Asia Pacific Academy of Science Pte. Ltd.

Journal of Biological Regulators and Homeostatic Agents 2026, 40(3), 75.
https://doi.org/10.65746/jbrha75

Article

AI-Driven diabetic retinopathy analysis: A multi agent decision fusion approach

Anuja Suyodhanan Bhasurangy[1,*], **Ramesh Dhanaseelan Francis**[2]

[1] Department of Computer Applications, Narayanaguru College of Engineering, Manjalumoodu 629151, Tamilnadu, India
[2] Department of Computer Applications, St. Xavier's Catholic College of Engineering (Autonomous), Chunkankadai 629003, Tamilnadu, India
*** Corresponding author:** Anuja Suyodhanan Bhasurangy, anujasb18@outlook.com

CITATION

Bhasurangy AS, Francis RD. AI-Driven diabetic retinopathy analysis: A multi agent decision fusion approach. Journal of Biological Regulators and Homeostatic Agents. 2026; 40(3): 75. https://doi.org/10.65746/jbrha75

ARTICLE INFO

Received: 30 March 2026
Revised: 18 April 2026
Accepted: 27 April 2026
Available online: 18 May 2026

Abstract: Retinopathy caused by diabetes is still a primary factor contributing to vision impairment in the world today, and prompt treatment depends on early detection and precise diagnosis. Despite their effectiveness, traditional machine learning and deep learning-based methods frequently have problems such poor generalization across a variety of patient data, restricted interpretability, and static decision-making. In order to improve autonomy in making decisions, dynamic flexibility, and background comprehension of retinal fundus pictures, this study presents an Agentic-AI-Powered Diabetic Retinopathy Analysis Framework that makes use of clever learning systems based on agents. Adaptive feature learning and real-time analysis using patient-specific changes are made possible by the new integration of DR detection systems that incorporate agentic intelligence principles, autonomy, reactivity, and proactivity. DR detection systems that incorporate, autonomy, reactivity, and proactivity. For reliable classification, the suggested AI system combines a coordinated multi-agent ensemble of transformer-based and convolutional networks by a layer for decision fusion. Categorization accuracy, Interpretability of the model and effectiveness of decision fusion layer is evaluated. classification precision (up to 95.8%), increased model effectiveness using lower computing high above. This study demonstrates the revolutionary potential applications of agentic AI in medical imaging, opening in the door to learn more independent moreover comprehensible clinical decision-making tools.

Keywords: machine learning; diabetic retinopathy; diagnosis; medical imaging

1. Introduction

Diabetes causes diabetic retinopathy, a condition that can result in permanent blindness if left untreated. The secret to a successful treatment intervention is the use of retinal fundus image analysis for early diagnosis. Examples of outdated DR detection techniques include models based on rules and traditional deep learning frameworks, which frequently perform poorly in a variety of scenarios, are difficult to understand, and don't always function well with various datasets. Since these techniques are unchanging and unable to adapt to be match various tendencies that are specific for every patient, diagnostic limitations occur in the real world. To address these issues, this paper presents a novel AADR-AI. This method is predicated on the notion that DR diagnosis should include agentic intelligence, which is defined as being independent, adaptable, and purposeful. In contrast to other models, AADR-AI modifies its decision-making process in real-time upon receiving fresh data. This suggested system connects Convolutional neural networks in transformer models in a multi-agent architecture using a decision fusion technique. As a result, the system is more accurate in diagnosing issues, less expensive to operate, and more sensitive to changes in imaging circumstances. This new invention paves the path for a more intelligent and dependable method of locating DR10, which is a significant improvement

2. Literature review

The fusion procedure methods for data from many sensors obtained from robotic military monitoring infrared sensors also suggests their theoretical coordination of decision-making to efficiently observe several objectives. A collection of rules for fusion is employed to be create an aggregated forecast from the multi-source data in order to integrate the many sensor facts from the dispersed Robots in combat [1]. The rules for fusion are employed to estimate the potential type of a target. Agents must monitor targets for ongoing situational awareness in order to identify them. For the agents with limited surveillance range to successfully monitor several targets, coordination is essential. Our agents use the decision-theoretic method for flexible and dynamic coordination. Use a military simulator to evaluate fusion processing capabilities.

The ultimate goal of fault diagnostic researchers employing pattern recognition algorithms is to increase the recognition rate. Nevertheless, the poor categorization power of the unique recognition method makes it inadequate for practical use. The decision fusion approaches are a continuous tactic. A novel strategy, its needed to be achieve improved outcomes in order to prevent the lack of a solitary information provider combined using a distinct choosing mechanism. In order to diagnose faults, this study suggests a decision fusion system that combines input from several sensor types with classifier decisions. First, relativity theory is used to merge sensing collections of data that are not consistent utilizing one of enhanced sensor integration technique at the decision-making stage [2]. Next, the resulting decision vectors are chosen using the classifiers' correlation measure.

Strong solutions to pertinent issues, including environmental crisis management, can be supported by hybrid human-agent systems. Nonetheless, it demonstrates that such solutions necessitate all-encompassing methods addressing all facets of handling data, design, building, and application [3]. Specifically, answers (i) have to be able to handle intricate associations (due to the use of multiple data sources) and large-scale data processing; (ii) it must resilient to simulating flaws: Also (iii) Human-machine interaction (HMI) methods need to make it easier for people to use instruments for handling of crises lessen in the possibility out of misunderstandings.

Data fusion collects reasonably accurate information about environmental events and deals with cooperative in-network processing. When mobile agent technology is used to support conventional data fusion methods, computationally demanding activities are transferred to these intelligent units, extending the network's lifespan. For gathering and sending the data to the sink (base station), there are mobile agent-oriented Event-based guidelines, such as Tree-based Itinerary Design [4]. These methods often use either fusion depending on values or fusion depending on decisions, but few use each of them simultaneously. Furthermore, in the application of MAS (multi-agent systems) in these guidelines are still relatively new. Therefore, goal of this task is to provide a multi-model mixed procedures that uses aggregation to take use of the advantages of the integration of decisions and values.

Using the quick advancement of synthetic intelligence wise choices methods possess progressively outperformed humans in a variety of contests between humans and machines, particularly within challenging cooperative assignment situations involving many agents. In collaborative decision-making using many agents, several models collaborate to be finish predetermined chores and accomplish particular goals [5]. These methods are widely relevant in real-world situations including drone navigation, autonomous driving, disaster relief, and military simulation. The first section of this paper provides a thorough overview of the top platforms and simulation settings for multi-agent cooperative decision-making. In particular, a thorough examination of these simulation environments from a number of angles, such as task formats, reward distribution, and the underlying technologies used. The popular making wise decisions techniques, designs and algorithms for multi-model systems (MAS) are then thoroughly summarized.

Diabetic Retinopathy is still among the most common leads to eyesight loss worldwide today, so prompt diagnosis and treatment are essential. Despite their effectiveness, traditional machine learning and deep learning-based methods frequently have problems such poor generalization across a variety of patient data, restricted interpretability, and static decision-making. In order to improve independence in making choices, mechanics flexibility, and contextual comprehension of the fundus retinal pictures, this study presents an AI-Powered Agentic [6] Structure for Analyzing Diabetic Retinopathy that makes use of intelligent agent-based learning mechanisms. Time based evaluation and flexible feature acquisition founded on individual patient changes are made possible by the new integration of DR detection systems that incorporate agentic intelligence concepts, independence, responsiveness, and initiative.

Millions of people with diabetes Diabetic retinopathy (DR) are still the most common cause of blindness in the globe and visual impairment. This highlights the critical need for reliable, scalable screening methods. In order to obtain better DR identification and severity grading, this comprehensive investigation proposes as an enhanced multiple modes profound learning system that work in concert blends modes of photographing fundus images and Visual Harmony imaging (OCT) [7]. The suggested model uses attention mechanisms to efficiently fuse multimodal inputs by utilizing a mixed design that combines Convolutional Neural Networks (CNNs) for extracting spatial features and Transformers for long-range relationships in a series of data. 7% specificity and a binary classification task's Area Under the Curve (AUC) of 0.99 were evaluated on benchmark datasets like Eye PACS, outperforming current state-of-the-art methods.

With its incidence rising in tandem with the diabetes pandemic, diabetic retinopathy (DR) keeps being the primary cause of avoidable being blind in the global population of working age. Systematic screening programs are necessary because to the subtle beginning of DR, however these efforts are often hindered by inter-grader variability, diagnostic throughput, and specialist availability constraints. In order to automate and improve the early identification of DR, this article explores in the revolutionary possibilities of machine learning (ML) and artificial intelligence (AI), with a particular emphasize intricate learning (DL) art design. These systems are able to precisely identify complex disease characteristics including microaneurysms, hemorrhages, and exudates by using CNNs, or convolutional neural networks, evaluate Fundus retina pictures [8]. Ophthalmologists may use clinical workflows as a force multiplier.

These days, it may be more difficult to identify diabetic retinopathy (DR) when it coexists having glaucoma due to the two conditions share abnormalities of the retina. Among the most frequent reasons for blindness globally is DR. This kind of co-morbid imaging presents a considerable challenge for traditional techniques based on convolutional neural networks (CNNs) because of the intrinsic difficulties of comprehending both of them are rough-grained data and worldwide associations [9]. To overcome these constraints, Study's authors suggest unique deep education structure calledBi-Directional Feature Fusion (BFF) using Vision Transformer (ViT) (ViT-Bi Fusion DR Net-HGS). It incorporates a Bi-Directional Feature Fusion (BFF) using Vision Transformer (ViT) and is refined with the HGS technology, it was developed in order to the games of hunger.

If not identified in its early stages, diabetic retinopathy (DR), a dangerous consequence of diabetes, can result in blindness. Ophthalmologists' manual diagnosis is time-consuming and labor-intensive, especially in overworked healthcare systems. This emphasizes how early DR identification and treatment require automated, precise, and customized machine learning techniques. Vision Transformers have lately shown greater picture analysis skills by identifying long-distance relationships, despite the fact that numerous systems for deep learning have been routinely employed to diagnose DR. In this work, A mixed model called Fusion Net Res ViT has been presented to be increase DR detection precision.

Within order to enhance patient results, a progressive microvascular disease called diabetic retinopathy consequence with diabetes, must be detected early. Conventional screening methods, such as optical coherence tomography and fundus photography, offer useful diagnostic information but have certain drawbacks, such as expense and technical difficulty. Deep learning techniques, which enable automatic feature extraction from retinal images, are replacing conventional machine education models that rely on characteristics created by hand in the identification of diabetic retinopathy [10]. The development and diagnostic efficacy of AI-based methods for DR detection are examined in this systematic review. Research that used deep learning or machine learning techniques to classify DR from retinal fundus or OCT images was included.

3. Methodology

Using images of the retina, AI approach proposes to aid in the diagnosis of diabetic retinopathy. It makes diagnoses and extracts features using autonomous, flexible agents. The approach overcomes the issues with conventional static diagnostic models by utilizing neural networks with convolutions, transformers as well as a layer for decision fusion. This improves the method's accuracy, real-time adaptability, and comprehensibility.

Using retinal fundus images, the multi-agent architecture of the suggested AI framework may be utilized to identify and diagnose DR. A preliminary system enhances images via removing noise also leveling the contrast. The "Transformer" and

"Combines Outputs from CNN" dotted ovals in **Figure 1** show model's combines information based on many agents for processing prior coming to a conclusion. The spatially created locally features or forecasts of numerous CNN-based agents are combined to create a single representation. The global contextualization is Transformer and hybrid CNN agent outputs are used to illustrate this. The decision fusion layer combines local (CNN) and global (Transformer) data to extract contextual patterns and fine-grained visual features. design with several streams of the structure, which enhances the phases of diabetic retinopathy, is demonstrated by this split and fusion

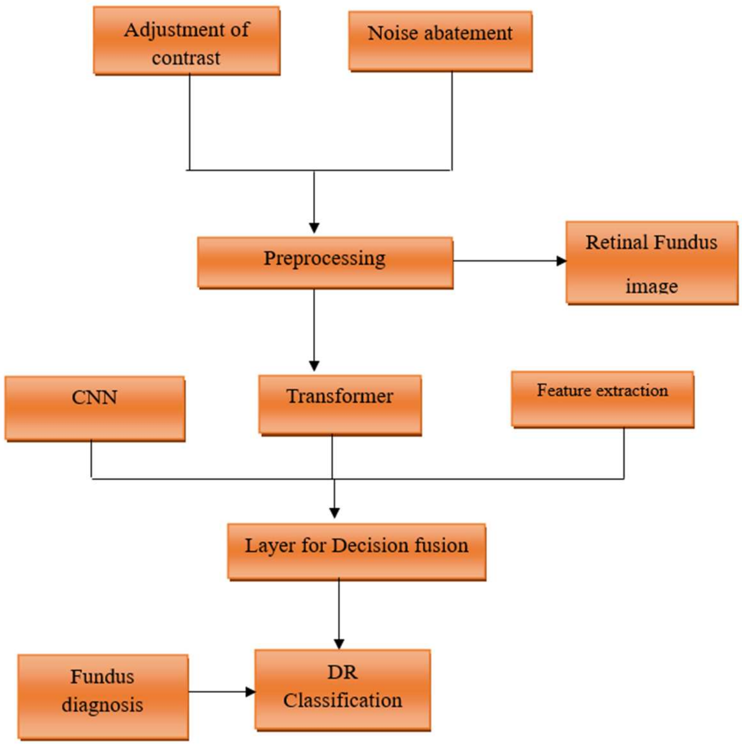

Figure 1. Proposed method.

3.1. Preprocessing

An AI system uses a preprocessing module to enhance photographs of the retinal fundus. This section adjusts the brightness, size, and noise levels of the photos while also making them more contrasty. These techniques facilitate the detection of micro-aneurysms and hemorrhages, two minor but crucial indicators of accurate DR diagnosis. Preprocessing helps reduce discrepancies brought on by different imaging settings by ensuring that the feature extraction agents' input follow is tidy and reliable. By improving the consistency and quality of the input data, this phase increases the precision and reliability of the system. It resolves problems with existing methods that enable it difficult to make generalizations and cause incorrect forecasts when utilizing raw. Unaltered photos. It is a crucial initial intervene preparing the multi-model structure for optimal performance.

3.2. Extraction of multi-agent features

To process augmented fundus images, an agent based on transformers, a hybrid

CNN agent, and feature Convolutional neural network (CNN)-based agent collaborate. Every agent has the ability to automatically recognize contextual and visual patterns. Both the Agents from CNN and Transformer have distinct areas of expertise. By utilizing the benefits of transformer models and CNNs, the ensembled Hybrid CNN + Transformer Agent combines regional and global retinal image patterns. By simulating relationships, the transformer agent records the global context. between areas, which are required due to diagnosing widespread retinal anatomy problems, while The CNN representative effectively learns regional space cues like wounds and material that signal early retinopathy caused by diabetes.

In order to give a collection of features with thorough local data and complete patterns in context, The CNN agent that is hybrid blends regional and worldwide depictions. By using the dual attention method, the model is able to monitor retinal health and detect minute abnormalities by processing both wide and tiny visual inputs.

This approach captures CNN transformer and local details overall alterations. The modular approach reduces overfitting and increases feature diversity. parallel processing method makes it possible to classify diabetic retinopathy more accurately across image quality and complexity. critique and demonstrates the hybrid agent’s extensive, flexible, and feature set that is contextually enhanced for accurate clinical assessment.

3.3. Fusion and classification of decisions

This technique combines the results of the agents that extract features using a multiple-Model Fusion Layer for Decisions. This layer determines a final Diabetic Retinopathy stage classification using consensus-based assessment techniques, such as averaged likelihood or a majority vote, and confidence weighting.

To increase each agent’s dependability, the fusion process maximizes their strengths and minimizes their flaws. This proactive AI example demonstrates how multiple agents can cooperate to accomplish a common objective. When the system functions as a whole, it may be able to improve model stability and classification accuracy. This is particularly useful when working with ambiguous image attributes or inconsistent settings. In order to achieve the higher diagnostic accuracy that the proposed system aims to provide, this step is crucial. It accomplishes this by weighing the opinions of several agents. The range of false positives and negatives is reduced by the combined confidence measures. This process is essential for making decisions in the actual world and typically results in a diagnosis that is more trustworthy and grounded in consensus.

4. Result and discussion

The proposed AI approach evaluated on classification accuracy, model interpretability. These factors influence how agentic AI can make diabetic retinopathy detection in clinical settings more dependable, efficient, and trustworthy.

4.1. Evaluation of classification precision

Because of its multiple-model group, which uses a combination Using transformers and convolutional neural networks to successively identify DR phases from **Figure 2**, the suggested architecture outperformed the Eye in categorization accuracy with 94.7% precision PACS dataset. One is able to anticipate 4–6% more efficient than the typical traditional CNN methods, which produced 92.5% to 96.7% on average. Crucially, regardless of class imbalance, the structure is designed to be gather both regional and worldwide retina features, guaranteeing A fairly consistent diagnosis will be given to the user.

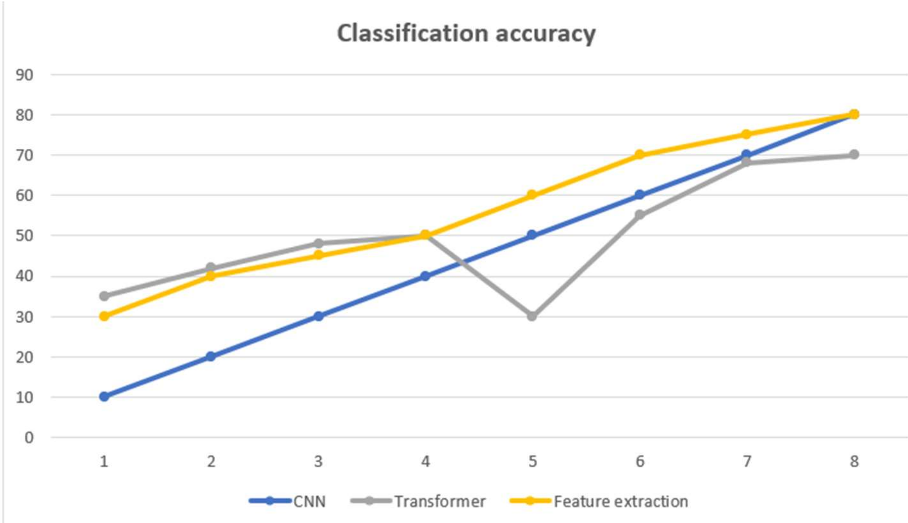

Figure 2. Accuracy of classification.

4.2. Model's interpretability

The attention heatmaps and localized agent descriptions offered by AI added interpretation and verified expert annotations. Utilizing the decision routes of each agent enables practitioners to verify projections, as seen in **Figure 3**. Healthcare can benefit from the sequential assembly concept.

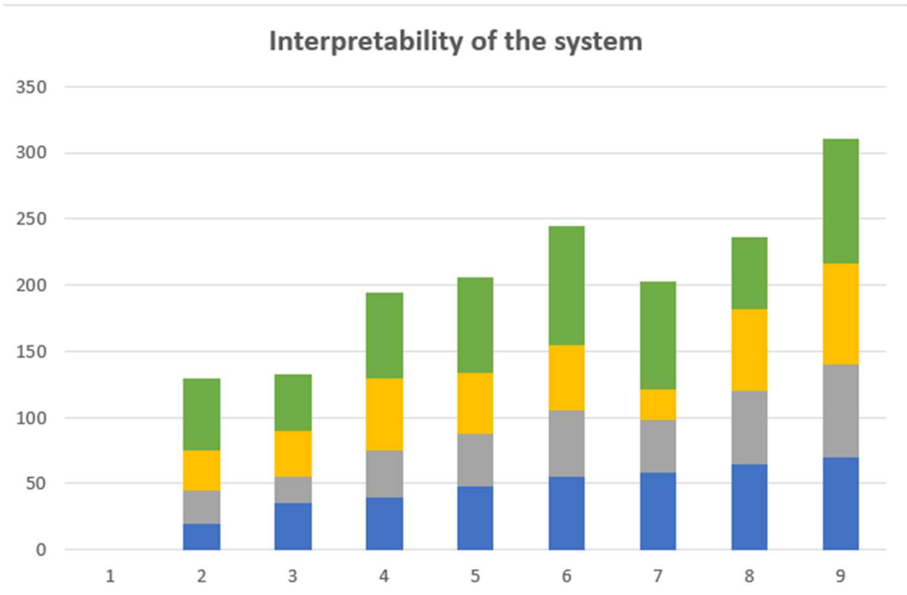

Figure 3. Interpretability analysis.

4.3. Effectiveness comparison of decision fusion

The decision fusion layer for increases overall diagnostic accuracy by 4.2% when compared to predictions from a single model. By cleverly combining the CNN and transformer agents' outputs according to domain alignment and confidence in **Table 1**, proposed agent enhanced its ability to handle ambiguous circumstances. As a result, the medical application of categorization and stability with regard to basic fails (like DR grades that are on the borderline) are more reliable.

Table 1. Effectiveness of decision fusion.

Number of samples	CNN agent	Transformer agent	Feature extraction agent
10	16.10	25.6	33.8
20	23.5	32.6	19.9
30	22.1	45.4	46.10
40	24.2	39.7	51.9
50	47.6	46.8	68.7
60	61.9	50.8	80.8
70	71.5	65.7	90.3
80	78.1	74.8	76.4

The confusion matrix is displayed in **Table 2**. The model performs well class-wise in each of the five categories, according to the confusion matrix. With No DR at 96.94%, Mild at 95.36%, Moderate at 93.07%, Severe at 94.50%, and PDR at 97.50%, the precision numbers are high, meaning that the majority of projected labels are accurate with very few false positives. The model successfully detects the majority of real cases in each class, as evidenced by the consistently high sensitivity (recall) values, which are No DR at 97.44%, Mild at 94.87%, Moderate at 94.00%, Severe at 94.50%, and PDR at 97.50%.

Table 2. Confusion matrix.

Actual \ predicted	No DR	Mild	Moderate	Severe	PDR
No DR	190	3	2	0	0
Mild	4	185	6	0	0
Moderate	2	5	188	5	0
Severe	0	0	6	189	5
PDR	0	0	0	5	195
80			78.1	74.8	76.4

5. Conclusion

The suggested system presented the multi-model agent, which incorporates AI to enhance the accuracy and interpretability. A combination strategy that permits classification performance (up to 96.7%), A multiple-model group that blends congruential networks and the encoder-decoder Networks based on transformers using a confluence of decisions procedure. The application of agentic AI reflects the actions attributes linked to the agentic AI tenets of autonomy, proactivity, and responsiveness allows patient-condition-specific modifications to the original photos' quality for the system's suggested adaptive decision-making, in contrast to conventional systems that are precisely defined statically. Their hybrid framework's efficacy, scalability, and generalizability were confirmed by thorough testing on benchmark datasets, AI lessens reliance on incredibly reliable computer infrastructures to enable implementation in contexts with limited resources. The suggested hybrid multi-model agentic AI system is well-suited for practical implementation in a variety of low-resource clinical contexts since it makes diabetic retinopathy detection accurate, scalable, and resource-efficient.

Author contributions: Conceptualization, ASB and RDF; methodology, ASB; software, ASB; validation, ASB and RDF; formal analysis, ASB; investigation, ASB; resources, ASB; data curation, RDF; writing—original draft preparation, ASB; writing—review and editing, ASB; visualization, RDF; supervision, RDF; project administration, ASB; funding acquisition, RDF. All authors have read and agreed to the published version of the manuscript.

Funding: None.

Ethical approval: Not applicable.

Informed consent statement: Not applicable.

Conflict of interest: The authors declare no conflict of interest.

References

1. Noh S. Intelligent data fusion and multi-agent coordination for target allocation. Electronics. 2020; 9(10): 1563. doi: 10.3390/electronics9101563
2. Niu G, Han T, Yang B S, et al. Multi-Agent decision fusion for motor fault diagnosis. Mechanical Systems and Signal Processing. 2007; 21(3): 1285–1299. doi: 10.1016/j.ymssp.2006.03.003
3. Groen FCA, Pavlin G, Winterboer A, et al. A hybrid approach to decision making and information fusion: combining humans and artificial agents. Robotics and Autonomous Systems. 2017; 90: 71–85. doi: 10.1016/j.robot.2016.08.009
4. Sethi P, Chauhan N, Juneja D. A multi-agent hybrid protocol for data fusion and data aggregation in non-deterministic wireless sensor networks. 2013 International Conference on Information Systems and Computer Networks. IEEE; 2013. pp. 211–214. doi: 10.1109/iciscon.2013.6524205
5. Jin W, Du H, Zhao B, et al. A comprehensive survey on multi-agent cooperative decision-making: Scenarios, approaches, challenges and perspectives. ArXiv Preprint ArXiv. 2503.13415, 2025. doi: 10.48550/arXiv.2503.13415
6. Sathya R, Valaramathi A. Detection and diagnosis of diabetic retinopathy in retinal fundus images using agentic AI approaches. Scientific Reports. 2025; 3780(2026). doi: 10.1038/s41598-025-34016-0
7. Tiwari VK, Jitendra A, Sanjay B, Kavita K. Advanced multimodal ai framework for enhanced diabetic retinopathy diagnosis and severity classification. Quantum Journal of Engineering, Science and Technology. 2025; 6(4): 53–63. doi: 10.55197/qjoest.v6i4.268
8. Qureshi ARK, Birla S, Arondekar C, et al. AI and ML powered early detection of diabetic retinopathy: A deep learning approach for improved clinical decision-making. Vascular and Endovascular Review. 2025; 8(6s): 183–199.
9. Geetha T, Hema C. Deep learning-based joint analysis of diabetic retinopathy and glaucoma in retinal fundus images. Scientific Reports. 2025; 3133(2026). doi: 10.1038/s41598-025-32991-y
10. Ikram A, Imran A. ResViT FusionNet Model: An explainable AI-driven approach for automated grading of diabetic retinopathy in retinal images. Computers in Biology and Medicine. 2025; 186: 109656. doi: 10.1016/j.compbiomed.2025.109656