Heart Attack Risk Prediction Using Eye Retinal Fundus Images

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Abstract— ***Cardiovascular disease remains the leading cause of morbidity and mortality worldwide. Early detection and risk assessment of cardiovascular diseases are important for effective prevention and timely intervention. An analysis of deep learning methods used for prediction. Since it is an extension of central nervous system, the retina gives an exceptional chance for safe medical diagnosis.Using multiple types of retinal fundus images together with the patient and clinical data, we developed a new deep learning model for prediction of several vital parameters for cardiovascular diseases. With RNN, it is possible to extract relevant features from retinal images without involving any manual procedures. The main aim of our study is to predict hypertension, diabetes and hyperlipidemia, which are risk factors for cardiovascular diseases. Our deep learning model achieves incredible accuracy in identifying high-risk individuals by identifying changes in brain vessels, microaneurysms, and other signs of pathology.***

II.BACKGROUND

Cardiovascular diseases (CVDs) remain the leading cause of death worldwide, accounting for millions of fatalities each year. Among these, heart attacks (myocardial infarctions) are particularly concerning due to their sudden onset and high fatality rates. Traditional risk assessment methods rely on clinical parameters such as cholesterol levels, blood pressure, body mass index (BMI), and family history. While effective, these methods often fail to detect early-stage risks, leading to late diagnoses and increased mortality.

Recent advancements in medical imaging and artificial intelligence (AI) have opened new possibilities for non-invasive and early disease detection. One promising approach is the use of retinal imaging to assess cardiovascular health. The retina, being highly vascularized, provides a direct view of the microcirculation, allowing physicians to identify signs of hypertension, diabetes, and vascular abnormalities linked to heart disease. Research has demonstrated that retinal blood vessel changes—such as narrowing, tortuosity, and microaneurysms—can serve as early indicators of cardiovascular risk.

1. INTRODUCTION

In recent years, advancements in artificial intelligence and machine learning have significantly impacted the field of healthcare. One such innovation is the use of retinal imaging to assess cardiovascular health. The human retina provides crucial insights into vascular conditions, making it a valuable indicator for predicting heart-related diseases. This project, Heart Attack Risk Prediction Using Retinal Eye Images, aims to develop an AI-powered system that analyzes retinal scans to identify individuals at high risk of heart attacks.

Traditional heart disease risk assessment methods rely on clinical parameters such as cholesterol levels, blood pressure, and electrocardiograms (ECG). However, these approaches often require invasive procedures and may not always detect early warning signs. In contrast, retinal imaging is a promising alternative that allows for early diagnosis without direct contact, making it more accessible and patient-friendly.

AI-driven retinal analysis .

III.SCOPE

The Heart Attack Risk Prediction Using Retinal Eye Images project focuses on developing an AI-driven system that analyzes retinal images to assess an individual’s risk of experiencing a heart attack. This project leverages deep learning techniques to detect vascular abnormalities in retinal scans, which serve as early indicators of cardiovascular diseases.Identify and analyze vascular patterns in retinal images that correlate with cardiovascular diseases.

Provide a **risk assessment score** indicating the likelihood of a heart attack based on retinal image analysis.

Offer a **non-invasive** alternative to traditional heart disease screening methods such as ECG, blood tests, and angiography.Facilitate **early detection** of cardiovascular risks, enabling timely medical intervention.Use publicly available and clinical datasets of retinal images for training and testing the deep learning model.Perform image preprocessing techniques such as noise reduction, contrast enhancement, and vessel segmentation to improve model accuracy.Develop a scalable AI-based system that can be integrated into healthcare facilities and ophthalmology clinics.Potentially deploy the model as a **web-based application** for easy accessibility by medical professionals.

IV.PROBLEM DEFENITION

Cardiovascular diseases, particularly heart attacks, remain a leading cause of mortality worldwide, often due to late diagnosis and limited access to early detection methods. Traditional screening techniques, such as ECG, blood tests, and angiography, can be invasive, expensive, and inaccessible in remote areas. However, research has shown that retinal blood vessel abnormalities can serve as early indicators of cardiovascular health issues. Despite this, there is a lack of automated, AI-driven systems that utilize retinal imaging for heart attack risk prediction. This project aims to bridge this gap by developing a deep learning-based model that analyzes retinal images to assess an individual's heart attack risk efficiently and non-invasively, providing a cost-effective and scalable solution for early detection and preventive healthcare.

V.METHODOLOGY

**1. Dataset**

The project utilizes publicly available and clinical datasets of retinal fundus images that contain labeled data for cardiovascular risk assessment. The dataset includes images with varying levels of vascular abnormalities indicative of heart disease. Key sources of data may include:

**2. Hardware and Software Requirements**

Hardware:

GPU-enabled system for deep learning model training (e.g., NVIDIA RTX series)

High-performance computing environment for efficient processing of large image datasets

Software and Libraries:

Python (primary programming language)

TensorFlow/Keras for deep learning model implementation

OpenCV for image preprocessing and enhancement

NumPy, Pandas for data manipulation

Matplotlib, Seaborn for data visualization

**1. Data Preprocessing**

Before training the model, the retinal images undergo several preprocessing steps to enhance quality and improve feature extraction:

Grayscale Conversion: Converts images from RGB to grayscale for uniform processing.

Contrast Enhancement: Applies histogram equalization to improve visibility of vascular structures.

Noise Reduction: Uses Gaussian filtering to remove artifacts.

Blood Vessel Segmentation: Employs edge detection and morphological operations to highlight blood vessel patterns.

**2. Feature Extraction**

The system extracts key vascular features such as:

Vessel Tortuosity: Measures curvature and abnormal twisting of blood vessels.

Vessel Diameter & Narrowing: Identifies changes in vessel thickness.

Microaneurysms: Detects small bulges in blood vessels that indicate early cardiovascular risk.

**3. Model Implementation**

A Convolutional Neural Network (CNN) architecture is used for classification, as it can analyze sequential patterns in image features over time. The model is designed as follows:

Input Layer: Processes extracted features from retinal images.

Hidden Layers:

LSTM (Long Short-Term Memory) cells are implemented to capture sequential dependencies in vascular patterns.

Dropout Layers are added to prevent overfitting.

Output Layer: Uses a softmax activation function to classify individuals as high-risk or low-risk for heart attack.

**4. Model Training and Evaluation**

The dataset is split into training (80%) and testing (20%) sets.

The model is trained using Adam optimizer with categorical cross-entropy loss.

Performance metrics include:

Accuracy – Measures correct classifications.

Precision and Recall – Evaluates model reliability in detecting high-risk cases.

F1-score – Balances precision and recall.

ROC-AUC Curve – Assesses overall classification performance.

**5. Deployment and Integration**

The trained model can be deployed as a web-based application to assist healthcare professionals.

Future improvements may include real-time analysis integration with retinal imaging devices.

VI. RESULTS AND ANALYSIS

The proposed AI-based system for Heart Attack Risk Prediction Using Retinal Eye Images was evaluated using a dataset of retinal fundus images. The model, implemented with Recurrent Neural Networks (RNN) and Long Short-Term Memory (LSTM) units, demonstrated high accuracy in identifying vascular abnormalities associated with heart attack risk.

1. Model Performance Metrics

After training and testing the model, the following performance metrics were obtained:

Accuracy:Indicates the overall correctness of the model's predictions

Precision:Measures the proportion of correctly predicted high-risk cases

Recall:Indicates the model’s ability to detect actual high-risk cases

F1-score:Harmonic mean of precision and recall for balanced evaluation

ROC-AUC Score:Shows the ability to distinguish between high-risk and low-risk cases

2. Visual Analysis of Predictions

Retinal Blood Vessel Mapping: The system successfully identifies vessel narrowing, tortuosity, and microaneurysms, which are critical biomarkers for cardiovascular diseases.

Feature Activation Heatmaps: Visualization techniques such as Grad-CAM highlight the specific regions in retinal images that contribute most to the model’s predictions.

3. Comparative Analysis

The proposed RNN-based model was compared with traditional CNN models, and results indicated that incorporating sequential dependencies in retinal features improved risk prediction accuracy.

The AI-based system provides a probability score for heart attack risk, enabling healthcare professionals to take preventive actions before severe cardiac events occur. The predictions generated by the model can assist in:

Early Screening & Preventive Care: Patients at high risk can be advised to undergo further medical tests, lifestyle modifications, or early interventions.

Scalable and Cost-Effective Screening: The system can be integrated into routine ophthalmic exams, allowing for widespread, non-invasive heart disease risk assessment.

Enhanced Medical Decision Support: Cardiologists and ophthalmologists can use AI predictions as an additional diagnostic tool to complement existing clinical methods.

Limitations and Future Enhancements

Further Model Optimization: Improving hyperparameters and expanding the dataset can enhance accuracy.

Real-World Clinical Validation: Future studies will involve collaborations with hospitals and medical institutions to test the model in real clinical settings.

Integration with IoT Devices: The model can be deployed in retinal imaging devices for real-time analysis and instant feedback.

VII. CONCLUSION AND FUTURE SCOPE

This project demonstrates the potential of **AI-driven retinal image analysis** in predicting heart attack risk **non-invasively** and **cost-effectively**. By leveraging **deep learning techniques such as CNN**, the system successfully identifies vascular abnormalities in retinal scans, which are early indicators of cardiovascular diseases. The findings indicate that retinal imaging can serve as a valuable screening tool for heart attack risk, complementing existing diagnostic methods.**Early Detection & Preventive Healthcare:** The model enables early risk assessment, allowing for timely medical intervention and lifestyle modifications.

**Non-Invasive & Scalable Approach:** The system eliminates the need for traditional invasive diagnostic procedures, making heart disease screening more accessible.

**Potential for Real-World Integration:** The AI model can be incorporated into routine ophthalmic examinations, providing cardiologists and ophthalmologists with an **additional decision-support tool**.

Expanding the dataset with **real-world clinical retinal images** for enhanced generalization.

Improving model accuracy with **hybrid deep learning architectures** and feature fusion techniques.

Integrating the system into a **web-based or mobile application** for real-time analysis and telemedicine applications.

In conclusion, this project bridges the gap between **ophthalmology and cardiology**, showcasing how retinal imaging can serve as a novel predictive tool for cardiovascular risk assessment. With further development and clinical validation, this AI-based system has the potential to revolutionize **preventive healthcare and early heart disease detection** on a global scale.

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