Diabetic Retinopathy Detection with AI Insights

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ABSTRACT

Diabetic Retinopathy (DR) is a major complication of diabetes and a leading cause of vision loss globally. Early detection is crucial, yet manual diagnosis is often slow and inconsistent. This research introduces an automated detection system powered by the ResNet50V2 deep learning model, integrated with clinical guidance and AI insights via Gemini API. Using a Kaggle-sourced dataset of retinal images, the model classifies DR into different stages and provides tailored clinical suggestions. Achieving an accuracy of 65%, this prototype also supports downloadable reports through a web interface built with Flask, HTML, CSS, and Tailwind CSS.

Keyword: - *Diabetic Retinopathy, Deep Learning, ResNet50V2, Gemini API, Retina Image Classification, Flask Web App, AI Insights*

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1. Introduction

Diabetic Retinopathy is a progressive eye disease caused by prolonged high blood sugar levels damaging retinal blood vessels. As it advances through stages—from mild to proliferative—it can lead to permanent blindness if untreated. Manual grading of retinal images is time-consuming and demands expert ophthalmologists.

AI-based methods can streamline early detection, offer consistent diagnosis, and suggest suitable treatments or precautions depending on the DR stage. Our system not only detects DR but also provides AI-generated clinical recommendations using Gemini API.

2. Literature Review

Past studies have applied CNNs for DR detection with varied success. Many use transfer learning with popular pretrained models like Inception or ResNet. Some projects also incorporate Explainable AI (XAI) for visualizing affected regions. However, most systems stop at classification and don't offer personalized guidance. Our project fills this gap by integrating Gemini AI for contextual feedback and a downloadable report feature.

3. Methodology

3.1 Dataset and Preprocessing

The dataset used was collected from Kaggle. It includes retinal fundus images labeled according to the stage of DR. All images were resized to 224x224, normalized, and split into training and testing sets. Gaussian filtering was already applied to reduce noise.

3.2 Model Architecture

We utilized the ResNet50V2 architecture, pretrained on ImageNet. The top layer was customized with dense layers for classification into five DR stages. Dropout layers were included to prevent overfitting.

3.3 Training

The model was trained using the Adam optimizer with a learning rate of 1e-4 and categorical cross-entropy loss. Early stopping and learning rate reduction were used to improve convergence. The final model reached 65% accuracy, reflecting a solid baseline for early-stage research.

4 Block Diagram

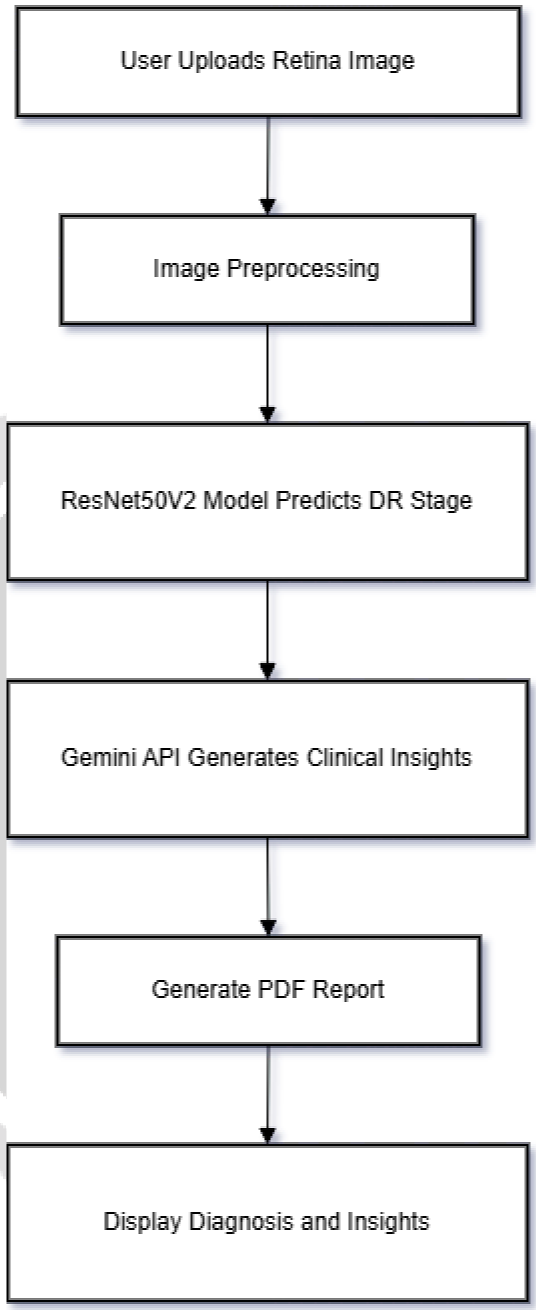

Fig No-1: Block Diagram

The user uploads a retina image, which is then preprocessed for analysis. The ResNet50V2 model predicts the stage of diabetic retinopathy. Using Gemini API, the system provides clinical advice based on the prediction. A PDF report is generated, and the diagnosis with insights is shown on the dashboard. This process helps in quick and easy detection of diabetic retinopathy.

5. Results and Discussion

The model achieved 65% classification accuracy. While not as high as some other medical models, it's acceptable for initial versions and will improve with more data and tuning. The AI insights feature stands out by helping users understand the condition better and guiding next steps.

Table -1: Performance Metrics Table

Total Accuracy	Validation Accuracy	Training Loss	Validation Loss
0.6562	0.6296	0.9911	1.0622

6. Limitations

While the proposed system demonstrates the potential of deep learning and AI in diabetic retinopathy detection, there are several limitations that must be

6.1 Moderate Accuracy

The model currently achieves a training accuracy of 65.62% and validation accuracy of 62.96%. This indicates room for improvement, especially for clinical-grade reliability.

6.2 Limited Dataset

The system was trained on a filtered dataset from Kaggle. A larger and more diverse dataset, including real-world cases with varied image quality, would likely improve performance.

6.3 Lack of Explainability

The model does not currently include explainable AI techniques (e.g., Grad-CAM) to highlight affected regions in retinal images. This can limit trust and usability for medical professionals.

6.4 Web-based Only

The current implementation is a web application and lacks a mobile or offline version, which may limit accessibility in remote or resource-constrained areas.

7. Future Scope

- Improve accuracy by using data augmentation and attention mechanisms.
- Add explainable AI tools (like Grad-CAM) to show affected regions.
- Deploy as a mobile/web app for real-time use in clinics.
- Enable multilingual support for patient-friendly reports.
- Integrate patient history for more personalized insights.

8. Conclusion

This project shows how AI can assist in the early diagnosis of diabetic retinopathy. It combines the strength of ResNet50V2 for image analysis with Gemini API for intelligent suggestions. With further tuning and deployment, the system could be a valuable aid for ophthalmologists and general practitioners in detecting DR early and preventing vision loss.

9. References

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