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Hybrid Machine Learning for IOT-Driven Heart Health Prediction: A Review

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Abstract – Heart disease remains one of the leading causes of death worldwide, particularly among elderly individuals and those with sedentary lifestyles. Early detection and real-time monitoring are essential to prevent life-threatening cardiac events. Traditional healthcare systems, which rely on manual supervision and prolonged hospitalization, are neither efficient nor scalable. This project presents a secure, IoT-enabled Body Sensor Network (BSN) integrated with a Hybrid Machine Learning model combining Artificial Neural Network (ANN) and Random Forest (RF) algorithms for accurate and reliable heart disease prediction. IoT sensors interfaced with an Arduino UNO continuously measure vital parameters such as ECG, heart rate, blood pressure, and body temperature. The data is transmitted to a cloud-based database for preprocessing and analysis. The hybrid ANN + RF model enhances classification accuracy by combining ANN's deep pattern recognition capabilities with RF's robust feature selection and ensemble learning. This integrated approach ensures high-accuracy disease prediction, real-time monitoring, and automatic alert generation to healthcare professionals. The proposed system promotes efficient, low-cost, and patient-centric healthcare, reducing manual intervention and enabling continuous remote supervision.

***Keywords*:** Internet of Things (IoT), Artificial Neural Network (ANN), Random Forest (RF), Hybrid Machine Learning, Disease Prediction, Smart Healthcare, Real-Time Monitoring

1.INTRODUCTION

Modern healthcare is rapidly evolving from traditional, hospital-based systems to IoT-driven, patient-centric models. Earlier, patients required constant supervision through wired medical instruments, which limited mobility and increased hospital costs. IoT technology now enables real-time tracking of physiological parameters through wireless sensors, offering patients greater autonomy and safety. The integration of IoT with Machine Learning has made predictive healthcare more efficient. In particular, the hybrid combination of ANN and RF allows accurate pattern detection from complex biomedical signals, addressing the limitations of single-model approaches. This project utilizes IoT-enabled sensors connected to Arduino UNO for continuous monitoring and employs hybrid machine learning techniques to predict potential cardiac anomalies, enabling early diagnosis and preventive care.

The integration of the Internet of Things (IoT) in healthcare has transformed traditional medical systems into intelligent, connected, and data-driven environments. IoT-enabled healthcare frameworks employ smart sensors and wearable devices to continuously monitor patients' physiological parameters such as body temperature, heart rate, blood pressure, and oxygen levels. These devices generate real-time data that can be transmitted to cloud platforms for analysis, enabling early detection of potential health risks and timely medical intervention. The combination of IoT and advanced machine learning techniques offers a promising solution for predictive healthcare, particularly in identifying disease patterns and providing personalized treatment recommendations.

However, the massive amount of heterogeneous data generated by IoT devices poses challenges related to accuracy, scalability, and data interpretation. Conventional machine learning models often struggle to capture complex nonlinear relationships and may exhibit limited performance in dynamic healthcare environments. To address these challenges, this study proposes a hybrid machine learning model that integrates Artificial Neural Networks (ANN) and Random Forest (RF) algorithms for disease prediction. The ANN component effectively learns deep, nonlinear patterns within biomedical data, while the RF classifier enhances decision stability through ensemble-based feature selection and voting mechanisms. This hybridization leverages the strengths of both approaches — the learning depth of ANN and the robustness of RF — to achieve improved classification accuracy and reliability in medical diagnostics.

Furthermore, the proposed IoT-based hybrid framework not only enables real-time disease prediction but also supports continuous patient monitoring and data-driven healthcare decision-making. By combining intelligent data analytics with IoT infrastructure, the system can detect anomalies in patient health, alert healthcare providers, and assist in preventive care. Such integration contributes to building a more efficient, cost-effective, and patient-centric healthcare ecosystem. The research emphasizes how IoT, combined with hybrid ANN-RF models, can serve as a cornerstone for developing smart healthcare systems capable of delivering accurate, timely, and automated disease diagnosis.

2. Existing Work

M. Tiwari and A. K. Waoo [1] proposed an IoT-based heart attack detection system that utilizes real-time heart rate monitoring to identify abnormal cardiac activity. Their system employs wearable sensors and microcontrollers to collect data, which is transmitted to a cloud-based platform for continuous analysis and emergency alerts. The model's goal is early detection of potential heart attacks, allowing for prompt medical intervention. The study emphasizes affordability and real-time decision-making capabilities in remote healthcare environments.

S. A. M. Al-Musheifri and S. A. Ahmed [2] developed an Arduino microcontroller-based IoT framework for remote heartbeat monitoring. The system captures heart rate signals through sensors and transmits them wirelessly to an online dashboard accessible by healthcare providers. This framework enables remote diagnosis and quick alert generation

in case of irregularities. Their research highlights the role of IoT in reducing manual supervision and enhancing telemedicine efficiency.

S. Nayab et al. [3] introduced an innovative IoT-driven framework aimed at continuous cardiovascular monitoring using low-cost and resource-efficient components. The proposed architecture integrates wearable sensors with cloud-based analytics to provide round-the-clock health tracking. Their system ensures scalability and energy efficiency, which are critical for large-scale patient monitoring. The framework demonstrates the effectiveness of IoT in improving patient care and long-term cardiac health management.

H. Kim, J. Park, and Y. Lee [4] developed an IoT and fog computing-based monitoring system for cardiovascular patients. Their system combines automatic ECG classification using deep neural networks with fog computing to minimize latency and data transmission costs. This hybrid model enhances the speed and accuracy of arrhythmia detection. The study shows how a reliable real-time healthcare monitoring platform can be created by combining AI, IoT, and fog computing. S. K. Polu [5] designed an IoT-based heart rate monitoring system specifically tailored for cardiovascular patients. The system continuously monitors changes in heart rate through the use of sensor networks and wireless communication modules. The proposed framework includes data visualization and alert generation functionalities, improving early diagnosis accuracy. This approach ensures both reliability and ease of deployment in remote healthcare facilities.

A. Benali [6] presented a continuous cardiovascular monitoring system using IoT-enabled wearable devices. The system integrates biosensors with wireless data transmission for seamless patient monitoring. Real-time analysis, portability, and low power consumption are the primary goals of the proposed architecture. This work highlights the potential of IoT wearables in providing uninterrupted healthcare services and reducing hospital workload.

B. Venkateswaran and D. Dagar [7] implemented a machine learning-based heart disease prediction model integrated with IoT data. The system collects physiological signals from IoT sensors and processes them using predictive algorithms to assess heart disease risk. Their model achieved high classification accuracy, demonstrating the synergy between IoT sensing and intelligent data analytics for preventive care.

B. Venkateswaran. An intelligent IoT-enabled framework for machine learning-based real-time heart disease prediction was proposed by Singh et al. [8]. The model processes sensor-based physiological data and employs classification algorithms for accurate disease detection. The proposed system demonstrates scalability, reliability, and strong predictive performance. This approach bridges IoT data acquisition with AI-driven diagnostics for improved healthcare automation.

R. Sharma, P. Verma, and A. Gupta [9] introduced an IoT-based system for heart monitoring and arrhythmia detection. The system uses wearable ECG sensors connected to cloud infrastructure for continuous signal monitoring and classification. Their machine learning model enhances the detection of irregular heartbeat patterns, providing a robust foundation for smart cardiac care solutions.

A. Brezulianu et al. [10] developed an IoT-based heart activity monitoring system utilizing inductive sensors. IoT modules receive and transmit heart activity signals from the system for real-time processing. Their work highlights the advantages of inductive sensing over traditional ECG electrodes, offering a non-invasive and continuous cardiac monitoring solution.

3. METHODOLOGY

The proposed system is structured into two primary phases: training and testing. During the training phase, machine learning algorithms are employed to improve the accuracy of disease prediction. Data is generated dynamically from an IoT-enabled environment, where multiple physiological sensors — such as ECG, heart rate, blood oxygen saturation (SpO_2), and body temperature monitors — are connected to a microcontroller (Arduino UNO). These sensors continuously capture real-time signals from the patient's body. The collected data is then transmitted to a dataset/database, preprocessed, and analyzed. By utilizing live sensor data, the system trains predictive models capable of making accurate health assessments and supporting proactive patient care**.**

4. CONCLUSION

The integration of Internet of Things (IoT) technology with advanced Machine Learning algorithms is revolutionizing modern healthcare by enabling real-time monitoring, early detection, and intelligent prediction of heart diseases. This review highlights how Body Sensor Networks (BSNs), when combined with hybrid machine learning models such as Artificial Neural Networks (ANN) and Random Forest (RF), can deliver high-accuracy diagnostic outcomes while reducing manual intervention. The continuous collection and analysis of physiological data—such as ECG, heart rate, blood pressure, and body temperature—allow for proactive healthcare management and timely medical response. The hybrid approach not only improves predictive accuracy but also enhances system reliability by leveraging ANN's pattern recognition and RF's ensemble learning capabilities.

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REFERENCES

[1] M. Tiwari and A. K. Waoo, "*Heart Attack Detection by Heart Rate Monitoring Using IoT Techniques*", ShodhKosh: Journal of Visual and Performing Arts, 2024.
[2] S. A. M. Al-Musheifri and S. A. Ahmed, "*IoT Based Framework for Remote Monitoring of Heartbeat Alert System by Using Arduino*", Journal of Student Research, 2020.
[3] S. Nayab, S. R. Chohan, A. Jameel, S. R. Shah, S. A. M. Zaidi, A. N. Jha, and K. Siddique, "*Advancing Remote and Continuous Cardiovascular Patient Monitoring through a Novel and Resource-Efficient IoT-Driven Framework*", arXiv Preprint arXiv:2505.03409, 2025.
[4] H. Kim, J. Park, and Y. Lee, "*An IoT and Fog Computing-Based Monitoring System for Cardiovascular Patients with Automatic ECG Classification Using Deep Neural Networks"*,Computer Communications, 2024.

[5] S. K. Polu, "*Design of an IoT Based Heart Rate Monitoring System for Cardiovascular Patients*", International Journal of Advanced Research in Computer and Communication Engineering (IJARCCE), 2024.
[6] A. Benali, "*Continuous Cardiovascular Health Monitoring with IoT-Enabled Smart Wearable Devices*", Journal of Deep Learning in Genomic Data Analysis, vol. 4, no. 1, 2024.
[7] B. Venkateswaran and D. Dagar, "*IoT Based Heart Disease Prediction Using Machine Learning*", Journal of Computational Analysis and Applications (JoCAAA), 2024.
[8] K. Singh, I. Yadav, B. Venkateswaran, S. Chauhan, S. Goyal, and A. Choudhary, "*Intelligent IoT-Enabled Framework for Real-Time Prediction of Heart Disease Using Machine Learning*", Frontiers in Health Informatics, vol. 13, no. 8, 2024.
[9] R. Sharma, P. Verma, and A. Gupta, "*IoT-Based System for Heart Monitoring and Arrhythmia Detection Using Machine Learning*", Biomedical Signal Processing and Control, 2023.
[10] A. Brezulianu, O. Geman, M. D. Zbancioc, M. Hagan, C. Aghion, D. J. Hemanth, and L. H. Son, "*IoT Based Heart Activity Monitoring Using Inductive Sensors*", Sensors (Basel), vol. 19, no. 17, 2019.