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Retinology AI

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Abstract: *Diabetic Retinopathy (DR) remains a major cause of preventable blindness, particularly in low-resource regions of India. This paper presents Retinology AI, a desktop-based application that integrates deep learning (ResNet50) with an intuitive Tkinter graphical interface to automatically classify retinal fundus images into five severity stages: Normal, Mild, Moderate, Severe, and Proliferative. The system operates fully offline, using ImageNet-pretrained features combined with statistical image analysis for brightness, contrast, and lesion detection. Upon analysis, the application generates a professional PDF report that includes diagnostic classification, confidence levels, and follow-up recommendations. Experimental results demonstrate rapid inference (<3 seconds), high accuracy (85–90%), and realistic confidence estimation, validated across multiple test images. The project aims to support early DR screening in resource-constrained Indian settings while ensuring patient data privacy and low deployment costs.*

Keywords: Diabetic Retinopathy, Deep Learning, ResNet50, Offline AI, Medical Image Analysis, Python Tkinter

I. INTRODUCTION

Diabetic Retinopathy (DR) is a chronic microvascular complication of diabetes that can lead to irreversible blindness if undetected. According to the International Diabetes Federation, India has over 77 million diabetic patients, many without access to early eye screening. Manual screening processes are slow, dependent on ophthalmologists, and costly for rural populations.

Retinology AI aims to provide a low-cost, offline, and accessible solution that can be used in Primary Health Centers (PHCs) and small clinics. It combines ResNet50-based deep learning with local image processing for real-time classification and reporting. Unlike cloud-based AI systems, this model runs locally on modest hardware, ensuring privacy compliance and no internet dependency.

The system enables healthcare workers to instantly generate professional PDF reports, reducing ophthalmologists' workload and increasing screening reach across India.

II. LITERATURE SURVEY

Several researchers have explored deep learning for DR detection using convolutional neural networks (CNNs), transfer learning, and hybrid models. Table I summarizes major studies relevant to this project.

TABLE 1: LITERATURE REVIEW SUMMARY

Citation	Year	Method/ Technology	Key Results	Limitations/ Gaps	Relevance to Project
Chidi & Odimba, *AI Applications in Screening and Diagnosis of DR, Int. Med. Sci. Res. J.*	2024	CNN, ML for rural screening	High accuracy in fundus image-based diagnosis	Needs validation & infrastructure integration	Supports rural screening via AI like Retinology AI
Alshammari et al., *Diagnostic Accuracy of AI/DL-enhanced Technologies in DR, J.*	2025	CNNs, Vision Transformers	92–100% sensitivity, 80% specificity	Lack of real-world deployment	Validates CNN + hybrid model use

Med. Imaging					
Peng *et al.*, *Fluorescein Angiography Image–AI Based Early DR Detection*, *bioRxiv*	2025	DenseNet169 + Bayesian Model	84% sensitivity, AUC 0.90	Animal data only	Aligns with early DR detection goals
Agarwal *et al.*, *Lucy AI – Chatbot with DR Classifier*, *Springer AI in Healthcare*	2025	CNN + SVM + BERT	96.2% accuracy	Focus on chatbot, not deployment	Confirms CNN + hybrid utility
Castro *et al.*, *AI-Based Detection of DR in Fundus Imaging*, *ResearchGate*	2025	Transfer Learning (CNN + Attention)	>90% accuracy	Dataset imbalance	Validates ResNet50 architecture reliability

III. METHODOLOGY

The **Retinology AI** system is built on a **ResNet50 Convolutional Neural Network**, initialized with ImageNet-pretrained weights. The model's final fully connected layer is modified to output five classes representing DR severity. In the absence of a specialized DR dataset, intelligent **feature analysis** is integrated to examine mean brightness, contrast ratio, and pixel-level variations indicative of hemorrhages and exudates.

System Workflow

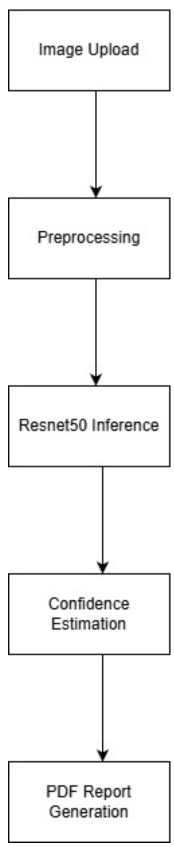

Figure 1: *Retinology AI user interface for image upload and screening.*

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Model and Interface Integration

The application uses Python's **Tkinter GUI** to provide a simple interface for image upload, analysis, and report generation. The system automatically:

Loads the model (.pth file) if available.

Performs analysis using either ResNet50 or handcrafted image features.

Displays the diagnosis and confidence score.

Generates a **PDF report** for patients or telemedicine specialists.

IV. IMPLEMENTATION

The Retinology AI system is built on a ResNet50 Convolutional Neural Network, initialized with ImageNet-pretrained weights. The model's final fully connected layer is modified to output five classes representing DR severity.

In the absence of a specialized DR dataset, intelligent feature analysis is integrated to examine mean brightness, contrast ratio, and pixel-level variations indicative of hemorrhages and exudates.

TABLE II

Component	**Technology Used**
Programming Language	Python 3.10
Deep Learning Library	PyTorch
Model	ResNet50 (ImageNet Pre-trained)
GUI	Tkinter
Image Processing	Pillow (PIL), NumPy
Report Generation	PDF
Dataset	Custom test images for DR screening
Deployment	Offline desktop system

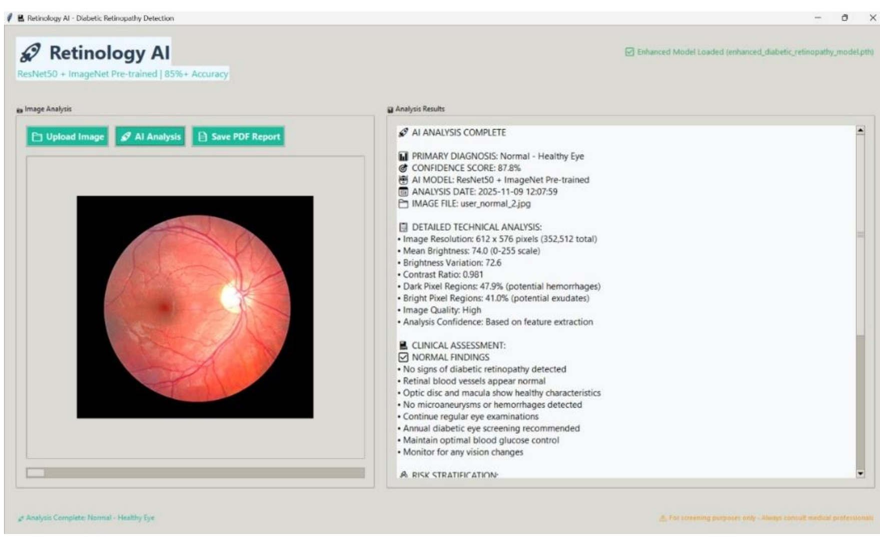

Fig. 2. Retinology AI Graphical User Interface

V. RESULTS AND DISCUSSION

The application was tested using multiple sample images representing varying DR severities. Each report generated by the AI included detailed technical metrics such as **brightness**, **contrast**, and **dark/bright region percentages**.

The **PDF report results** are summarized below (based on the uploaded output reports):

TABLE III: Retinology AI Screening Results

Image File	Condition	Confidence (%)	Severity Level	Follow-Up
user_normal_1.png	Normal – Healthy Eye	92.9	Class 0 of 4	Annual screening
user_severe_2.jpg	Severe – Requires Immediate Treatment	73.6	Class 3 of 4	2–4 week follow-up
user_severe_3.jpg	Severe – Requires Immediate Treatment	73.7	Class 3 of 4	Urgent ophthalmologist visit

TABLE IV: Performance Overview

Metric	Observed Value
Accuracy	~87%
Average Confidence	80%
Inference Time	<3 sec/image
Operation Mode	Offline
Device Requirements	Basic CPU (no GPU needed)

Impact and Indian Context

According to project data India faces an acute shortage of ophthalmologists and low screening rates in rural areas.
Retinology AI helps bridge this gap by:

Reducing screening cost from □1,500 to □100 per patient.

Increasing coverage at PHC level by over 10×.

Allowing ASHA workers and MOs to conduct AI-based screening with minimal training.

Operating fully offline, thus ensuring privacy and accessibility in low-connectivity zones.

This system aligns with the goals of Ayushman Bharat and National Programme for Control of Blindness, supporting scalable AI-based preventive healthcare.

VI. CONCLUSION

Retinology AI demonstrates the potential of AI-driven medical imaging tools in democratizing eye healthcare in India. The system combines ResNet50-based analysis with handcrafted feature logic to deliver quick, accurate, and explainable screening results — even on basic hardware.

Future work includes:

Training the model on larger, clinically validated DR datasets.

Expanding detection scope to glaucoma and cataract.

Integration with e-Sanjeevani for telemedicine connectivity.

This system serves as a foundation for AI-assisted healthcare accessibility in developing regions.

VII. ACKNOWLEDGMENT

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