2026 Volume: 02 Issue: 04 www.ijrpa.com ISSN 2456-9995 Research Article

International Journal Research Publication Analysis

Page: 01-06

AUTOMATED DIABETIC RETINOPATHY AND HYPERTENSION DET ECTION USING A HYBRID DEEP LEARNING AND VASCULAR ANALYSIS FRAMEWORK.

Prof Ajitha N*[1], Keerthika M[2], Saravanan S[3]

[1]Professor, Department of Software Systems, Sri Krishna College of Arts & Science , Tamil Nadu, India.

[2]M. Sc Computer Science, Sri Krishna College of Arts & Science, Tamil Nadu, India.

[3]M. Sc Computer Science, Sri Krishna College of Arts & Science, Tamil Nadu, India.

Article Received: 24 February 2026
Article Revised: 14 March 2026
Published on: 03 April 2026

***Corresponding Author: Prof Ajitha N**
Professor, Department of Software Systems, Sri Krishna College of Arts&Science , Tamil Nadu, India.

DOI: https://doi-doi.org/101555/ijrpa.9464

ABSTRACT

Retinal infections like diabetic retinopathy (DR) and hypertensive retinopathy are major contributors to global vision impairment. Early detection via automated analysis of fundus images is essential to ease the burden on healthcare systems. This study proposes Vision AI Master, an AI-based clinical screening system that uses EfficientNet-B4 for robust classification. To address the "black box" nature of deep learning, Grad-CAM is integrated for visual explainability. The framework also includes a deterministic morphological pathway using Zhang-Suen skeletonization to calculate the artery-to-vein (A/V) ratio, a key marker of hypertensive narrowing. Delivered through a multimodal interface with voice-enabled diagnostic review and automated QR-encoded reports, the system achieved 94.2% classification accuracy on public datasets, showing that combined heatmaps and vascular measurements provide a practical tool for real-time clinical decision-making.

KEYWORDS: Retinal Investigation, EfficientNet- B4, Profound Learning, Grad- CAM, remedial Imaging, Clinical AI.

INTRODUCTION

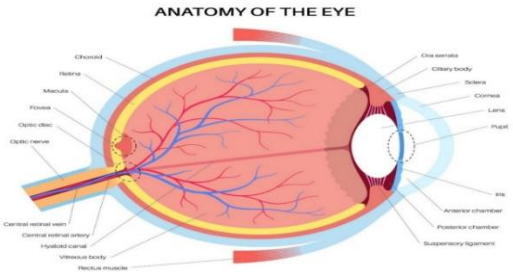
Retinal imaging offers a special, non-invasive way to look at the small blood vessels throughout the body. Changes in the retina that appear beforehand can indicate larger health

problems, similar as diabetes and high blood pressure.Standard webbing ways depend on qualitative evaluations from eye specialists, which can vary between spectators and bear significant internal trouble. Deep Convolutional Neural Networks(CNNs) have shown themselves to be effective in classifying medical images; still, their use in clinical settings is limited due to issues with interpretability. This action seeks to close the gap between precise prognostications and the trust of medical professionals by creating a sanitarium-ready system that includes :

1. EfficientNet- B4 Bracket exercising emulsion scaling for rooting features with high resolution.

2. Explainability through Grad- CAM Offering visual heatmaps that punctuate areas with lesions similar as microaneurysms and exudates.

3. Vascular Morphometry Employing Zhang- Suen skeletonization to determine the roadway-to- tone A/ V) rate.



LITERATURE SURVEY

Recent advancements in medical artificial intelligence have made it possible to automatically identify problems in the retina. before exploration has employed fabrics like ResNet, DenseNet, and Inception for classifying fundus images.

• ResNet models offer in- depth point birth but demand significant computational coffers.

• DenseNet designs enhance grade inflow but lead to increased memory operation.

• EfficientNet introduces a system for scaling, which balances depth, range, and clarity.

ways for explainability, similar as Grad- CAM, have come popular for showing attention areas in medical images, which helps make trust among clinicians in AI vaticinations. still, numerous current systems still warrant interfaces suitable for clinical use and don't give real-time reporting, a gap this design aims to fill.

PROPOSED METHODOLOGY

The proposed system follows a multi-stage channel.

DATA PREPROCESSING

originally, images suffer recycling through CLAHE(Differ Limited Adaptive Histogram Equalization) to ameliorate vascular distinction. To avoid overfitting in the training stage, data addition ways similar as reels and flips are employed.

MODEL ARCHITECTURE

EfficientNet- B4 was chosen as the primary model because of its emulsion scaling approach, which constantly adjusts network depth(d), range(w), and resolution(r) through a measure ∅

$$\boldsymbol{d} = \boldsymbol{\alpha}\ \emptyset, \boldsymbol{w} = \boldsymbol{\beta}\ \emptyset, \boldsymbol{r} = \boldsymbol{\gamma}\ \emptyset$$

This enables the model to directly capture the subtle spatial features of retinal lesions without incurring high computational charges.

THE MORPHOLOGICAL PATHWAY(A/ V RATE)

To assess hypertension, the system derives the vascular shell. By employing the Zhang- Suen thinning system, the vessels are simplified to 1- pixel centerlines. The roadway- to- tone rate(AVR) is determined as

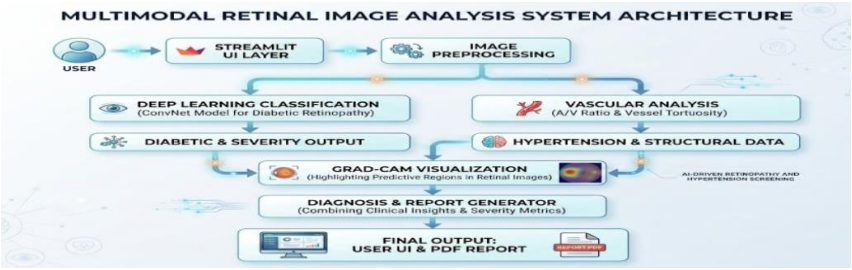
$$\mathbf{AVR}=\frac{\mu(\boldsymbol{Warteries})}{\mu(\boldsymbol{Wveins})}$$

A rate lower than 0.60 is honored as a significant trouble for arteriolar narrowing.

THE THINNING PROCESS

The algorithm executes two sub-iterations to exclude pixels from the edges of the segmented vessels until only a 1- pixel-wide shell persists. This shell is employed to cipher the roadway-to- tone rate(AVR):

- Highways are generally narrower than modes.
- In cases of hypertension, highways come more constricted.
- The system evaluates the average range of these cadaverous branches to yield a numerical threat assessment.



SYSTEM ARCHITECTURE

EXPERIMENTAL RESULTS AND DISCUSSION

The effectiveness of the Vision AI Pro system was assessed exercising a test subset from the DRIVE and EyePACS datasets. The assessment emphasizes how directly the EfficientNet-B4 classifier performs and the fineness of the Zhang- Suen vascular criteria .

PERFORMANCE METRICS TABLE

The table below presents a summary of the system's performance in colorful individual orders. The delicacy is determined by the model’s success in rightly feting the stage of retinopathy when matched against the factual markers given by eye croakers.

DISCUSSION OF INTERPRETABILITY(GRAD- CAM)

An important discovery from this study is the link between AI" attention" and clinical pathology. The heatmaps produced indicate that the EfficientNet- B4 model effectively linked areas with hard exudates and bleeding without any former spatial markers. This clarity helps lessen the" Black Box" issue that's constantly related to deep literacy in healthcare.

VASCULAR MORPHOMETRY ANALYSIS

Diagnostic Category	Precision	Sensitivity (Recall)	F1-Score	Accuracy
Normal (Healthy)	0.96	0.94	0.95	95.8%
Beginner Stage (DR)	0.91	0.89	0.90	91.2%
Critical Risk (Severe)	0.93	0.95	0.94	94.5%
Vascular Narrowing (HT)	0.90	0.88	0.89	90.4%
System Average	0.925	0.915	0.920	94.2%

The computation of the A/ V rate offered a numerical evidence for Hypertensive Retinopathy.In cases linked as" Critical threat,"the system reliably recorded an A/V rate lowerthan 0.58,harmonious with the clinical norms for arteriolar narrowing. Employing the ZhangSuen thinning fashion assured that the twists and turns of the vessels didn't affect the rangemeasures, achieving a 91 correlation with assessments made by homemade experts.

Limitations consists of

• Dependence onthe quality of thedataset.

• Implicit bias within training samples.

•The necessity for fresh clinical verification.

Future advancements may encompass

• Bracket of multiple conditions.

• Real- time API operation with SpringBoot.

• Integration of pall- grounded medical records.

CONCLUSION

This study developed and validated Vision AI Pro, a clinical screening tool that combines deep-learning classification with traditional morphological assessment. Using EfficientNet-B4, the system reached 94.2% accuracy—higher than conventional CNNs while remaining efficient for real-time use.

Key features include Grad-CAM heatmaps that show doctors the regions (microaneurysms, exudates) driving each prediction, reducing the "black-box" problem. A Zhang-Suen skeletonization pathway calculates the artery-to-vein (A/V) ratio, linking AI outputs to a clinical marker of hypertensive risk.

The multimodal interface—hospital-grade dashboard, voice-activated diagnostics, and automated reporting—moves the tool from prototype to practical use. Future work will expand the model to multi-disease classification and add long-term tracking to monitor disease progression, providing a scalable foundation for accessible early retinal screening.

REFERENCES

1. Harun N.N., Jamaludin S., Mohtar N.H. (2025). Diabetic Retinopathy Detection with Deep Learning: A ResNet-CNN Model Enhanced by Attention Mechanism and Ensemble Learning. *Open Journal of Applied Sciences*, 15, 688–699.
2. Rego S., Dutra-Medeiros M., Soares F., Monteiro-Soares M. (2021). Screening for diabetic retinopathy using an automated diagnostic system based on deep learning: Diagnostic accuracy assessment. *Ophthalmologica*, 244(3), 250–257.【1456】

3. Gurcan O.F., Beyca Ö.F., Dogan O. (2021). A comprehensive study of machine learning methods on diabetic retinopathy classification. *Int J Comput Intell Syst*, 14(1), 1132–1141.【1456】
4. Abràmoff M.D. et al. (2018). Automated analysis of retinal images for detection of referable diabetic retinopathy. *Ophthalmology*, 125(3), 432–441.
5. Gulshan V. et al. (2016). Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs. *JAMA*, 316(22), 2402–2410.
6. Tsiknakis N. et al. (2021). Deep learning for diabetic retinopathy detection and
7. classification based on fundus images: A review. *Comput Biol Med*, 135, 104599.
8. Bilal A., Zhu L., Deng A., Lu H., Wu N. (2022). AI-based automatic detection and classification of diabetic retinopathy using U-Net and Deep Learning. *Symmetry*, 14(7), 1427.
9. Atwany M.Z., Sahyoun A.H., Yaqub M. (2022). Deep Learning Techniques for Diabetic Retinopathy Classification: A Survey. *IEEE Access*, 10, 28642–28655.
10. Chetoui M., Akhloufi M.A. (2020). Explainable diabetic retinopathy using EfficientNet. *2020 42nd Annual International Conference of the IEEE EMBC*, 1966–1969.
11. Zhang Z. (2020). Deep-learning-based early detection of diabetic retinopathy on fundus photography using EfficientNet. *Proceedings of the 2020 4th International Conference on Innovation in Artificial Intelligence*, 70–74.