International Journal of Innovative Research in Engineering
Volume 7, Issue 6 (November - December 2026), PP: 157-160.
https://www.doi.org/10.59256/ijire.20260706018
www.theijire.com
ISSN No: 2582-8746

A Deep Learning Approach for Predicting Heart Disease from Retinal Images

Dr. A. Vijendhar[1], Kinnera Shravani[2], Sambari Madhan Kumar[3], Uppari Shiva Kumar[4], Debbati Sharanya[5]

[1] *Associate Professor, Department of Computer Science and Engineering (AI&ML), CMR Engineering College, Hyderabad, Telangana, India.*

[2,3,4,5] *Department of Computer Science and Engineering (AI&ML), CMR Engineering College, Hyderabad, Telangana, India.*

How to cite this paper:
Dr. A. Vijendhar[1], Kinnera Shravani[2], Sambari Madhan Kumar[3], Uppari Shiva Kumar[4], Debbati Sharanya[5], "A Deep Learning Approach for Predicting Heart Disease from Retinal Images", IJIRE-V7I6-157-160.

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Abstract: *Heart disease is a major health issue around the world. Identifying it early can lead to better treatment and prevention. Traditional diagnostic methods are often expensive and take time. Recent studies show that retinal fundus images can provide valuable information about blood vessels, which relate closely to heart health. This paper presents a deep learning method to predict heart disease risk using retinal images and important patient health details. A Convolutional Neural Network (CNN) is used to automatically extract key vascular and structural features from the retina.*

Key Words: *Retinal Fundus Imaging, Heart Disease Risk Prediction, Deep Learning, Convolutional Neural Network, Clinical Data Fusion, Cardiovascular Screening.*

I.INTRODUCTION

Cardiovascular disease remains a significant global health issue. This makes early risk identification crucial for prevention and treatment. Traditional diagnostic methods, like ECG, angiography, and blood tests, provide reliable results. However, they often come with high costs, require specialized facilities, and need expert oversight. This limits their use for large-scale routine screening. Recently, retinal fundus imaging has become a promising alternative for cardiovascular assessment. The small blood vessels in the retina can indicate broader vascular health. Because retinal imaging is non-invasive, affordable, and increasingly available, it has great potential for early cardiovascular screening in areas with limited resources. Advances in artificial intelligence and deep learning have also made this method even more effective.

Intelligence (AI) has had significant success in analyzing medical images. CNNs can automatically detect important patterns in retinal images. By combining these images, we can build a more accurate system to predict heart disease risk. Most current heart disease prediction systems rely only on clinical data. This method aims to offer a fast, cost-effective, and non-invasive solution for early heart disease screening. It helps doctors make better and quicker decisions.

II. RELATED WORK

Recent studies have found that retinal fundus images have information about blood vessels. This research is mostly about diseases like retinopathy and high blood pressure. These studies show that changes in blood vessels can tell us about our overall heart and circulatory health.

Deep learning methods, Convolutional Neural Networks (CNNs) are often used to analyze retinal images. They can learn about vessel structures and small changes in blood vessels on their own. This is helpful because it means we do not have to pick out the features.Some studies have used information about a persons health, such as age, blood pressure and cholesterol levels to predict heart disease. While these methods work okay they do not use the information that's in retinal images.

Retinal fundus images and health information can both provide clues, about heart health. Using both may lead to predictions.We still need to find a way to effectively combine these two types of information.

So we have these ways of looking at retinal analysis like the ones that use attention and transformers. These models, the attention-driven and transformer-based retinal analysis models are really good at finding out how different parts of the retina are connected.

health data for better prediction accuracy. Many studies have also explored transformer- based models for retinal image analysis, showing promise in capturing complex relationships in medical images.

The current methods are limited in one or more ways:

- They focus mainly on diabetes or hypertension rather than heart disease.
- They rarely combine retinal images with detailed clinical risk factors.
- There is limited work on creating end-to-end pipelines that can automatically predict heart disease risk in a non-invasive and practical manner.

This study is trying to fix some problems by using a kind of computer program that looks at pictures of the back of the eye and information about the patients health to figure out if they are likely to get heart disease.

The computer program is not just looking at pictures there are ways to do this too. Some people have used computer programs that can learn and get better on their own like Random Forests and Artificial Neural Networks to look at health information and try to predict if someone will get heart disease. These computer programs can look at lots of health information. Make pretty good guesses but they are not very good, at looking at pictures of the eye and figuring out what they mean. The deep learning model that combines image features and clinical data has gained attention.

These methods take features from images using CNNs and merge them with health data for classification. Some studies experiment with Vision Transformers for image analysis.

III. PROPOSED SYSTEM

This system is used to figure out if someone's at risk of getting heart disease. It looks at pictures of the back of the eye and information about the patient health. This way of doing things combines what the doctor can see in the pictures with the patients health information. The doctor can make a more accurate decision without having to do any surgery. The system is set up to work from start to finish beginning with getting the pictures and health information then making sure it is all correct taking out the parts putting it all together deciding what it means and finally figuring out the risk of heart disease. The first step is to get pictures of the back of the eye and information about the patients health. These pictures are taken from groups of people or from hospital exams and they show the tiny blood vessels in the eye that can tell us about heart health.

Before we use images in a network we need to prepare them first. This preparation step is called preprocessing. It helps make the images better and improves how well the model works. The images of the back of the eye called fundus images are changed to a size. This is so they fit the needs of the CNN. The images are also adjusted to have brightness levels. This helps the model learn smoothly. Techniques like CLAHE are used to make blood vessels more visible in the images. CLAHE helps to make the contrast better. Noise filters are used to get rid of details in the background. We also do things to the images like rotating them flipping them and adjusting how bright they are. This helps us have images to work with and prevents the model from getting too focused on one thing. We do preparation for the clinical data. If there are missing values we fill them in. We also make sure all the numbers are on the scale. This helps the model understand everything.

The doctor looks at patterns from the pictures of the back of the eye like how wide the blood vessels. how twisted they are and if there are any other small problems with the tiny blood vessels. These things can tell us if someone is at risk for heart problems. The computer uses tools to look at these pictures and find the important parts. It does this by using layers that look at small parts of the picture and then it uses a special way to make sure it is not looking at things in a straight line. The computer then makes the picture smaller while keeping the parts and it changes the picture into a list of numbers that it can use to learn more. The computer takes these numbers. Combines them with other information about the patients health like their age and medical history. It puts all of this information together

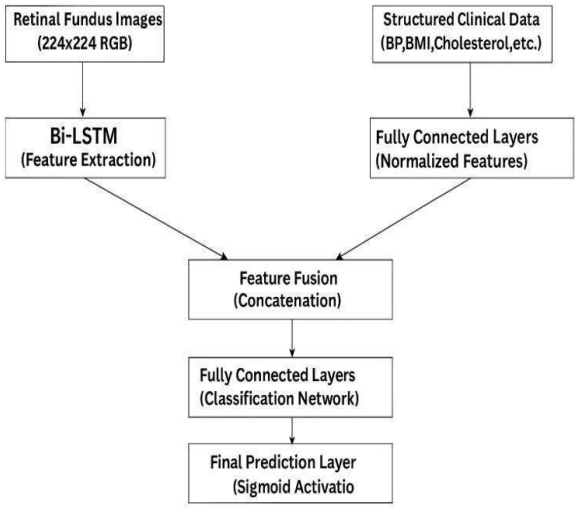

Fig. 1. Proposed System Architecture

IV. METHODOLOGY

The proposed system works by predicting heart disease risk from images and patient details. The workflow starts with collecting images and patient information like age, blood pressure and cholesterol levels. This information also includes body mass index diabetes history and smoking habits. The collected data is then divided into three parts, for training, validation and testing to ensure results. The retinal fundus images and clinical parameters are used together to make predictions. The goal is to use these images and patient details to find the risk of heart disease. The complete process helps

in getting results by using a large dataset. The system uses fundus images and patient clinical parameters for predicting heart disease risk.

A Convolutional Neural Network is used to learn things from images. This Convolutional Neural Network looks at the blood vessels in the eye. It checks how thick the blood vessels are, how they branch out and if they are twisted. The Convolutional Neural Network also looks for problems with the blood vessels. The Convolutional Neural Network has layers that help it understand what it sees. These layers take the information. Make sense of it. Here are some simple things the Convolutional Neural Network looks for: how thick the blood vessels are, how the blood vessels branch out, if the blood vessels are twisted, and problems with the blood vessels. Then the list of things the Convolutional Neural Network finds in the image is combined with information, from the clinic. This makes a set of information that includes both the image and the clinical information. The Convolutional Neural Network is a part of this process. It helps with learning things from the images This makes a set of information that includes both the image and the clinical information. The Convolutional Neural Network is a part of this process. It helps with learning things from the images..

The model refines its understanding by using layers that connect all the data. This helps it see how retinal issues relate to a patients health. It looks at both retinal problems and clinical data together. This way it finds connections that are not clear when looking at just one type of data. The model learns from both image details and regular health signs at the same time. The combined data is then passed through layers to make a prediction. It uses these layers and a special classification layer to guess the patients heart disease risk. The model is taught using a method and a suitable speed. It also uses a way to measure mistakes. The proposed methods success is judged using measures. These measures help understand how well the model works. The model uses these steps to make its predictions. It relies on both types of data to make guesses. The goal is to provide a complete picture of the patients heart disease risk..

V. ILLUSTRATIVE EXAMPLE

The proposed system predicts heart disease by integrating retinal fundus images with patient clinical data. Initially, a retinal image is captured using a fundus camera, and clinical parameters. This combination ensures the model considers both anatomical and traditional health risk factors. Next, the retinal images undergo preprocessing, which includes resizing, normalization, contrast enhancement using CLAHE, and noise reduction. Data augmentation techniques like rotation, flipping, and brightness adjustments are applied to increase variability and reduce overfitting. Clinical data is also preprocessed by normalizing numerical values and handling missing entries.

The images are then passed through a Neural Network (CNN) that automatically takes features like as vessel patterns, width, tortuosity, and microvascular anomalies. These features are fused with the clinical data to make a hybrid feature set. This fusion makes the system to utilize both visual and numerical health indicators for improved accuracy. Finally, model is fed into full layers, and the model outputs a risk prediction, classifying patients into low, medium, or high-risk categories. This workflow enables a non-invasive, quick, and reliable assessment of cardiovascular risk, making it suitable for real-world clinical applications.

VI. EXPERIMENTAL RESULTS AND DISCUSSION

The new framework that combines two things was tested using pictures of the back of the eye and information about the patients health. To make sure the test was fair all the data was split into three groups: 70 percent for training 15 percent for checking and 15 percent, for testing. The training was done using a method called Adam and some specific settings: a very small step of 0.001 a group size of 32 and 50 rounds.

To make the system more stable some changes were made to the pictures during training like turning them flipping them sideways and changing how bright they were. Also a special technique called dropout was used in the layers to stop the system from getting too good at the training data and to make it work better with new data.

The performance of the model was checked using some standard measures: how often it was right how precise it was, how well it remembered things a special score called F1-score and a confusion matrix analysis. Three models were compared: one that only used information, one that only used pictures of the eye and the new model that combined both. The confusion matrix shows that most of the samples were classified correctly whether they were risk, medium risk or high risk and there were very few mistakes.

Hybrid which demonstrates that combining retinal image features with clinical parameters significantly.

Model	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)
Clinical Data	82	80	78	79
CNN(Images)	85	83	82	82
Hybrid Model	92	90	91	90.5

Table I: Comparative Performance of Models

Actual \ Predicted	Low	Medium	High
Low	70	5	0
Medium	4	65	6
High	0	3	72

Table II: Confusion Matrix (Hybrid Model)

VII. CONCLUSION AND FUTURE WORK

In this study, a deep learning model was developed to predict heart disease risk by combining retinal fundus images with clinical data. The system leverages a CNN to extract image features and fuses them with structured patient information to give an with a comprehensive risk assessment. Results shows that the hybrid approach significantly outperforms models using only clinical data or only image features, achieving high accuracy, precision, and recall.The proposed method offers a non-invasive, efficient, and reliable tool for early cardiovascular risk detection.

Doctors will identify high-risk patients early, enabling preventive care.

For future work, the system can be enhanced by integrating bigger and more large Data Bundles, including multi-center patient data, to improve generalization. Additionally, the inclusion of advanced deep learning architectures, such as transformers or attention-based networks, could further improve feature extraction from retinal images. Real-time deployment through mobile or cloud platforms could make this system more accessible in remote and under-served areas.

Acknowledgement

We are extremely grateful to Dr. A. Srinivasula Reddy, Principal, and Dr. Madhavi Pingili, Professor & HOD, Department of CSE (AI&ML), CMR Engineering College, for their constant support.We are sincerely thankful to Dr. A. Vijendar, Associate Professor and Internal Guide, Department of CSE (AI&ML), for his continuous guidance, encouragement, and moral support throughout this major project.

We thank to the authors of the references and other literature consulted in this major project.

We thank Mr. G. Venkateswarlu, Major Project Coordinator, for his constant support in carrying out project activities and reviews.

We express our gratitude to all staff members and friends for their help and coordination in bringing this major project to completion on time.

Finally, we are very thankful to our parents, who guided us at every step.

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