Journal Publication of International Research for Engineering and Management (JOIREM)
Volume: 04 Issue: 06 | June-2026
ISSN (O) 3107-6696

DR Vision: Deep Learning–Based Diabetic Retinopathy Detection Using Retinal Images

Ambresh Bhadrashetty[1], Manjulabai Bhadrashetty[2] , B Vaishnavi[3]

[1]*Assistant Professor, Department of Computer Science and Engineering (MCA) Visvesvaraya Technological University, Centre for PG Studies, Kalaburagi, India*

[2]*Associate Professor , Department Of Computer Science, Government First Grade College for Women's ,Jewargi Colony, Kalaburagi, India*

[3]*Student, Department of Computer Science and Engineering (MCA) Visvesvaraya Technological University, Centre for PG Studies, Kalaburagi, India*

Abstract - Diabetic Retinopathy (DR) is a progressive eye disorder caused by diabetes and remains one of the major contributors to vision impairment worldwide. Early identification of retinal abnormalities is essential for preventing severe visual complications; however, conventional screening methods rely heavily on expert ophthalmologists and are often time-consuming. This study presents an intelligent Diabetic Retinopathy detection framework that utilizes deep learning techniques for automated analysis of retinal fundus images. The proposed approach incorporates image preprocessing, feature extraction, and a convolutional neural network-based classification model to categorize retinal images into five severity levels: No DR, Mild, Moderate, Severe, and Proliferative DR. To enhance model transparency, Gradient-weighted Class Activation Mapping (Grad-CAM) is employed to highlight critical retinal regions influencing the prediction process. A web-based application is developed to provide a user-friendly platform for image upload, disease prediction, and result visualization. Experimental evaluation demonstrates the effectiveness of the proposed system in accurately identifying disease stages while supporting interpretable decision-making. The developed solution has the potential to assist healthcare professionals in large-scale screening programs, reduce diagnostic workload, and improve access to early retinal disease assessment. The study highlights the growing role of artificial intelligence in advancing medical image analysis and supporting efficient healthcare delivery.

Key Words: Diabetic Retinopathy, Deep Learning, Convolutional Neural Network, Medical Image Analysis, Explainable Artificial Intelligence, Grad-CAM, Retinal Fundus Images.

1.INTRODUCTION

Diabetes has become one of the most widespread chronic health conditions across the world, affecting people of all age groups and increasing the risk of several long-term complications. Among these complications, Diabetic Retinopathy (DR) is recognized as a major cause of visual impairment and blindness. The disease develops when prolonged high blood glucose levels damage the small blood vessels of the retina, leading to abnormalities that gradually affect vision. Because early-stage DR often progresses without obvious symptoms, many patients remain undiagnosed until significant retinal damage has already occurred.

The growing number of diabetic patients has created a substantial demand for retinal screening services. Conventional diagnosis requires retinal images to be examined by trained ophthalmologists, a process that can be expensive, time-consuming, and difficult to implement on a large scale. The shortage of eye-care specialists in many regions further limits the availability of timely screening and increases the possibility of delayed treatment. As a result, there is a strong need for intelligent technologies that can support medical professionals by providing rapid and reliable assessments of retinal conditions.

Artificial Intelligence has emerged as a powerful tool for solving complex image analysis problems. In particular, deep learning models have demonstrated exceptional capability in extracting meaningful patterns from medical images without the need for manual feature engineering. Convolutional Neural Networks (CNNs) have achieved significant success in disease detection tasks by automatically learning discriminative visual features directly from image data. These capabilities make deep learning an attractive approach for automated retinal disease screening.

The work presented in this study focuses on the development of an automated Diabetic Retinopathy detection framework using retinal fundus images. The proposed system combines image preprocessing techniques, deep learning-based

classification, and visual interpretation methods to identify disease severity levels efficiently. In addition to generating predictions, the system provides explanatory visual outputs that help users understand the factors influencing the model's decisions. A web-based implementation further improves accessibility by enabling image analysis through a simple and interactive interface.

By integrating artificial intelligence with medical image analysis, the proposed approach aims to support early disease identification, reduce screening workload, and enhance the efficiency of retinal examination procedures. The study demonstrates how modern deep learning techniques can contribute to the development of practical healthcare solutions that assist in the prevention of diabetes-related vision loss.

2.PROBLEM STATEMENT

Diabetic Retinopathy is a progressive retinal disorder that can lead to severe vision impairment if not identified and managed at an early stage. Despite the availability of retinal screening methods, a large number of diabetic patients do not undergo regular eye examinations due to limited healthcare resources, lack of awareness, and insufficient access to specialized ophthalmic services. Early symptoms are often absent, making timely diagnosis challenging and increasing the risk of irreversible retinal damage.

Traditional screening procedures depend heavily on manual evaluation of retinal fundus images by experienced specialists. This approach requires significant time, effort, and expertise, making it difficult to handle the growing number of diabetic patients requiring routine monitoring. In addition, variations in clinical interpretation may affect diagnostic consistency, particularly when large-scale screening programs are conducted.

The rapid growth of medical imaging data has created a demand for intelligent systems capable of supporting healthcare professionals in disease detection and assessment. However, many existing automated solutions face challenges related to classification accuracy, scalability, interpretability, and practical deployment in real-world environments.

Therefore, there is a need for an efficient, reliable, and automated system that can analyze retinal fundus images, accurately identify the presence and severity of Diabetic Retinopathy, and provide understandable results to support clinical decision-making. Such a system can contribute to earlier diagnosis, improved screening efficiency, and better management of diabetes-related eye complications.

3. OBJECTIVES

The main objective of this study is to develop an intelligent and automated Diabetic Retinopathy detection system that utilizes deep learning techniques to analyze retinal fundus images and identify different stages of the disease. The proposed system aims to support early diagnosis by providing accurate and timely assessment of retinal abnormalities, thereby reducing the risk of vision loss associated with delayed treatment. The research focuses on developing a robust image classification model capable of distinguishing multiple severity levels of Diabetic Retinopathy while maintaining high prediction performance. Another objective is to enhance the quality of retinal images through appropriate preprocessing techniques to improve the effectiveness of the learning process. The study also aims to incorporate explainable artificial intelligence methods that provide visual insights into the model's decision-making process, increasing transparency and user confidence. Furthermore, a web-based application is developed to enable secure image upload, automated prediction, and intuitive result visualization. The overall goal is to create a practical decision-support tool that can assist healthcare professionals in large-scale screening programs, improve diagnostic efficiency, and demonstrate the potential of artificial intelligence in modern ophthalmic healthcare.

4. METHODOLOGY

The proposed research follows a systematic methodology to develop an automated Diabetic Retinopathy detection system using retinal fundus images and deep learning techniques. The process begins with the collection of retinal image data from publicly available datasets containing images representing different stages of Diabetic Retinopathy. The acquired images undergo a preprocessing phase, where operations such as resizing, normalization, and enhancement are performed to improve image quality and ensure consistency across the dataset. Data augmentation techniques are also applied to increase the diversity of training samples and improve the model's ability to generalize to unseen data.

Following preprocessing, the prepared images are utilized to train a deep learning model based on a Convolutional Neural Network (CNN) architecture. The model automatically learns significant retinal features associated with disease progression and classifies images into multiple severity categories. During the training process, optimization algorithms and validation techniques are employed to enhance prediction accuracy and minimize classification errors. Once the training phase is completed, the model is evaluated using standard performance measures to assess its effectiveness in detecting and grading Diabetic Retinopathy.

To improve the interpretability of the system, an explainable artificial intelligence mechanism is incorporated to identify and visualize the retinal regions that contribute most to the model's predictions. This feature helps users understand the reasoning behind classification results and increases trust in the system. Finally, the trained model is integrated into a web-based application that allows users to upload retinal images, obtain automated predictions, and view graphical

representations of the results through an interactive interface. This methodology ensures a structured approach toward developing an efficient, accurate, and user-friendly solution for Diabetic Retinopathy screening and assessment.

5. LITERATURE SURVEY

The application of artificial intelligence in healthcare has created new opportunities for the early identification of retinal diseases, particularly Diabetic Retinopathy. Over the years, numerous studies have focused on developing automated systems capable of analyzing retinal fundus images and assisting medical professionals in disease diagnosis. Initial research efforts relied on conventional image analysis methods that utilized manually extracted features to identify retinal abnormalities. While these techniques provided a foundation for automated screening, their effectiveness was often restricted by variations in image quality, disease presentation, and feature extraction accuracy.

The rapid development of deep learning has transformed the field of medical image interpretation by enabling computers to learn complex visual patterns directly from image data. Researchers have employed various neural network architectures to improve disease classification performance and reduce the limitations associated with traditional approaches. Deep learning models have shown strong capability in detecting subtle retinal changes associated with different stages of Diabetic Retinopathy, making them suitable for large-scale screening applications. The integration of transfer learning strategies has further improved model efficiency by leveraging knowledge acquired from previously trained networks.

In recent years, attention has shifted toward developing more transparent and clinically useful diagnostic systems. Explainable artificial intelligence techniques have been incorporated into retinal image analysis frameworks to provide visual evidence supporting model predictions. These methods help bridge the gap between automated decision-making and clinical acceptance by enabling healthcare professionals to better understand algorithmic outcomes. Researchers have also explored web-based and cloud-enabled solutions to extend the reach of automated screening services and improve accessibility in regions with limited medical resources.

Although existing studies have reported encouraging results, several challenges remain unresolved. Issues such as dataset diversity, class imbalance, model interpretability, and real-world deployment continue to influence the reliability and adoption of automated diagnostic systems. Consequently, ongoing research aims to develop more accurate, scalable, and trustworthy solutions that can support early detection, reduce diagnostic burden, and contribute to improved patient care. The collective findings from previous investigations demonstrate the significant potential of deep learning and explainable artificial intelligence in advancing Diabetic Retinopathy screening and management.

6. SYSTEM DESIGN

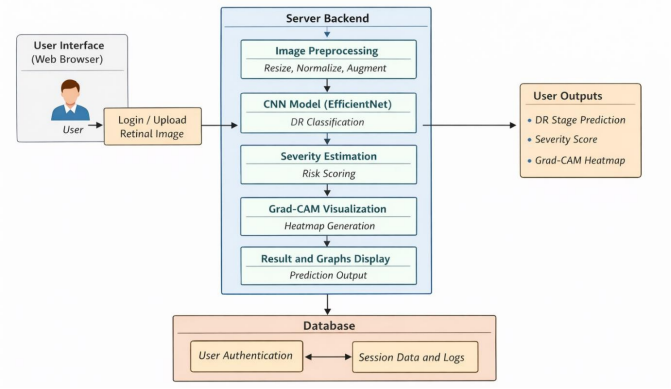

Figure 1: Proposed System Architecture.

The process begins at the user interface, where an authorized user accesses the web application through a browser and uploads a retinal fundus image. The uploaded image is transmitted to the server backend, which serves as the central processing unit of the system. Within the backend, the image first passes through the preprocessing module, where operations such as resizing, normalization, and data augmentation are performed to improve image quality and prepare the data for analysis.

After preprocessing, the image is forwarded to the deep learning classification module based on the EfficientNet architecture. This model extracts important retinal features and classifies the image into the appropriate Diabetic Retinopathy severity category. Following classification, the severity estimation module calculates a risk score that reflects the progression level of the detected condition. This score provides additional information that can assist in understanding the seriousness of the disease.

To improve transparency and interpretability, the system incorporates a Grad-CAM visualization module. This component generates heatmaps that highlight the retinal regions that have the greatest influence on the model's prediction. These visual explanations help users understand the basis of the classification result and enhance confidence in the automated decision-making process.

The generated outputs, including the predicted disease stage, severity score, and Grad-CAM visualization, are presented through the result and graph display module. This module organizes the prediction results in a clear and user-friendly format, enabling effective analysis and interpretation.

Journal Publication of International Research for Engineering and Management (JOIREM)
Volume: 04 Issue: 06 | June-2026
ISSN (O) 3107-6696

A database module supports the overall operation of the system by managing user authentication, session information, and activity logs. This ensures secure access, maintains data integrity, and enables reliable interaction between different system components. The architecture provides a scalable and modular framework that can be extended in the future to support additional retinal diseases, cloud deployment, and integration with healthcare information systems.

7. SCREENSHOTS

1. Home Page

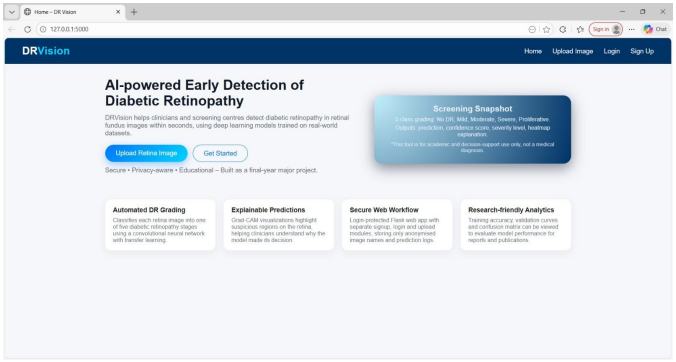

Figure 2: Home Page

2. Login Page

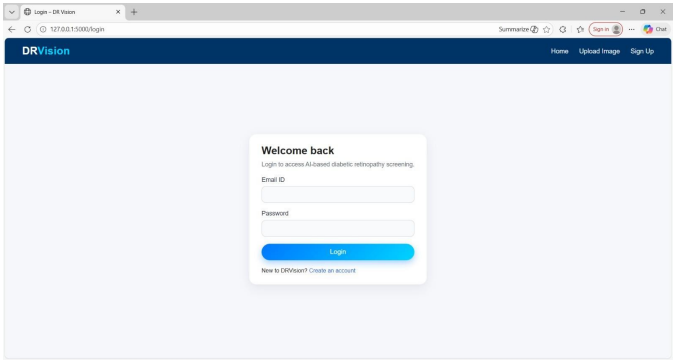

Figure 3: Login Page

3.Upload Page

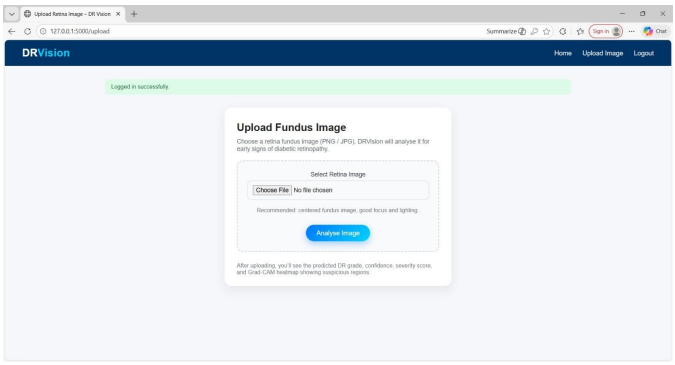

Figure 4: Upload Page

4. Prediction Result Page

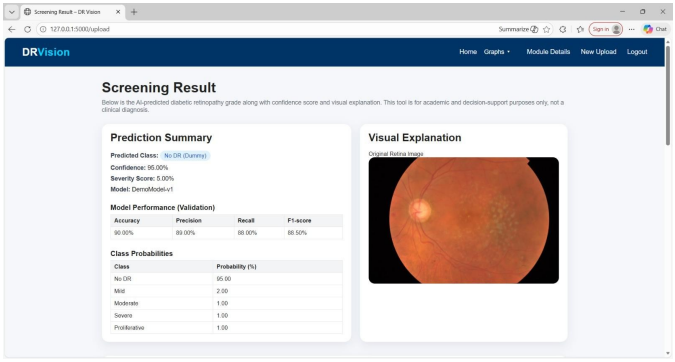

Figure 5: Prediction Result Page

8. CONCLUSION & FUTURE SCOPE

The present study demonstrates the successful development of an intelligent Diabetic Retinopathy detection system that leverages deep learning and medical image analysis for automated retinal screening. The proposed framework processes retinal fundus images, identifies disease-related abnormalities, and classifies them into appropriate severity levels with minimal human intervention. By combining image preprocessing techniques, deep learning-based classification, severity assessment, and explainable artificial intelligence mechanisms, the system provides both accurate predictions and meaningful visual interpretations. The web-based implementation further enhances usability by enabling secure image upload, rapid analysis, and convenient result visualization. The developed solution has the potential to support healthcare professionals in improving screening efficiency, reducing diagnostic workload, and facilitating early identification of retinal complications associated with diabetes. The findings of this study demonstrate the growing significance of artificial intelligence in modern healthcare and its capability to assist in timely disease management and prevention of vision impairment.

Despite the encouraging performance of the proposed system, there remain several opportunities for future enhancement.

Expanding the training process with larger and more diverse datasets can improve model robustness and adaptability across different patient populations. The incorporation of advanced neural network architectures, including transformer-based and ensemble learning models, may further increase diagnostic accuracy and reliability. Future versions of the system can be extended to identify multiple retinal disorders within a single platform, creating a comprehensive ophthalmic screening solution. Integration with cloud technologies, mobile healthcare applications, and hospital information systems can enhance accessibility and support real-time clinical deployment. Additional research focused on explainability, clinical validation, and large-scale implementation will contribute to the development of more trustworthy and practical AI-driven healthcare systems. These advancements can strengthen the role of automated retinal screening in improving patient outcomes and expanding access to quality eye care services.

9. REFERENCES

[1] W. Gong, Y. Pu, T. Ning, Y. Zhu, G. Mu, and J. Li, "Deep Learning-Based Prediction of Diabetic Retinopathy Using Clinical and Retinal Data," *Journal of Healthcare Engineering*, vol. 2025, pp. 1–12, 2025.

[2] S. Akhtar, S. Aftab, O. Ali, M. A. Khan, S. Abbas, and T. M. Ghazal, "RSG-Net: A Deep Learning Framework for Automated Diabetic Retinopathy Grading," *Biomedical Signal Processing and Control*, vol. 92, pp. 105–118, 2025.

[3] F. M. Dejene, T. G. Debelee, F. Schwenker, Y. Ayano, and D. W. Feyisa, "Machine Learning Approaches for Diabetic Retinopathy Screening: A Systematic Review," *Artificial Intelligence in Medicine*, vol. 148, pp. 102–118, 2025.

[4] A. M. Mutawa, K. Al-Sabti, S. Raizada, and S. Sruthi, "Detection of Diabetic Retinopathy Stages Using Deep Learning and Wavelet-Based Feature Extraction," *Expert Systems with Applications*, vol. 245, pp. 121–134, 2024.

[5] R. M. Gaikwad, H. D. Solanki, and N. R. Kharche, "Transfer Learning-Based Convolutional Neural Networks for Diabetic Retinopathy Classification," *Computer Methods and Programs in Biomedicine*, vol. 238, pp. 107–119, 2024.

[6] D. Bhulakshmi and D. S. Rajput, "A Comprehensive Review of Deep Learning Techniques for Diabetic Retinopathy Detection and Classification," *Multimedia Tools and Applications*, vol. 83, no. 14, pp. 41235–41258, 2024.

[7] A. Sebastian, O. Elharrouss, S. Al-Maadeed, and N. Almaadeed, "Deep Learning-Based Diabetic Retinopathy Classification: A Survey of Recent Advances," *IEEE Access*, vol. 11, pp. 86542–86567, 2023.

[8] S. S. Shaikh and S. B. Patil, "Automated Diabetic Retinopathy Detection Using Enhanced Convolutional Neural Networks," *International Journal of Intelligent Systems and Applications*, vol. 15, no. 4, pp. 56–68, 2023.

[9] A. Bajwa, N. Nosheen, K. I. Talpur, and S. Akram, "A Prospective Deep Learning Approach for Early Detection of Diabetic Retinopathy from Fundus Images," *Diagnostics*, vol. 13, no. 18, pp. 2891–2905, 2023.

[10] A. Shamsan, E. M. Senan, and H. S. A. Shatnawi, "Hybrid Deep Learning and Feature Fusion Techniques for Diabetic Retinopathy Severity Classification," *Applied Sciences*, vol. 13, no. 22, pp. 12450–12467, 2023.

[11] M. D. K. Manikandan and K. S. C. Bhuvaneshwari, "Optimized Deep CNN Model for Automatic Diabetic Retinopathy Grading," *Neural Computing and Applications*, vol. 35, no. 19, pp. 14285–14301, 2023.

[12] A. T. Muthu, R. Manikandan, and K. Jeganathan, "CNN-LSTM Hybrid Architecture for Accurate Diabetic Retinopathy Classification," *Biomedical Engineering Letters*, vol. 13, no. 3, pp. 521–533, 2023.