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"Automated Cardiovascular Risk Classification from Retinal Fundus Images using Deep Learning,"

Sanjana G Pujar [1], Sannidhi [2], Swathi [3], Sindhu Sree [4], Dr. Sheela B.P [5], Dr. B. Shreepathi [6]

[1,2,3] Students, Department of Information Science & Engineering

[4] Faculty, Department of Information Science & Engineering

[6] Professor and HOD, Department of Information Science & Engineering

Information Science and Engineering, Rao Bahadur Y Mahabaleswarappa Engineering College, Ballari /Belagavi VTU student, Karnataka, India.

ABSTRACT:

Cardiovascular diseases are one of the major health concerns worldwide, and early assessment of cardiovascular risk plays an important role in supporting timely medical intervention. Traditional cardiovascular risk assessment may require several clinical measurements and professional interpretation. This project, entitled "Automated Cardiovascular Risk Classification from Retinal Fundus Images using Deep Learning," proposes an automated approach for analysing retinal fundus images and classifying cardiovascular risk using deep-learning techniques. Retinal fundus images capture the internal structures of the eye, including the retina and its blood vessels. These visible vascular patterns may provide useful information for cardiovascular risk assessment. The proposed system uses image processing and deep learning to analyse an uploaded retinal fundus image and classify the predicted risk into three categories' Risk.

Introduction:

Cardiovascular diseases (CVDs) are a group of conditions that affect the heart and blood vessels. Early assessment of cardiovascular risk can help healthcare professionals identify individuals who may require further examination or preventive care. Conventional risk assessment considers factors such as age, blood pressure, cholesterol levels, diabetes, smoking history, lifestyle, and family history. A retinal fundus image is a photograph of the back of the eye that shows the retina, optic disc, and retinal blood vessels. Researchers have investigated whether patterns in these blood vessels may provide useful information about systemic health. However, retinal images alone cannot establish a definitive diagnosis of cardiovascular disease, and any risk-classification model requires proper training, testing, and independent validation.

The project, "Auto mated Cardiovascular Risk Classification from Retinal Fundus Images using Deep Learning," proposes an application that processes retinal fundus images using a trained deep-learning model and classifies the predicted cardiovascular risk into three categories: Low Risk, Moderate Risk, and High Risk.

The proposed system also aims to display a prediction score, provide visual explanations using Gradient-weighted Class Activation Mapping (Grad-CAM), and support prediction history and report generation where these features are implemented. The main purpose of this project is to explore how image processing and deep learning can be combined in a healthcare decision-support application. The system is intended for research and educational purposes and is not a replacement for professional medical diagnosis or clinical assessment

Deep learning is a branch of machine learning that uses multilayer neural networks to learn patterns from data. Convolutional Neural Networks (CNNs) are widely used for image analysis because they can identify visual features such as edges, textures, shapes, and complex patterns. Transfer learning adapts a model trained on a large dataset to a specific task. The performance of these techniques depends on the quality of the dataset, model design, and evaluation process.

Convolutional Neural Networks (CNNs) are widely used in medical image analysis because they can automatically learn visual features from images. Transfer learning can also be applied by adapting a model previously trained on a large image dataset to a specific classification task. These techniques provide a foundation for investigating automated cardiovascular risk classification from retinal images.

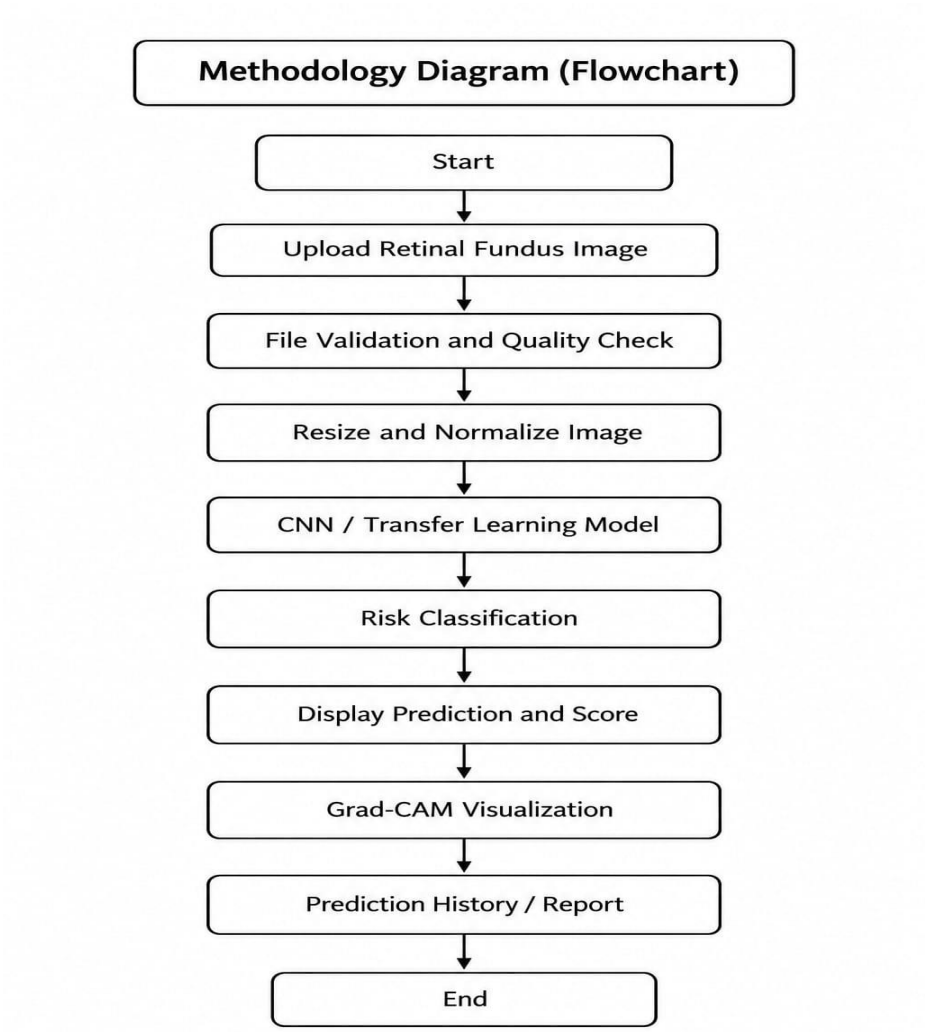
Retinal fundus imaging is a non-invasive technique used to capture images of the retina, including its blood vessels. Research has shown that deep learning models can analyse retinal fundus photographs to predict certain cardiovascular risk factors and related health outcomes. Poplin et al. (2018) demonstrated the potential of deep learning to identify several health-related characteristics from retinal images [1].

However, research findings must be interpreted carefully. A systematic review published in 2024 identified promising developments in retinal-image-based cardiovascular risk prediction but also highlighted the need for stronger external validation and further prospective studies [2]

Based on this research, the present project explores a deep learning-based system intended to classify cardiovascular risk into Low Risk, Moderate Risk, and High-Risk categories. The proposed workflow includes image preprocessing, model inference, prediction display, and visual explanation where implemented. The project focuses on evaluating the feasibility of this approach and does not intend to replace professional medical assessment Beyond these studies, the references listed at the end of this report also provide supporting background: the use of blockchains and smart contracts for trusted record keeping [7], the relationship between land registration, governance and development [8], the suitability of blockchain for trustworthy records [9], blockchain-enabled e-government for land records [10], and the use of blockchain to protect personal data [11].

Methodology:

Figure 1.1: Flowchart of the proposed cardiovascular risk classification system.



- **Diagram Description:** The flowchart illustrates the workflow of the proposed cardiovascular risk classification system. It begins with uploading a retinal fundus image, followed by file validation, image-quality checking, and preprocessing. The processed image is analysed using a deep learning model to predict Low Risk, Moderate Risk, or High Risk. The predicted result and score are then displayed. Grad CAM visualization and prediction history or report generation are included where implemented **Transaction monitoring:** the web interface lets users and authorities view land records, verify ownership history and track transactions securely.
- The flowchart represents the sequence of steps involved in the proposed cardiovascular risk classification system using retinal fundus images. It provides a clear overview of how an input image is processed and how the predicted result is generated.
- The process begins when the user uploads a retinal fundus image. The system checks the image file format, size, resolution, and quality. If the image is invalid, an error message is displayed, and the user is asked to upload another image.
- If the image passes validation, preprocessing techniques such as resizing and normalization are applied to prepare it for analysis. The processed image is then intended to be analysed using a deep learning model, such as a Convolutional Neural Network (CNN) or a transfer-learning model. Based on the model output, the system is designed to classify cardiovascular risk into three categories: Low Risk, Moderate Risk, and High Risk. The predicted category and confidence score are then displayed to the user. Grad-CAM visualization may also be included to explain which image regions influenced the prediction, if implemented. Finally, the model's performance should be evaluated using an independent test dataset and appropriate metrics, including accuracy, precision, recall, and F1-score. Since model training and testing are pending, the workflow represents the proposed methodology rather than a completed experimental result

Results

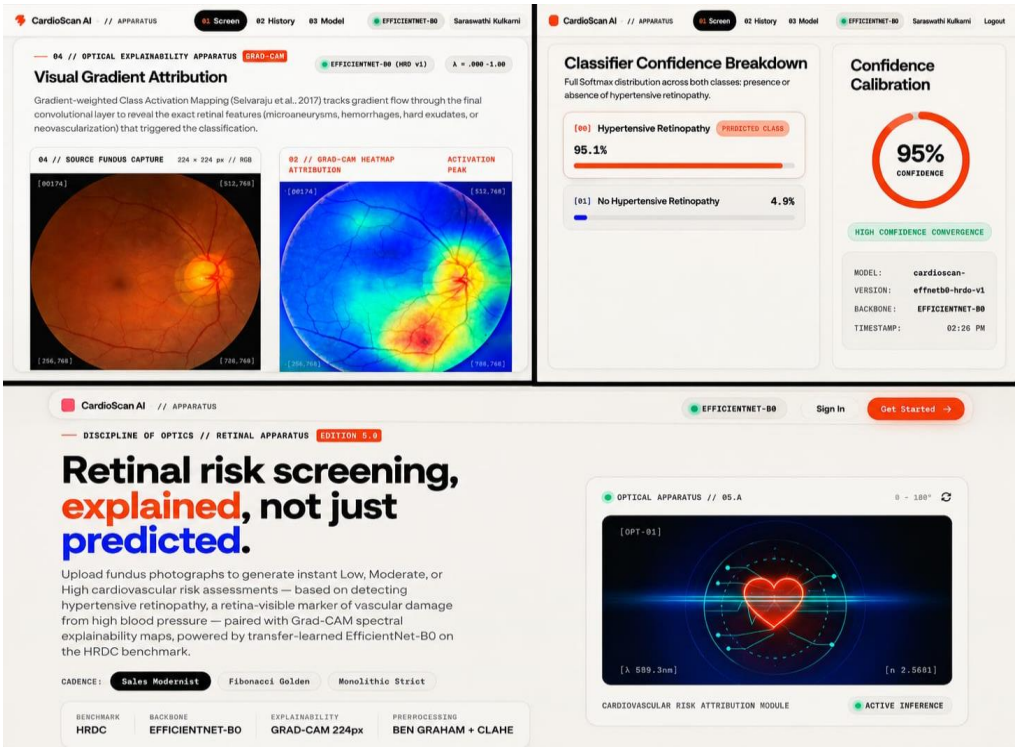
Performance Analysis

Table 5.2 compares the proposed system with the existing manual and centralized approaches on the basis of the features discussed in this report.

Feature	Manual / paper-based	Centralized database	Proposed system
Tamper resistance	Low	Medium (single point of failure)	High (immutable ledger)
Transparency	Low	Limited	High (traceable transactions)
Verification speed	Slow	Moderate	Fast (real-time lookup)
Spatial / boundary validation	Not available	Often absent	Map-based verification
Duplicate registration check	Manual	Limited	Automated by smart contract and map check
Processing time per transaction	Long	Short	Additional blockchain confirmation time

Table 5.2: Qualitative comparison with existing approaches

The proposed system trades a small increase in transaction processing time, caused by blockchain confirmation, for higher security, transparency and automated duplicate detection. Quantitative metrics such as average transaction confirmation time and API response time are to be measured on the final build and added here.



Conclusion

The project, "Automated Cardiovascular Risk Classification from Retinal Fundus Images using Deep Learning," explores the use of image processing and deep learning techniques for classifying cardiovascular risk from retinal fundus images. The proposed system aims to process uploaded images and classify the estimated risk into Low Risk, Moderate Risk, and High-Risk categories.

The project provides a foundation for studying automated image-based risk classification and includes the possibility of displaying prediction scores and visual explanations. The effectiveness of the system depends on proper model training, testing, and validation. The project is intended for research and preliminary risk assessment and cannot replace professional medical evaluation

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