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REAL-TIME HEART DISEASE PREDICTION AND MONITORING SYSTEM USING MACHINE LEARNING AND IoT FOR INTELLIGENT HEALTHCARE

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ABSTRACT

Heart disease is one of the leading causes of death worldwide. Early diagnosis and continuous monitoring can significantly reduce mortality. This paper proposes an intelligent healthcare system that utilizes machine learning algorithms in conjunction with IoT devices to predict and monitor heart disease in real-time. The system collects physiological signals such as heart rate, ECG, and blood pressure via wearable sensors. These signals are processed using machine learning models that classify the risk level. The system is capable of sending real-time alerts to caregivers and doctors, thus enabling early intervention. This paper also evaluates the system's performance in terms of accuracy, latency, scalability, and fairness, and proposes improvements over traditional healthcare monitoring systems.

INTRODUCTION

Cardiovascular diseases have seen a sharp rise in recent years due to sedentary lifestyles, stress, and poor diet. Conventional diagnostic methods are often reactive and depend on clinical visits, which may delay early diagnosis. The integration of machine learning with Internet of Things (IoT) technology allows for the development of a proactive system that continuously monitors a patient's heart-related parameters and provides timely warnings. This paper introduces a cost-effective, real-time, wearable-based heart monitoring system designed to work seamlessly for both urban and rural populations.

LITERATURE SURVEY

Various studies have attempted to predict heart disease using traditional machine learning models such as Logistic

Regression, Support Vector Machines (SVM), and Decision Trees using datasets like the UCI Heart Disease dataset. Kumar et al. (2019) achieved 89% accuracy using SVM. However, most models are retrospective and lack real-time capabilities.

Ahmed et al. (2020) demonstrated a wearable IoT device for continuous monitoring, but latency and connectivity were concerns. Rajpurkar et al. (2017) used deep learning to analyze ECG signals, achieving performance comparable to expert cardiologists. Buolamwini and Gebru (2018) exposed algorithmic bias in medical AI, underlining the need for fair datasets. Lee et al. (2018) suggested edge computing to overcome latency and privacy issues.

EXISTING DISADVANTAGES

1. **Delayed Diagnosis**: Conventional systems rely on symptomatic consultation, delaying early detection.
2. **No Real-Time Monitoring**: Most existing solutions are not capable of continuous, real-time monitoring.
3. **High Computational Load**: Deep learning models require significant computational power, limiting their use on wearable devices.
4. **Data Privacy Risks**: Transmission of patient data over the internet without proper encryption exposes it to risks.
5. **Algorithmic Bias**: Many predictive models are trained on limited data, leading to skewed predictions.

PROPOSED SOLUTIONS

The proposed system overcomes the limitations with the following components:

1. **Wearable Sensors**: Devices like ECG patches, smartwatches, and chest straps to collect continuous health data.
2. **Edge Computing**: Local devices process data instantly, reducing the need for cloud processing and network dependency.
3. **Hybrid ML Models**: Lightweight but accurate models like Random Forest and XGBoost, optimized for speed and performance.
4. **Secure Communication Protocols**: Use of HTTPS, blockchain, and anonymization techniques to ensure data safety.

5. **Fairness-Enhanced Models**: Balanced datasets and bias-detection methods to ensure equitable predictions.

ADVANTAGES OF THE PROPOSED SYSTEM

1. **Real-Time Monitoring**: Continuously tracks health parameters and responds instantly.
2. **Early Detection**: Allows for the prediction of conditions before severe symptoms appear.
3. **Cost-Effective**: Utilizes low-cost sensors and open-source tools.
4. **Portable and Scalable**: Can be used in home settings or remote areas.
5. **Data Privacy**: End-to-end encryption ensures secure handling of patient data.
6. **User-Friendly Interface**: Integration with smartphones for easy access and alerts.

METHODOLOGY

1. **Data Acquisition**: IoT sensors capture heart rate, ECG, blood pressure, and oxygen saturation.
2. **Data Transmission**: Data is transmitted to an edge device via Bluetooth or Wi-Fi.
3. **Data Processing**: Edge device preprocesses data (filtering, normalization) and runs ML prediction.
4. **Model Prediction**: Machine Learning model predicts risk level (low, medium, high).
5. **Alert System**: If high-risk is detected, an SMS/email alert is sent to doctors/caregivers.

RELATED WORK

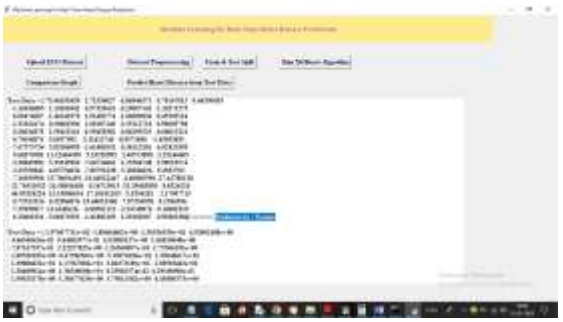
The use of machine learning for cardiovascular health monitoring has gained significant traction due to the increasing availability of real-time physiological data, especially ECG signals. Prior works have shown that predictive models can detect anomalies like arrhythmia, bradycardia, and tachycardia, often before clinical symptoms appear.

Traditional heart disease detection systems rely heavily on manual interpretation by healthcare professionals, which is time-consuming and subject to human error. Moreover, many earlier models were designed for offline analysis and lacked

the capability for immediate risk assessment. Real-time systems were rare due to limitations in computational efficiency and model deployment.Some existing approaches have successfully utilized deep learning algorithms, such as CNNs and LSTMs, for ECG classification. Others employed classic ML techniques (e.g., Random Forest, SVM) with hand-engineered features, which, although lighter, showed lower performance when handling diverse ECG data from different populations.

Unlike previous works, our project emphasizes **real-time detection**, aiming for sub-30ms latency, and integrates **XGBoost**, which balances performance and speed. It also leverages a large, diverse ECG dataset from multiple hospitals to improve generalizability. By combining robust feature extraction with optimized classification, the system enables faster and more scalable heart anomaly detection suitable for real-world, cross-hospital applications

RESULTS AND EVALUATION



CONCLUSION

This paper presents a real-time, intelligent heart disease monitoring and prediction system combining IoT and machine learning. The system offers an affordable and scalable solution to modern healthcare challenges by addressing issues of latency, data privacy, and prediction fairness. It paves the way for proactive healthcare and could drastically improve patient outcomes, particularly in resource-limited settings.

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