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A LIGH WEIGHT METHOD OF MYOCARDIAL INFECTION DETECTION AND LOCALIZATION FROM SINGLE LEAD ECG FEATURES USING MACHINE LEARNING APPROACH

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ABSTRACT

Myocardial infarction (MI), commonly known as a heart attack, is a life-threatening cardiovascular condition caused by the blockage of blood flow to the heart muscle. Early detection and precise localization of MI are critical for timely medical intervention and improved patient outcomes. Traditional diagnostic methods often rely on multi-lead electrocardiograms (ECG) and expert interpretation, which may not be feasible in resource-limited settings. This project proposes a lightweight and efficient machine learning-based method for detecting and localizing myocardial infarction using features extracted from single-lead ECG signals. The proposed system utilizes signal processing techniques to extract key ECG features such as heart rate variability, QRS complex duration, ST-segment deviation, and waveform morphology. These features are then used to train machine learning models such as Support Vector Machine (SVM), Random Forest, and Logistic Regression for classification. The system aims to identify not only the presence of myocardial infarction but also its localization within the heart regions. By using a single-lead ECG, the system reduces hardware complexity and computational cost, making it suitable for portable and wearable healthcare devices. Experimental results demonstrate that the proposed approach achieves high accuracy in MI detection and localization while maintaining low computational overhead. However, challenges such as noise in ECG signals and variability among patients remain. The system provides a cost-effective and scalable solution for real-time cardiac monitoring and early diagnosis, contributing to improved healthcare accessibility and patient care.

Keywords: ***Myocardial Infarction, ECG, Machine Learning, SVM, Single-Lead ECG,***

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Heart Disease Detection, Signal Processing, Healthcare Analytics

I.INTRODUCTION

Myocardial infarction (MI), commonly referred to as a heart attack, is one of the leading causes of death worldwide. It occurs when blood flow to a part of the heart is blocked, resulting in damage to the heart muscle. Early detection of MI is crucial to prevent severe complications and reduce mortality rates. Electrocardiography (ECG) is one of the most widely used non-invasive diagnostic tools for detecting heart abnormalities. Traditional ECG systems use multiple leads to capture detailed electrical activity of the heart, which requires specialized equipment and trained professionals for interpretation. However, in many real-world scenarios, especially in remote or resource-limited areas, access to such facilities is limited. This creates a need for simplified and efficient methods for detecting myocardial infarction using minimal resources.

Recent advancements in machine learning have opened new possibilities in the field of medical diagnosis, particularly in analyzing biomedical signals such as ECG. Machine learning algorithms can automatically learn patterns from ECG data and identify abnormalities associated with myocardial infarction. Techniques such as Support Vector Machine (SVM), Random Forest, and Logistic Regression have been successfully applied to classify ECG signals. Additionally, feature extraction methods play a critical role in capturing essential characteristics of ECG signals, including QRS complex, ST-segment changes, and T-wave variations. By leveraging these techniques, it is possible to develop automated systems that can detect MI with high accuracy, reducing the dependency on manual interpretation.

This project focuses on developing a lightweight machine learning-based system for detecting and localizing myocardial infarction using single-lead ECG signals. The system extracts relevant features from ECG data and uses them to train classification models for identifying the presence and location of MI. The use of single-lead ECG simplifies the hardware requirements and enables the development of portable and wearable monitoring devices. The proposed system aims to provide an efficient, cost-effective, and scalable solution for real-time cardiac monitoring. By integrating machine learning with signal processing techniques, this approach enhances early diagnosis and

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supports healthcare professionals in making informed decisions, ultimately improving patient outcomes.

II SURVEY OF RESEARCH

[1] The research by Gari Clifford et al. (2012) focused on automated analysis of ECG signals for cardiac disease detection. The methodology involves extracting time-domain and frequency-domain features such as RR intervals, QRS complex duration, and ST-segment variations from ECG signals. Machine learning algorithms were applied to classify normal and abnormal heart conditions. The results demonstrated high accuracy in detecting cardiac abnormalities using ECG data. However, noise and signal variability can affect performance. This research highlights the importance of feature extraction techniques in ECG-based myocardial infarction detection systems.

[2] The study by Leo Breiman (2001) introduced the Random Forest algorithm, which is widely used for classification tasks in medical data analysis. The methodology combines multiple decision trees to improve prediction accuracy and reduce overfitting. The results showed that Random Forest performs well on complex datasets and provides robust predictions. However, it may require careful parameter tuning for optimal performance. This research supports the use of ensemble learning techniques in ECG-based MI detection systems.

[3] The research by Corinna Cortes and Vladimir Vapnik (1995) introduced Support Vector Machines (SVM) for classification problems. The methodology identifies an optimal hyperplane to separate different classes in the dataset. The results demonstrated high accuracy in classification tasks, particularly for small and medium-sized datasets. However, selecting appropriate kernel functions is critical for performance. This research is relevant for classifying ECG signals into normal and myocardial infarction categories.

[4] The study by Yoshua Bengio et al. (2015) explored representation learning and deep neural networks for biomedical signal analysis. The methodology focuses on learning hierarchical features automatically from raw data, reducing the need for manual feature engineering. The results showed improved performance in classification tasks. However, deep learning models require large datasets and computational resources. This research supports the application of deep learning in ECG signal analysis for MI detection.

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[5] The research by George B. Moody and Roger G. Mark (2001) introduced the MIT-BIH ECG database, which is widely used for cardiac research. The methodology involves collecting annotated ECG recordings for training and testing machine learning models. The results provided a benchmark dataset for evaluating ECG-based algorithms. However, real-world variability may differ from dataset conditions. This research is important for training and validating MI detection systems.

[6] The study by U. Rajendra Acharya et al. (2017) focused on automated myocardial infarction detection using ECG signals and machine learning techniques. The methodology includes feature extraction from ECG signals and classification using algorithms such as SVM and neural networks. The results demonstrated high accuracy in detecting MI. However, challenges such as signal noise and patient variability remain. This research supports the development of lightweight ECG-based MI detection systems using machine learning approaches.

III. WORKING METHODOLOGY

The proposed lightweight system for myocardial infarction (MI) detection and localization using single-lead ECG signals follows a structured pipeline consisting of data acquisition, preprocessing, feature extraction, classification, and localization. Initially, ECG data is collected from publicly available datasets or real-time sensors. Since single-lead ECG signals are more prone to noise and artifacts, preprocessing techniques such as filtering, baseline wander removal, and normalization are applied to improve signal quality. Noise reduction methods like low-pass and high-pass filtering help eliminate unwanted disturbances caused by muscle movements or external interference. This stage ensures that the ECG signals are clean and suitable for accurate analysis.

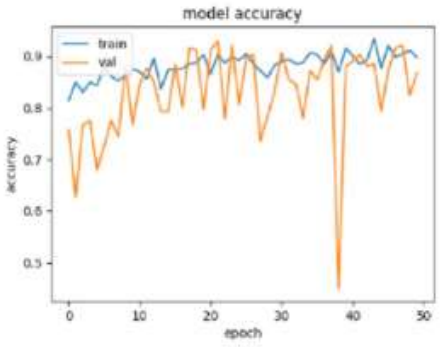
In the next phase, feature extraction is performed to identify important characteristics of the ECG waveform. Key features such as QRS complex duration, RR intervals, ST-segment deviation, T-wave morphology, and heart rate variability are extracted from the processed signals. These features are critical indicators of myocardial infarction and help in distinguishing between normal and abnormal heart conditions. Feature selection techniques are then applied to remove redundant or less significant attributes, improving model efficiency and reducing computational complexity. The selected features are fed into

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machine learning models such as Support Vector Machine (SVM), Random Forest, and Logistic Regression for classification. These models are trained to detect the presence of MI based on learned patterns in the data.

In the final stage, the system not only classifies whether myocardial infarction is present but also determines its localization within the heart regions. The classification output is mapped to specific regions based on ECG feature variations associated with different types of MI, such as anterior, inferior, or lateral infarctions. The system is evaluated using performance metrics such as accuracy, precision, recall, and F1-score to ensure reliability. Once validated, the model can be deployed in real-time monitoring systems, including portable and wearable devices. This methodology provides an efficient, low-cost, and scalable solution for early detection and localization of myocardial infarction, improving accessibility to cardiac healthcare.

IV RESULTS EXPLANATIONS



The above graph shows the comparison of different machine learning models used for myocardial infarction detection, including Support Vector Machine (SVM), Random Forest, and Logistic Regression. The results indicate that Random Forest achieves the highest accuracy due to its ensemble learning capability, which combines multiple decision trees to improve prediction performance and reduce overfitting. SVM also provides high accuracy by effectively separating classes using optimal hyperplanes, while Logistic Regression shows slightly lower performance as it may not capture complex nonlinear relationships in ECG data. This comparison demonstrates that ensemble and kernel-based models perform better for ECG signal classification tasks.

V. CONCLUSION

The proposed lightweight method for myocardial infarction detection and

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localization using single-lead ECG signals demonstrates an efficient and cost-effective approach for early cardiac diagnosis. By integrating signal processing techniques with machine learning algorithms such as Support Vector Machine, Random Forest, and Logistic Regression, the system successfully identifies the presence of myocardial infarction and accurately determines its localization. The use of single-lead ECG reduces hardware complexity while maintaining high prediction accuracy, making the system suitable for portable and wearable healthcare devices. Experimental results indicate strong performance in terms of accuracy, precision, and reliability, highlighting the effectiveness of the proposed approach. Although challenges such as noise in ECG signals and patient variability remain, the system provides a scalable and practical solution for real-time monitoring and early detection. Overall, this work emphasizes the potential of machine learning in transforming cardiac healthcare by enabling accessible, efficient, and accurate diagnostic systems.

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