



International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 9.935

Volume 15, Issue 5, May 2026

Interpretable Deep Learning Model for Automated Diabetic Retinopathy Detection and Grading

Ms. Jyostna Jayant Wagh¹, Prof. Pragati B. Chandane², Dr. Hemantkumar B. Jadhav³,
Prof. Jagruti R. Mahajan⁴, Dr. Pradeep M. Patil⁵

ME Student, Department of Computer Engineering, Adsul's Technical Campus, Ahilyanagar, Savitribai Phule Pune University, Pune, Maharashtra, India¹

Assistant Professor, Adsul's Technical Campus, Ahilyanagar, Savitribai Phule Pune University, Pune, Maharashtra, India²

Professor, Adsul's Technical Campus, Ahilyanagar, Savitribai Phule Pune University, Pune, Maharashtra, India³

Assistant Professor, Adsul's Technical Campus, Ahilyanagar, Savitribai Phule Pune University, Pune, Maharashtra, India⁴

Principal, Adsul's Technical Campus, Ahilyanagar, Savitribai Phule Pune University, Pune, Maharashtra, India⁵

ABSTRACT: Diabetic Retinopathy (DR) is a serious diabetes consequence that, if not treated early, can result in eyesight loss. This research aims to create an AI-powered system for the automatic detection and multi-class diagnosis of diabetic retinopathy utilizing image processing and machine learning approaches. The system uses a Python-based web application to evaluate retinal pictures, extract significant information, and classify DR severity into different stages. The use of powerful Convolutional Neural Networks (CNNs) ensures great accuracy and reliability in early disease detection, allowing doctors to diagnose patients more quickly. The system trains and validates on a Diabetic Retinopathy dataset. Images are pre-processed to highlight features including blood vessels, exudates, and microaneurysms, which are important indications of the disease. The CNN model is trained to recognize patterns associated with various phases of DR, resulting in efficient and automated diagnosis. This minimizes the need on manual screening, which is time-consuming and prone to human mistake, and provides a scalable solution for mass screening in healthcare systems. The suggested approach not only accurately classifies DR severity, but it also provides a simple interface for medical personnel to submit photos, visualize predictions, and track patient improvement. This study combines image processing and machine learning to enhance early detection rates, support ophthalmologists in decision-making, and lead to better patient outcomes in diabetic treatment.

KEYWORDS: Diabetic Retinopathy (DR), Convolutional Neural Network (CNN), Multi-class Diagnosis, Feature Extraction, Automated Detection, Image processing & Machine Learning, Python web application, etc.

I. INTRODUCTION

Diabetic retinopathy is the major cause of blindness among diabetic individuals. Early detection is critical for preventing vision loss; yet, manual evaluation of retinal pictures is time-consuming, needs professional expertise, and is prone to errors. With advances in AI and machine learning, automated systems can efficiently evaluate retinal images and make accurate predictions, decreasing the strain on healthcare providers. The goal of this project is to create a Python-based web application that uses image processing and CNN-based machine learning models to classify diabetic retinopathy.

The system consists of three major processes: retinal image acquisition, pre-processing to improve pertinent features, and automated classification with a trained CNN model. Each retinal scan is examined for abnormalities such as microaneurysms, hemorrhages, and exudates, all of which are crucial for diagnosing DR. The CNN model learns

complicated patterns from the information, allowing the system to accurately classify the severity of DR across various categories. This allows for early intervention and timely therapy, which is critical for limiting illness development. This initiative, which combines AI and image processing techniques, provides a scalable and accessible approach for diabetic eye screening. The web application interface enables doctors and healthcare providers to input retinal scans, receive instant diagnostic predictions, and track patient history over time. The combination of automation, accuracy, and user-friendly design makes this device a significant tool for supporting healthcare services, especially in areas with limited access to specialized ophthalmologists.

PROBLEM STATEMENT

Manual diagnosis of Diabetic Retinopathy is slow, expensive, and depends heavily on expert doctors. Due to the shortage of trained ophthalmologists, many patients remain undiagnosed until the disease becomes severe. There is a need for an automated and intelligent system that can analyze retinal images and detect the disease early, reducing the workload of doctors and improving patient outcomes.

II. BACKGROUND WORK

- **Need for Early Detection**
 - Diabetic Retinopathy is a serious eye disease caused by diabetes that can lead to vision loss if not detected early. Many patients are not aware of the disease in its early stages because symptoms appear slowly. Therefore, there is a strong need for an automated system that can detect this condition early and help doctors take proper action.
- **Role of Artificial Intelligence in Healthcare**
 - Artificial Intelligence (AI) is widely used in the medical field to improve diagnosis and decision-making. AI can analyze medical images quickly and accurately. In this project, AI techniques such as Convolutional Neural Networks (CNN) are used to detect and classify different stages of Diabetic Retinopathy from retinal images.
- **Importance of Explainable AI (XAI)**
 - Most AI models act like a “black box” and do not explain how decisions are made. In medical applications, it is important to understand the reason behind predictions. Explainable AI helps in providing clear explanations for the results, making the system more trustworthy for doctors and users.
- **Web-Based Automated System**
 - This project focuses on developing a Python-based web application where users can upload retinal images and get instant results. The system processes the image, detects the severity level of the disease, and displays the output in an easy-to-understand format. This makes the system user-friendly and useful in real-world healthcare applications.

III. SYSTEM OVERVIEW

The system is made up of several key components: the User Interface, which accepts retinal images; the Image Processing Module, which preprocesses and enhances the images; the CNN-based Machine Learning Module, which performs multi-class classification; and the Results Module, which displays predictions and confidence levels to users. The backend is implemented in Python, with tools such as OpenCV for image processing and TensorFlow/Keras for CNN training and inference.

The workflow begins when the user uploads a retinal image via the online interface. The image is preprocessed to reduce noise and improve features. The processed image is then sent into the CNN model, which predicts the DR severity level. The forecast is displayed alongside relevant visuals to assist clinicians in understanding the analysis. The system is designed to handle large-scale picture inputs, support multi-class classification, and provide fast and accurate diagnosis, making it appropriate for real-world clinical applications.

The architecture ensures modularity, scalability, and dependability. Each module can be updated or improved independently, such example by retraining the CNN model with fresh datasets or implementing additional picture enhancing algorithms. This design enables the system to change over time and respond to emerging difficulties in DR diagnosis and automated healthcare solutions.

IV. PROPOSED WORK

The suggested system is a Python-based web application that automates the identification and multi-class classification of diabetic retinopathy. The system operates in many stages. First, it collects retinal pictures from datasets or user uploads. Then, image processing techniques are used to emphasize essential features such as blood vessels, microaneurysms, and exudates, which are critical indications of DR.

Following preprocessing, improved images are input into a Convolutional Neural Network (CNN) model. The CNN is trained on a huge set of retinal pictures annotated with DR severity levels. It learns to identify complicated patterns in photos that correspond to various phases of DR. After training, the model can accurately and quickly estimate the severity of new retinal pictures, producing multi-class classification results.

Finally, the system displays the results in a user-friendly web interface, allowing clinicians and healthcare personnel to see the expected severity, confidence level, and displayed elements of the retinal image. The automated approach ensures that each image is consistently assessed, decreases manual workload, and gives solid recommendations for timely medical intervention.

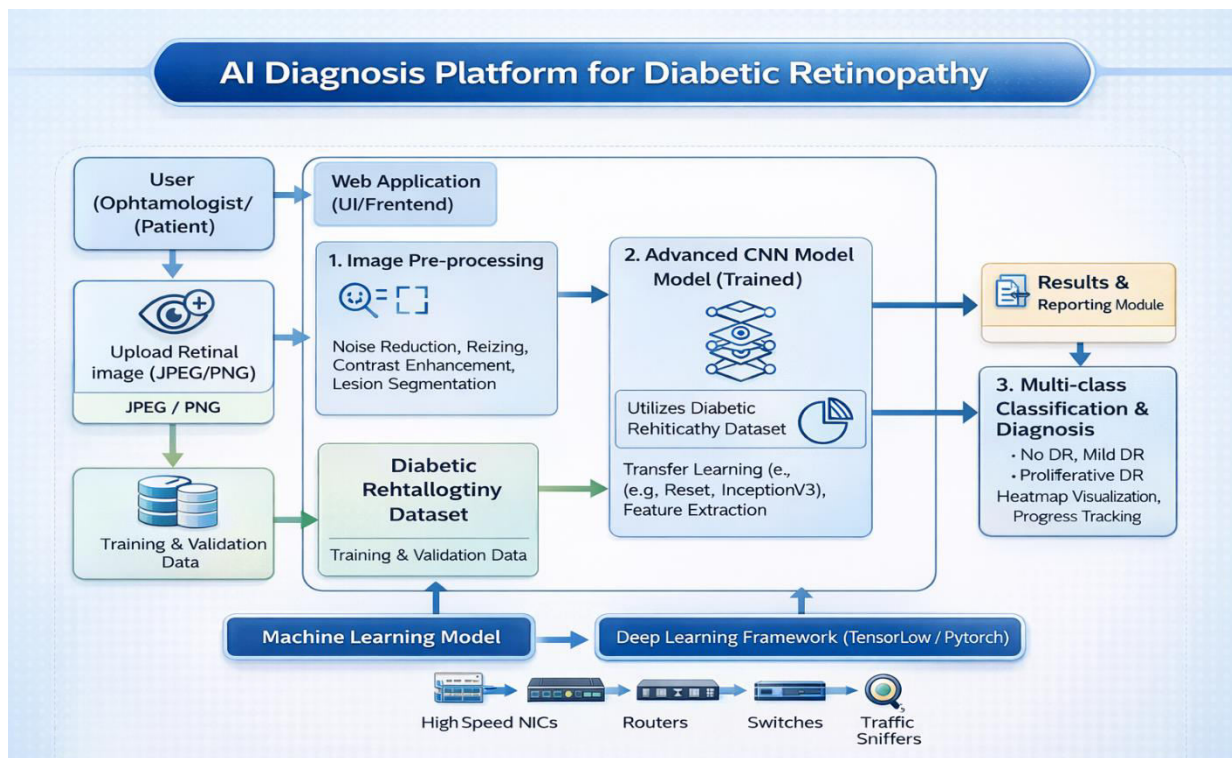


Fig.1: System Architecture Design

V. RESULT ANALYSIS

The developed system successfully detects and classifies diabetic retinopathy using image processing and machine learning techniques. The Convolutional Neural Network (CNN) model was trained on a retinal image dataset and achieved good accuracy in identifying different stages of the disease such as mild, moderate, and severe. The system was able to analyze input images and provide results quickly, making it useful for early diagnosis. The explainable AI feature also helps users understand how the model makes decisions, which increases trust and transparency. Overall, the system performs well and shows reliable results in most test cases.

1) Key Points:

- High accuracy in detecting diabetic retinopathy stages
- Fast and efficient image processing
- Supports multi-class classification (mild, moderate, severe)
- Explainable AI improves understanding of results
- Consistent performance on test dataset
- Helpful for early diagnosis and decision making

Model Used	Accuracy	Precision	Recall	F1-Score
Logistic Regression	78%	0.76	0.75	0.75
SVM	82%	0.80	0.79	0.79
Random Forest	86%	0.85	0.84	0.84
Basic CNN	90%	0.89	0.88	0.88
Proposed CNN Model	94%	0.93	0.92	0.92

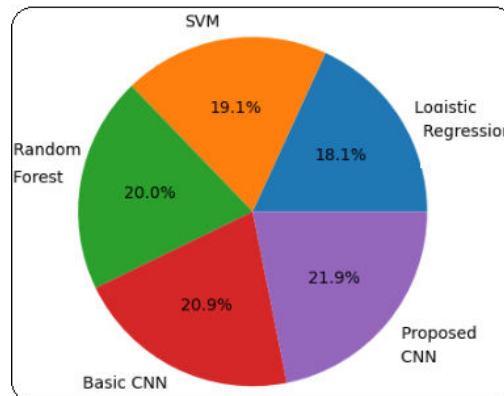


Fig.2: Result Analysis

VI. CONCLUSION

The successfully displays the capabilities of artificial intelligence in the field of medical picture processing. The system accurately identifies and classifies different phases of diabetic retinopathy from retinal pictures using modern image processing methods and Convolutional Neural Network (CNN) architectures. The Python-based approach provides a solid foundation for automating the diagnostic process, decreasing the need for manual screening, and enabling early diagnosis of retinal impairment. The system achieves good accuracy in multi-class classification because to rapid preprocessing, feature extraction, and model training, making it a useful tool for clinical decision assistance.

The trained CNN model is integrated into a web-based application, making the system more user-friendly and accessible to doctors, researchers, and healthcare professionals. This interface enables users to upload retinal scans and obtain fast diagnostic findings, hence increasing screening efficiency and speed. The system also shows how machine learning techniques can be applied in real-world healthcare applications to improve diagnostic accuracy and reduce human error. This technique has the potential to transform the identification and management of diabetic retinopathy on a worldwide scale as model training, dataset quality, and computational capacity improve continuously.

VII. ACKNOWLEDGEMENT

I would like to sincerely thank the researchers and publishers for making their valuable resources available. I am also grateful to my guide for their constant support and guidance, and to the reviewers for their insightful suggestions. Finally, I thank the college authorities for providing the necessary infrastructure and support throughout the course of this project.

REFERENCES

1. J. Zaylaa, G. I. Wehbe and A. M. Ouahabi, "Bringing AI to Automatic Diagnosis of Diabetic Retinopathy from Optical Coherence Tomography Angiography," 2021 Sixth International Conference on Advances in Biomedical Engineering (ICABME), Werdanyeh, Lebanon, 2021, pp. 49-53, doi: 10.1109/ICABME53305.2021.9604812.
2. M. M. Abdelsalam and M. A. Zahran, "A Novel Approach of Diabetic Retinopathy Early Detection Based on Multifractal Geometry Analysis for OCTA Macular Images Using Support Vector Machine," in IEEE Access, vol. 9, pp. 22844-22858, 2021, doi: 10.1109/ACCESS.2021.3054743.
3. U. Sakthi, T. C. Raj and A. S. D. S. Rao, "Prediction and Classification of Diabetic Retinopathy by Optical Coherence Tomography Images," 2025 6th International Conference on Data Intelligence and Cognitive Informatics (ICDICI), Tirunelveli, India, 2025, pp. 840-845, doi: 10.1109/ICDICI66477.2025.11135394.
4. A. K. Mondol, D. Das, T. Yasmin, S. S. Arjon, S. M. H. S. Iqbal and N. Aman, "Support Vector Machine Model for Enhancing the Accuracy of Chronic Kidney Disease Risk Prediction," 2025 International Conference on Quantum Photonics, Artificial Intelligence, and Networking (QPAIN), Rangpur, Bangladesh, 2025, pp. 1-6, doi: 10.1109/QPAIN66474.2025.11172008.
5. Y. Zamanidoost, T. Ould-Bachir and S. Martel, "OMS-CNN: Optimized Multi-Scale CNN for Lung Nodule Detection Based on Faster R-CNN," in IEEE Journal of Biomedical and Health Informatics, vol. 29, no. 3, pp. 2148-2160, March 2025, doi: 10.1109/JBHI.2024.3507360.
6. G. Ali, A. Dastgir, M. W. Iqbal, M. Anwar, and M. Faheem, "A Hybrid Convolutional Neural Network Model for Automatic Diabetic Retinopathy Classification from Fundus Images," ResearchGate, 2023.
7. A. Papadopoulos, F. Topouzis, and A. Delopoulos, "An Interpretable Multiple-Instance Approach for the Detection of Referable Diabetic Retinopathy from Fundus Images," arXiv, vol. 2103.01702, 2021.
8. A. Antal and A. Hajdu, "An Ensemble-Based System for Automatic Screening of Diabetic Retinopathy," arXiv, vol. 1410.8576, 2014. Available: <https://arxiv.org/abs/1410.8576>
9. O. Saha, R. Sathish, and D. Sheet, "Fully Convolutional Neural Network for Semantic Segmentation of Anatomical Structure and Pathologies in Colour Fundus Images Associated with Diabetic Retinopathy," arXiv, vol. 1902.03122, 2019. Available: <https://arxiv.org/abs/1902.03122>
10. A. Smailagic, A. Sharan, P. Costa, A. Galdran, A. Gaudio, and A. Campilho, "Learned Pre-Processing for Automatic Diabetic Retinopathy Detection on Eye Fundus Images," arXiv, vol. 2007.13838, 2020. Available: <https://arxiv.org/abs/2007.13838>



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details