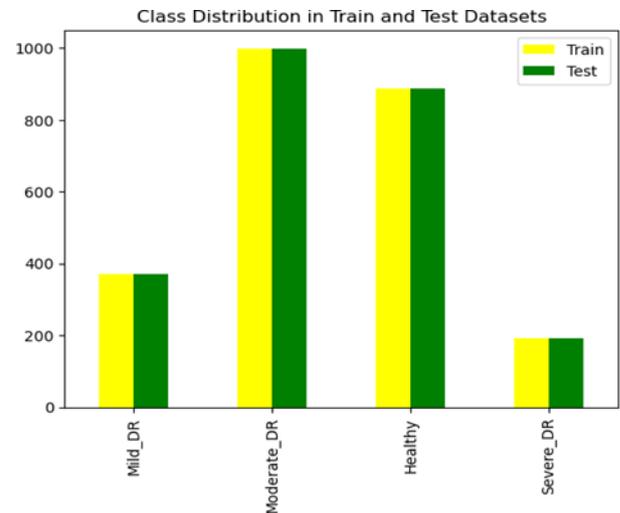


Fig:2 Class Distribution in Train and Test Datasets

The dataset for diabetic retinopathy is fairly balanced, with the most images in the Moderate_DR and Healthy categories, and fewer in Mild_DR and Severe_DR. The sample images show a good variety of eye conditions, though some classes clearly have more data than others. The model does well overall, especially with the common classes, but it struggles a bit with the less frequent ones often confusing them with Moderate_DR. With some tweaks like balancing the classes or adding more diverse training images, the model's accuracy could get even better



Fig:3 DR classification using DNN gives output as Moderate DR.

The classification of DR by using DNN gives the output as shows in the below figure. This retinal fundus image is labelled as Moderate Diabetic Retinopathy (Moderate_DR), showing early signs of retinal damage. It is used in training deep learning models for automated diabetic retinopathy classification.

CONCLUSION

This paper presents an efficient Deep Neural Network (DNN)-based approach for the classification of Diabetic Retinopathy (DR) using retinal images. The proposed system significantly outperforms traditional machine learning methods such as Support Vector Machine (SVM). By automatically learning hierarchical features, the DNN overcomes the limitations of handcrafted feature extraction. The model effectively handles complex non-linear patterns present in medical images. Performance evaluation using accuracy, precision, and recall

demonstrates improved classification results. The enhanced detection capability supports early diagnosis of DR. Early detection enables timely medical intervention and reduces the risk of vision loss. The system is particularly beneficial for remote and underserved regions. Overall, the proposed approach improves diagnostic reliability. This work contributes to the advancement of AI-based healthcare solutions.

FUTURE SCOPE

Future work can focus on integrating advanced deep learning architectures such as Convolutional Neural Networks (CNNs) for improved spatial feature extraction. Vision Transformers can be explored to capture long-range dependencies in retinal images. The system can be trained using larger and more diverse datasets to improve robustness and generalization. Real-time deployment can be achieved through mobile or cloud-based platforms. Integration with telemedicine systems can enhance accessibility for remote patients. Explainable AI techniques can be incorporated to improve transparency and clinical trust. Multi-class severity grading of DR can be further refined. The model can be extended to detect other retinal diseases. Optimization techniques can be applied for faster inference. These advancements will

strengthen the impact of AI in medical diagnostics.

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