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Intelligent Retinal Image Analysis for Predicting Cardiovascular Disease Risk Using Deep Neural Networks

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Abstract: ***Cardio-vascular disease is the leading cause of mortality in world. The early detection of the cardio-vascular disease risk. Now days there is a technology is get introduced in the medical field called as the Retinopathy. This is used for the detecting the retinal diseases in past but by adding advancement into this we can used for Diabetes Risk prediction and know by doing advancement into this we build it for prediction of Cardiovascular Diseases Risk Prediction Using retinopathy. Retinopathy is the technique of capturing the image of the retina of the eye. Retina is the light sensitive tissues lining the back of the eye, responsible for converting light into the signals that the brain detects and process as images. There are multiple diseases present which may cause the defect in the retina of the eye. By this system we can detect several diseases which are the symptom of the cardiovascular health, or which may be affected by cardiovascular disease. Building the machine learning model for detecting the predicting the output using the various deep learning model.***

Keywords: Retinal eye images, Cardiovascular risk, cardiovascular health, Machine Learning, image processing, predictive modelling, health care analysis, CNN, Mobile net V2, Resnet 50, VGG, Deep learning, Retinal imaging

I. INTRODUCTION

Cardiovascular Disease is the cause of death globally. According to the reported cases, there is a 271 million increment from 1990 to 523 million in 2019. There are other factors, including hypertension, obesity, and smoking contribute to the increased incidence of CVD. According to the survey, some of the diseases may cause several CVDs.

Early detection of cardiovascular disease and risk assessment are effective in preventing high risk. Based on the RFI we used the analysis methods of the deep learning for prediction of CVR. The retina gives us chance to safe medical diagnosis. Using the various funds images and the clinical data, we developed a model based on deep learning concepts for predicting the several vital parameters for the CVD. By using the various types of the machine learning concept, we made a tool which can detect and predict the cardiovascular disease. The primary goal of the research is to predict the risk of cardiovascular diseases using retinal imaging and developing a model based on deep learning. By using the deep learning algorithms, we can build the CNN model. In this research, we use the large amount data and the CNN to predict disease. In most of the studies, retinal microvascular due to microaneurysms, retinal haemorrhages and vascular changes may indicate the presence of disease in the human body, including high blood pressure, stress, diabetes, and various heart diseases. Manipulating Colour Fundus (CF) images for predicting CVD risk offers several advantages, including non-invasiveness and convenience for examine large populations. Through this research we demonstrate that most of the retinal images for CVD risk not only provides consistent results within individuals but also establishes a significant association.

II. LITERATURE SURVEY

A. Enhancing stability in cardiovascular disease risk prediction: (2023)

Author name - Weiyi Zhang a, Zhen Tian a, Fan Song a, Pusheng Xu b, Danli Shi a,c, Mingguang He.

In this research, they focused on Reti-WHO scores, Reveal inflate stability compared to WHO CVD scores calculated uniquely from the patient's physical indicators, suggesting that the features learned from retinal fundus photographs serve as indicators of CVD risk. However, the model may still exhibit accurate in high-risk predictions, requiring research for purification. Future directions involve validating the model across wide populations and using multi-image and multi-modal approaches to increase prediction accuracy. Additionally, integrating advanced machine learning techniques could improve the model's ability to discern subtle patterns in retinal images that correlate with cardiovascular health. Emphasizing collaboration with clinical practitioners may facilitate real-world implementation, ensuring that the Reti-WHO scores can effectively contribute to early detection and preventative strategies in cardiovascular care.

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B. Heart Disease Prediction Using Eye Retinal Images (2023)

Author name -Sameer Shaikh, Ishan Wagh, Vrushab Zaveri, Mohammad Bazil Mujawar, Divya Surve.

In this research, they have commenced on a large-scale study using retinal images and patient characteristics such as age, blood pressure, haemoglobin levels, and body weight to predict cardiovascular disease. Their goal is to provide a accurate tool for early diagnosis of severe heart attacks.

The results of their work were excellent; their model achieved an accuracy of 98.9%. These advances Reveal the feasibility of deep learning techniques, including neural networks (RNN) and fuzzy C-means (FCM). The integration of retinal imaging with patient data not only enhances predictive power but also highlights the potential for non-invasive diagnostics in cardiovascular health. Future work may focus on refining the model to reduce false positives and exploring its application in diverse clinical settings to ensure its broad utility.

C. Prediction of Cardiovascular Diseases with Retinal Images Using Deep Learning (2024)

Author name- Tumu Vineethal, Danda Rami Reddy2, Kandimalla Mahendra2 and Ballanki Dhana Lakshmi

The paper presents a model for predicting cardiovascular diseases (CVDs) through the analysis of retinal images using deep learning algorithms. Has a lot of prospective for utilizing artificial intelligence to help with risk assessment and early identification. Through picture analysis, the system can recognize patterns and markers associated with variables that raise the likelihood of problems. The study employs convolutional neural networks (CNNs) integrated with MobileNet architecture to create an efficient and accurate prediction model.

The proposed system processes retinal images by collecting, preprocessing, and augmenting the data to enhance model validity. They use CNN model which enhanced using the MobileNet framework and classify of retinal images into categories based on the presence of CVD. Steps include image preprocessing, training using algorithms like stochastic gradient descent (SGD) and to prevent overfitting need fine-tuning the model.

The model shows potential in the early detection of CVD, achieving high training accuracy, further efforts are required to enhance accuracy and reduce overfitting. The study infers that integrating retinal imaging and deep learning could offer a cost-effective and non-invasive method for predicting CVDs, improving patient outcomes, and reducing complications.

If this technology proves to be effective, it has the potential to completely transform the way we anticipate illnesses by providing a non-invasive, easily available option to supplement existing diagnostic techniques. To enhance and improve this system and produce better patient care and results, more investigation and validation are needed.

D. Predicting the Risk of Heart Attack Using Retinal Eye Image Analysis (2024)

The paper investigates novel method for early heart disease detection using retinal images. Cardiovascular diseases (CVDs) are the main reason of death worldwide, and early diagnosis is crucial.

The study leverages retinal image analysis, as retinal vascular structures have similarities with cardiovascular systems, making them useful for identifying potential heart conditions.

They used Recurrent Neural Networks (RNNs) to process sequential retinal image data. RNNs are used for detecting patterns in time-dependent data, making them ideal for this application. The methodology involves

collecting retinal images, preprocessing them to maintain consistency, developing an RNN model to predict heart disease risk, and testing the model's accuracy. The eventual goal is to create a non-invasive and cost-effective tool that can predict heart disease through retinal images, potentially improving early intervention.

E. Heart Attack risk prediction using retinal eye images

Author name - By Paila Reddy, Dathu Yochitha, Medam Kavya, Dr.M.D. Nazamoddin (2023)

This project represents a crucial advancement in cardiovascular health detection. By utilizing the power of retinal imaging and advanced machine learning techniques, this project offers a non-invasive and accessible method for early risk prediction of heart attacks. The ability of system to correlate retinal features with cardiovascular health indicators provides a more comprehensive and accurate assessment.

This approach has the potential to revolutionize preventive healthcare by identifying individuals at risk of heart attacks at an early stage, enabling timely interventions and potentially saving lives. It addresses the limitations of traditional risk assessments and offers a more inclusive and cost-effective solution.

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III. METHODLOGY

A. Data Collection

High –quality retinal eye images were collected from different sources such as kaggle, google as well as from hospital. Dataset has retinal images labeled with the cardiovascular diseases. The dataset include both healthy as well as damaged retinal eye images, providing the balanced foundation of supervised learning.

B. Data preprocessing

1) Resizing: All images are resized at 2240X224 dimension to maintain consistency across model.
2) Normalization: Pixel intensity values normalized to 0 to 1 standard range which is efficient for training model and make model stable.
3) Noise Removal: There were many techniques to noise removal Gaussian filtering and histogram equalization was applied to remove noice and preserving vascular structures.
4) Contrast Environment: It helps to improve the visibility of retinal vessels by using Histogram equalization and Contrast Limited Adaptive Histogram.
5) Data Augmentation: Data augmentation techniques like rotation, flipping, zooming and shifting were used to increase dataset size and model robustness. It used to model generalization

C. Feature Extraction

Two approaches were explored:

1) Handcrafted Features: Retinal vessel segmentation was performed using morphological operations vessel tortuosity, bifurcation density, and arteriolar-to-venular diameter ratio (AVR) were extracted each of the features are linked with the cardiovascular condition as these are known biomarkers for cardiovascular risk.
2) Deep Learning-based Features: Pre-trained Convolutional Neural Networks (CNNs) were fine-tuned on the dataset. high-level image features relevant to heart disease represented by intermediate layers Features. The model comprises several convolution layers for feature extraction, pooling layers to reduce dimensionality, and a dense layer for classification.

D. Classification

Classification models get extracted features as input to predict the risk of a heart attack following models are used

1) Machine Learning Models: Support Vector Machine (SVM), Random Forest, and XGBoost were tested on handcrafted features.
2) Deep Learning Models: CNN-based classifiers were trained end-to-end using retinal images to predict binary (heart attack risk vs. no risk) or multiclass outcomes.

E. Performance Evalution

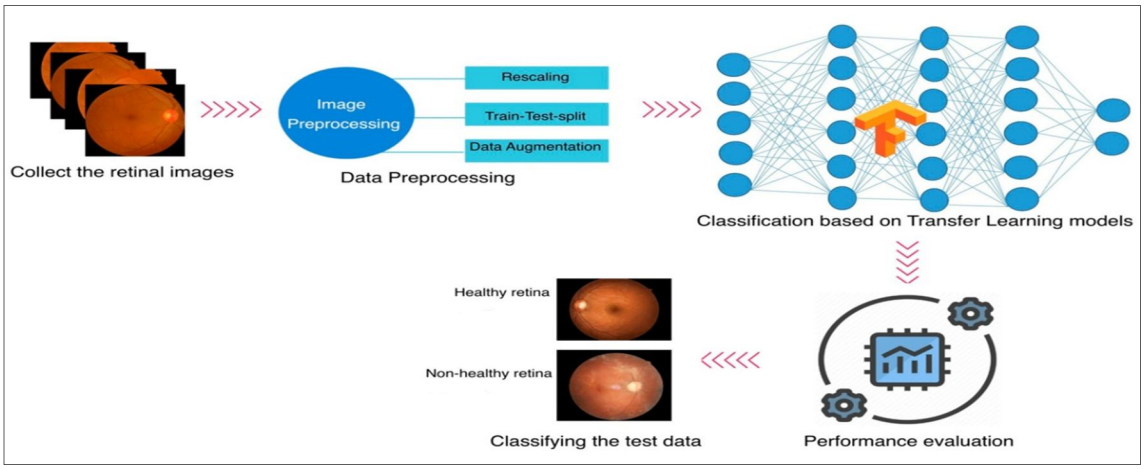
Model performance was evaluated using the following metrics:

1) Accuracy: Overall correctness of the model.
2) Precision and Recall: To evaluate model reliability, especially for imbalanced data.
3) F1-Score: Harmonic mean of precision and recall.
4) ROC-AUC: Area under the Receiver Operating Characteristic curve to evaluate the true positive rate vs. false positive rate

F. Result and Discussion

The model was evaluated using metrics like accuracy, sensitivity, specificity, and AUC-ROC. The CNN Model demonstrated strong performance, with an accuracy and AUC-ROC score. Explainability techniques provided insight into the model's decision-making, enhancing trustworthiness and applicability in clinical settings. Challenges included managing computational resources and ensuring data quality, especially in federated learning.

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IV. FUTURE SCOPE

1) *Integration With Clinical System:* Integrating the model into Electrical Health Record (EHR) System. This integration make professional which turns into the which makes data driven decision quicker, maintain patient monitoring.
2) *Real – Time Application:* Optimizing model performance to work on the real time data. This may include the reducing the latency in prediction, running efficiently on edge device and giving the result at time of examination of eye *Improving the Accuracy with Large Data Sets:* By including the some more images and real time data which make the model more effecting. Also, by generalizing the model by using data ethnicities, ages, and genders.
3) *Integration With The AI:* We can add based system for giving the information or we use the AI Chat-bot for guide the users of the system with real time interaction with user and also, we add the AI agent for the doctor's professional's advice for the patient.
4) *Making model federated:* We build the model as federated by which significantly enhance the security and efficiency and improves scalability. Federated models make model decentralized, by this approach is to use diverse datasets from various locations, improving the model's accuracy, and robustness to image variations.

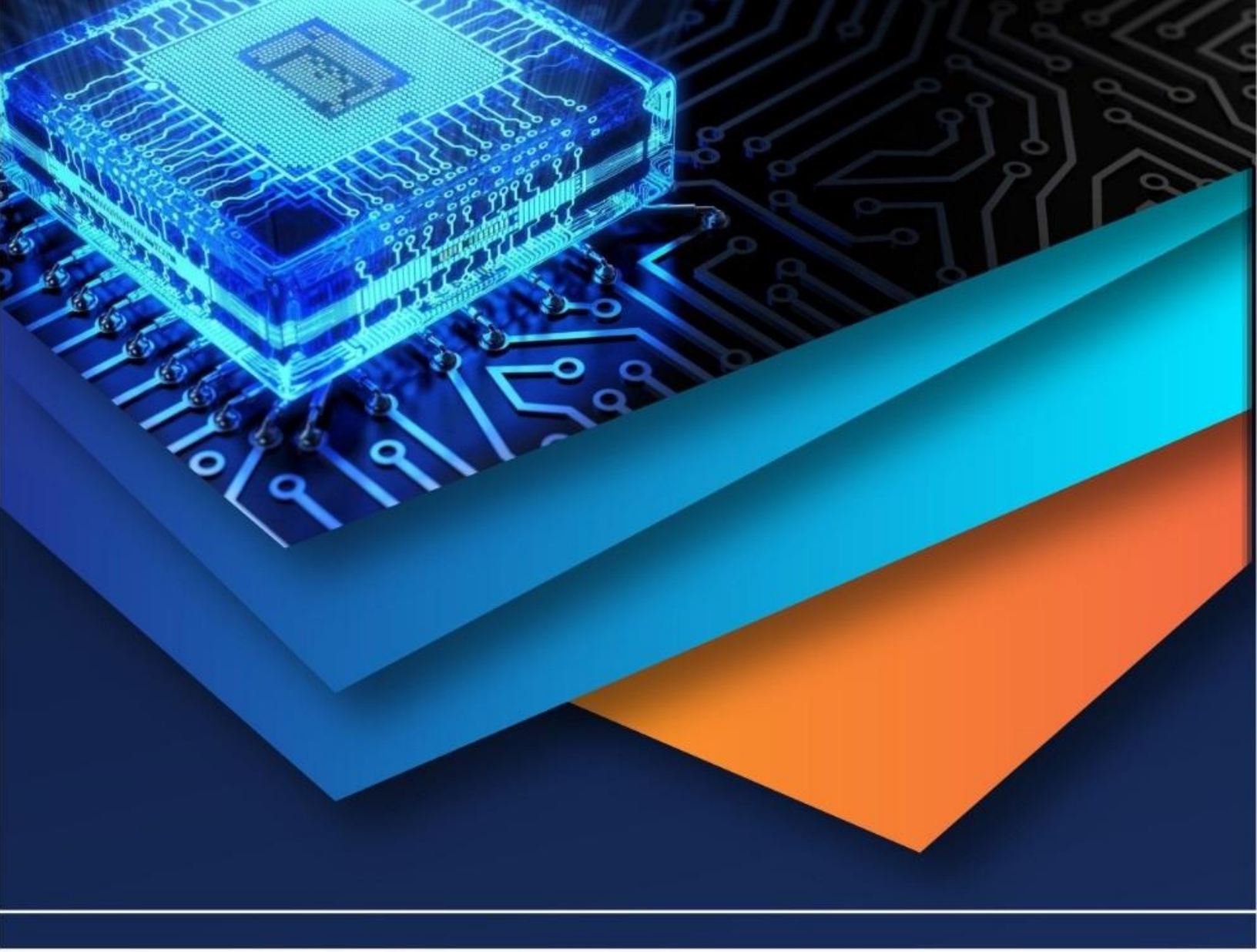
V. CONCLUSION

The scope of this research of using the deep learning specially CNN, to predict the risk of the cardiovascular disease by analysing the retinal images. Retinal microcirculatory vessels such as microaneurysms, haemorrhages, and vascular abnormalities serve as important indicator of underlying heart-related conditions. The developed model offers external, efficient, and scalable approach for early disease detection, which could significantly improve preventive healthcare and reduce the burden of cardiovascular disease. In future integration with the federated learning can further enhance the capabilities of the model by adding the collaborative training with the institutions while preserving patient data privacy. This would lead to a more robust, accurate, and ethical complaints system suitable for real –world clinical development.

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