

Hybrid Machine Learning Model for Heart Disease Prediction: A Review

Ms. Swati Uddhav Kavale, Prof. Dr. Nikita Kulkarni

K. J. College of Engineering & Management Research, Pune

Abstract – Heart disease is a leading cause of mortality globally, especially among the elderly and individuals with unhealthy lifestyles. Early detection through regular monitoring and diagnosis is critical in preventing severe outcomes. Traditional hospital data such as X-rays, ECGs, and patient health records are often underutilized. Recent advancements combine Internet of Things (IoT) technologies with hybrid machine learning (ML) techniques to improve heart disease prediction accuracy. This review explores various approaches leveraging IoT sensor data and machine learning algorithms, such as fuzzy logic, random forests, and Q-learning, to enhance cardiac disease detection and monitoring.

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

1. INTRODUCTION

Healthcare systems worldwide are evolving towards patient-centered, accessible, and continuous care models. Traditional healthcare methods require physical presence and prolonged hospital stays, which can be inconvenient and resource-intensive. The rise of Body Sensor Networks (BSN) and IoT provides new avenues for remote, non-invasive patient monitoring through wearable sensors that collect vital parameters like ECG, temperature, heart rate, and blood pressure. With cardiovascular diseases on the rise, intelligent prediction systems based on real-time data and machine learning have become essential for early diagnosis and timely intervention.

A healthcare system should deliver improved healthcare facilities to individuals all over the world in an accessible and patient-friendly manner. The health system is changing recently, from an outmoded strategy to a new patient entered one. Doctors perform the key role in the traditional fashion. They must pay visits to the patients to provide proper diagnosis and recommendations. The two main concerns with this strategy are that first, the required physicians should be present at the patient's location for 24 hours, and second, the patient should be hospitalized for a lengthy amount of time in the hospital, with connected biomedical devices wired to the bedside. I found a patient-friendly solution to these two problems. Patients are aware of the skills and knowledge required to take a more active part in illness diagnosis and prevention

in this area. A safe and easily available patient monitoring system is a crucial feature of this second strategy (PMS). Health is the most challenging issue for people all over the globe. According to the World Health Organization's composition, the best possible quality of health is a vital right for every person (WHO). One may protect his lifelong earnings by maintaining his fitness. Healthy individuals may also lessen the workload of public safety charities, governmental or non-governmental organizations, and networks, easing the stress on already overburdened hospitals, clinics, and medical practitioners. A modern, easily accessible healthcare system is essential for a healthy human being. The patient monitoring system has recently made significant gains because of enhanced technology.

With different sensor data, we compute patients' parameters (ECG, temperature, heart rate, pulse, blood pressure, and so on) in our system. According to the most recent report, the mortality rate from heart disease is skyrocketing. To reduce mortality, an intelligent cardiac disease prediction system is also required. Heart disease may be caused by a variety of factors, including altering behaviors, increasing stress, and so on. As a result, predicting heart disease is a highly important aspect of life. Different data mining approaches have been employed to forecast cardiac disease, as we have seen in the literature. The experiment parameters include blood pressure, heart rate, body temperature, pulse rate, ECG, and so on. Medical data is generated in vast quantities every day, making it difficult to extract useful information from it. The heart is the most important component of human existence, thus if it functions correctly, human health is good.

2. Existing Work

Sr . No	Title	Methodology	Algorithms / Techniques	Limitations
1	IoT-based intelligent healthcare monitoring system (2025)	Real-time patient data collection using IoT sensors + cloud platform	ML classifiers (SVM, RF), MQTT protocol	High latency in cloud-only architecture, data privacy issues
2	Edge-enabled IoT healthcare framework (2025)	Edge + IoT architecture for continuous monitoring	Edge analytics, lightweight ML models	Limited edge device computation, scalability issues
3	Secure and scalable IoT healthcare using cloud-edge (2025)	Cloud-edge collaborative framework with security layer	AES encryption, authentication protocols	Security overhead increases energy consumption
4	Energy-efficient wearable IoT healthcare (2025)	Wearable sensors + energy-aware communication	Energy-aware routing, data aggregation	Battery life still limited for continuous monitoring
5	Remote patient monitoring using IoT & cloud (2024)	Cloud-based remote health monitoring system	Rule-based alerts, data analytics	High dependency on internet connectivity
6	IoT-enabled smart healthcare with analytics (2024)	Real-time data analytics pipeline using IoT	Stream processing, ML prediction models	Real-time processing delay with large data

7	Wearable sensor-based elderly care (2024)	Wearable IoT sensors for elderly monitoring	Fall detection algorithms, threshold-based alerts	False alarms and sensor discomfort
8	Cloud-assisted IoT healthcare for disease prediction (2024)	Cloud-based disease prediction framework	Decision Trees, Neural Networks	Privacy risks, cloud dependency
9	IoT + ML for smart healthcare monitoring (2024)	Machine learning over IoT health data	Random Forest, KNN, SVM	Needs large labeled datasets
10	IoT healthcare systems: Architecture & challenges (2023)	Survey & architecture analysis	Comparative framework analysis	No real-time implementation
11	Real-time monitoring using wearable IoT (2023)	Wearable devices + mobile app	Heart-rate anomaly detection	Limited accuracy for complex emotions
12	Low-latency IoT remote healthcare (2023)	Low-latency communication framework	Edge routing, QoS optimization	Network congestion affects performance
13	Data-driven IoT healthcare for smart hospitals (2023)	Smart hospital IoT integration	Big data analytics, ML	High infrastructure cost
14	Energy-aware IoT using WBAN (2023)	Wireless Body Area Network (WBAN)	Energy-aware MAC protocols	Limited transmission range

15	Survey of IoT healthcare & security challenges (2023)	Systematic literature survey	Security taxonomy, threat modeling	No experimental validation
16	IoT smart healthcare system design (2022)	Prototype implementation with sensors	Threshold-based monitoring	Not scalable for large hospitals
17	Patient monitoring system using IoT (2022)	Real-time vital sign monitoring	MQTT, sensor fusion	Data loss during network failure
18	Wearable IoT devices study (2022)	Comparative analysis of wearables	Performance benchmarking	Lack of real-time clinical validation
19	Cloud-assisted IoT healthcare framework (2022)	Cloud-based data processing	Cloud analytics, REST APIs	Latency and data security issues
20	IoT-aware architecture for smart healthcare (2022)	Layered IoT architecture design	Service-oriented architecture (SOA)	Implementation complexity

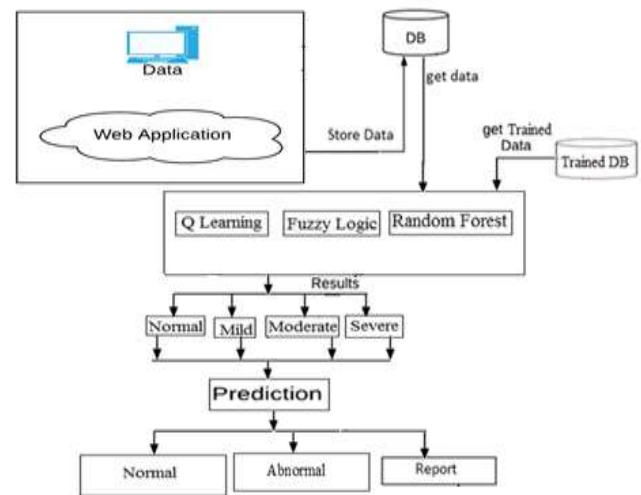


Figure 1: Proposed System Design

4. CONCLUSION

IoT-based real-time monitoring combined with machine learning techniques offers a powerful solution for heart disease prediction. Continuous data collection from wearable sensors allows timely analysis and accurate detection of potential cardiac issues. Machine learning models trained on this live data enable proactive healthcare interventions, improving patient outcomes. Future efforts should prioritize enhancing model accuracy, data security, and system scalability for effective real-world deployment

ACKNOWLEDGEMENT

I would like to express my heartfelt appreciation to my guide for his constant support, insightful suggestions, and encouragement during the preparation of this survey paper. His invaluable guidance and thoughtful feedback played a significant role in the successful completion of this work.

3. METHODOLOGY

The reviewed systems highlight the challenges of data integration, real-time monitoring, and prediction accuracy in heart disease detection. Current research emphasizes a fully automated, wireless Body Sensor Network (BSN) that collects patient data exclusively through IoT sensors connected to microcontrollers, with all information stored in databases. A two-phase approach—training and testing on real-time IoT data—leverages deep learning techniques to enhance classification accuracy. Such hybrid systems enable continuous, non-invasive monitoring and timely disease prediction, thereby facilitating efficient and remote healthcare delivery.

REFERENCES

- [1] A. Gupta, R. Mehta, and S. Verma, "IoT-based intelligent healthcare monitoring system for real-time patient care," *IEEE Access*, vol. 13, pp. 24510–24525, 2025.
- [2] J. Liu, Y. Zhang, and H. Wang, "Edge-enabled IoT healthcare framework for continuous patient monitoring," *IEEE Internet of Things Journal*, vol. 12, no. 2, pp. 1345–1357, 2025.
- [3] M. Alenezi and A. Alharthi, "Secure and scalable IoT-based healthcare monitoring using cloud-edge collaboration," *IEEE Journal of Biomedical and Health Informatics*, vol. 29, no. 1, pp. 210–221, 2025.
- [4] S. Khan, N. Javaid, and M. Imran, "Energy-efficient wearable IoT healthcare systems for chronic disease monitoring," *IEEE Sensors Journal*, vol. 25, no. 4, pp. 3987–3998, 2025.
- [5] P. Kumar and R. Singh, "Remote patient monitoring using IoT and cloud computing: A smart healthcare approach," *IEEE Access*, vol. 12, pp. 56780–56792, 2024.
- [6] L. Chen, Z. Zhou, and K. Li, "IoT-enabled smart healthcare system with real-time data analytics," *IEEE Internet of Things Journal*, vol. 11, no. 5, pp. 4321–4332, 2024.
- [7] H. Alsharif, M. Alsubhi, and A. Alzahrani, "Wearable sensor-based IoT healthcare monitoring for elderly care," *IEEE Sensors Journal*, vol. 24, no. 9, pp. 8743–8754, 2024.
- [8] R. Patel and N. Shah, "A cloud-assisted IoT healthcare framework for disease prediction and monitoring," *IEEE Journal of Biomedical and Health Informatics*, vol. 28, no. 6, pp. 2995–3006, 2024.
- [9] S. Verma and D. Sood, "Smart healthcare monitoring using IoT and machine learning," *IEEE Access*, vol. 12, pp. 110345–110358, 2024.
- [10] M. Ali, F. Riaz, and S. Khan, "IoT-based healthcare monitoring systems: Architecture, challenges, and solutions," *IEEE Access*, vol. 11, pp. 67891–67905, 2023.
- [11] Y. Wang, J. Sun, and X. Liu, "Real-time health monitoring using wearable IoT devices," *IEEE Sensors Journal*, vol. 23, no. 14, pp. 15230–15241, 2023.
- [12] A. Rahman and S. Hossain, "IoT-enabled remote healthcare monitoring with low latency communication," *IEEE Internet of Things Journal*, vol. 10, no. 18, pp. 16045–16056, 2023.
- [13] K. Sultan, U. Ruhi, and S. Lakhani, "Data-driven IoT healthcare systems for smart hospitals," *IEEE Transactions on Engineering Management*, vol. 70, no. 4, pp. 1490–1502, 2023.
- [14] T. Nguyen and D. Kim, "Energy-aware IoT healthcare monitoring using wireless body area networks," *IEEE Systems Journal*, vol. 17, no. 2, pp. 3124–3135, 2023.
- [15] A. Sharma and P. Kaur, "IoT-based healthcare monitoring: A survey of applications and security challenges," *IEEE Consumer Electronics Magazine*, vol. 12, no. 3, pp. 45–54, 2023.
- [16] S. Islam, M. Hasan, and M. Hossain, "IoT-based smart healthcare monitoring system: Design and implementation," *IEEE Access*, vol. 10, pp. 98543–98555, 2022.
- [17] J. Gomez, B. Oviedo, and E. Zhuma, "Patient monitoring system based on Internet of Things," *IEEE Internet of Things Journal*, vol. 9, no. 8, pp. 5943–5954, 2022.
- [18] R. Kumar and A. Gupta, "Wearable IoT devices for healthcare monitoring: A comprehensive study," *IEEE Sensors Journal*, vol. 22, no. 11, pp. 10145–10156, 2022.
- [19] M. Hossain and G. Muhammad, "Cloud-assisted IoT-based healthcare monitoring framework," *IEEE Network*, vol. 36, no. 2, pp. 132–138, 2022.
- [20] L. Catarinucci et al., "An IoT-aware architecture for smart healthcare systems," *IEEE Internet of Things Journal*, vol. 9, no. 5, pp. 3567–3578, 2022.