Artificial Intelligence Approach for CAD Detection Using ECG Images and Patient Biometrics

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Abstract: Coronary Artery Disease (CAD) remains one of the leading causes of death throughout the world, primary diagnosis essential for reducing patient risk with improving treatment outcomes[1-3]. Conventional CAD diagnosis generally depends on electrocardiogram (ECG) interpretation, clinical examination, or imaging modalities, each having certain limitations when used independently[5]. Recent advances in Artificial Intelligence (AI) have demonstrated significant potential in improving diagnostic accuracy through automated analysis of medical data. This article recommends an AI framework that integrates ECG images and patient biometric information to improve CAD classification. The study employed CNN for extracting deep features from ECG images, while ML Algorithms such as Random Forest and Naïve Bayes analyze biometric attributes including age of a person, glucose level, gender, cholesterol level, blood pressure, and body mass index[8-11]. The outputs of both models are fused to classify patients into three categories: first one is Normal, second is Abnormal, and third one is Myocardial Infarction (MI)[]. The proposed framework enhances diagnostic reliability by combining complementary information from multiple modalities. Furthermore, Grad-CAM and SHAP are incorporated to improve model transparency and clinician trust[12]. The proposed approach demonstrates the potential of multimodal AI systems in supporting early CAD diagnosis and clinical decision-making.

Keywords: Coronary Artery Disease, Artificial Intelligence, Deep Learning, Machine Learning, ECG Images, CNN, Explainable AI, Random Forest.

Introduction

Cardiovascular diseases account for approximately one-third of global deaths, with Coronary Artery Disease (CAD) representing the most prevalent form[1-3]. CAD occurs due to blockage of arteries caused due to plaque accumulation, reducing heart muscles blood flow with increased myocardial infarction risk. Traditional diagnosis relies on ECG interpretation, stress testing, angiography, and clinical biomarkers. Although these techniques provide valuable information, they often require specialist expertise and may produce inconsistent results due to inter-observer variability. Recent developments in Artificial Intelligence (AI) have enabled automated analysis of medical images and structured clinical data with remarkable diagnostic performance.

Deep Learning models[13], demonstrated excellent capability for extracting discriminative features from ECG images[16], while classical Machine Learning algorithms efficiently analyse patient biometric data. However, most existing studies utilize only a single data modality, thereby limiting diagnostic performance.

This research proposes a multi-source AI framework that integrates ECG images and biometric parameters to improve CAD classification[18]. The combined framework aims to provide more accurate, interpretable, and clinically applicable predictions.

Proposed Methodology

The proposed system combines ECG image analysis with patient biometric information to improve disease classification.

Initially, ECG images undergo preprocessing involving grayscale conversion, resizing, normalization, and noise removal[17]. A custom Convolutional Neural Network extracts high-level spatial features from ECG images and predicts one of three classes: Normal, Abnormal, or Myocardial Infarction.

Simultaneously, patient biometric information including Age, Gender, Blood Pressure, Cholesterol, Blood Sugar, Body Mass Index, Chest Pain Type, Heart Rate, and Resting ECG values is processed using Machine Learning algorithms. Random Forest and Naïve Bayes classifiers are employed due to their strong predictive capability and computational efficiency.

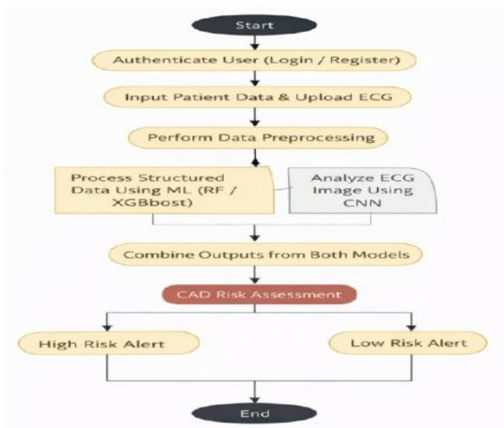

Figure 1 workflow of the CAD detection system.

The ECG datasets considered include PTB-XL, PTB Diagnostic ECG Database, and ECG Image datasets containing Normal, Abnormal, and Myocardial Infarction samples.

Experimental Results and Discussion

ECG Dataset Samples and AI-Based Prediction

To evaluate the proposed multi-source AI framework, representative ECG images corresponding to different cardiac conditions were used. The dataset contains ECG records with three classes: Normal, Abnormal, and MI. Each ECG image is pre-processed before being provided as input to the custom Convolutional Neural Network (CNN). Simultaneously, patient biometric parameters are analyzed using Machine Learning algorithms. The predictions from both models are combined to generate the final diagnosis. Figure 2 illustrates representative ECG samples from the dataset together with the output generated by the proposed AI-based prediction system. The prediction interface displays the predicted cardiac condition, confidence score, disease severity, and probability distribution across all disease classes.

Figure 2. Representative ECG samples and AI prediction results

Conclusions

Although the proposed framework demonstrates significant promise, challenges remain regarding dataset quality, class imbalance, computational complexity, and generalizability across diverse patient populations. Future work will focus on larger multicentre datasets, Transformer-based deep learning architectures, federated learning for privacy-preserving healthcare, and deployment as a cloud-based clinical decision support system. Overall, the proposed multi-source Artificial Intelligence framework provides an effective, interpretable, and scalable solution for early coronary artery disease diagnosis, with strong potential for real-world clinical applications.

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