HEART ATTACK PREDICTION SYSTEM USING MACHINE LEARNING

Nitin Thakre[1], Kanishka S. Jiwane[2], Khushi S. Chakole[3], Prerna K. Patil[4], Prajakta G. Dongare[5]

1 Assistant Professor, Department Of Computer Science & Engineering, Govindrao Wanjari College of Engineering & Technology, Nagpur, Maharashtra, India
nitinthakre2020@gmail.com

2 Student, Department Of Computer Science & Engineering, Govindrao Wanjari College of Engineering & Technology, Nagpur, Maharashtra, India
kanishkajiwane442@gmail.com

3 Student, Department Of Computer Science & Engineering, Govindrao Wanjari College of Engineering & Technology, Nagpur, Maharashtra, India
khushichakole0312@gmail.com

4 Student, Department Of Computer Science & Engineering, Govindrao Wanjari College of Engineering & Technology, Nagpur, Maharashtra, India
patilprerna885@gmail.com

5 Student, Department Of Computer Science & Engineering, Govindrao Wanjari College of Engineering & Technology, Nagpur, Maharashtra, India
prajktadongre97@gmail.com

Abstract

Cardiovascular diseases, particularly heart attacks, remain one of the leading causes of mortality worldwide, emphasizing the need for early detection and preventive healthcare solutions. This paper presents a Heart Attack Prediction System using Machine Learning techniques to accurately identify individuals at risk. The proposed system analyses patient health parameters such as age, blood pressure, cholesterol level, heart rate, and ECG-related attributes. Supervised learning algorithms are employed to learn patterns from historical medical data and classify the likelihood of heart attack occurrence. The performance of the model is evaluated using standard metrics including accuracy, precision, recall, and confusion matrix. Experimental results demonstrate that the machine learning-based approach achieves higher prediction accuracy and reliability compared to conventional diagnostic methods, while also reducing human error and diagnostic time. The proposed system can assist healthcare professionals in making timely and informed decisions and can be integrated with IoT-based or embedded health monitoring devices for real-time prediction. This contributes to improved patient care, early intervention, and effective preventive healthcare management.

Keywords: *Heart Attack Prediction, Machine Learning, Artificial Intelligence, IoT, SpO_2, Heart Rate, Real-Time Monitoring, Smart Healthcare.*

Introduction

The Heart attack prediction systems represent a crucial component of the future of smart healthcare. In the current global health scenario, cardiovascular diseases are one of the leading causes of mortality, especially in urban and metropolitan regions due to lifestyle changes, stress, and lack of early diagnosis. Traditional medical diagnosis methods are often time-consuming and depend heavily on manual analysis, which may not be sufficient to handle the increasing number of patients and complex health conditions. The purpose of this paper is to propose a smart heart attack prediction system using machine learning techniques to accurately analyse patient health data and predict the risk of heart attack at an early stage. An efficient machine learning algorithm is employed to classify patients into different risk categories, enabling early prediction and prevention of severe cardiac events. Additionally, real-time data collected from wearable health monitoring devices can be integrated into the system to continuously monitor patient conditions. In emergency situations, such as abnormal heart rate or sudden cardiac abnormalities, the system can immediately notify hospitals, doctors, or caregivers for quick medical intervention. The system also supports intelligent decision-making by assisting doctors with accurate predictions and reducing diagnostic errors. Technologies such as Python, machine learning libraries, and healthcare databases are used to develop and implement the predicted model.

Heart rate and pulse signals are vital physiological indicators that reflect the functioning of the human cardiovascular system. Abnormal pulse rate patterns and irregular heartbeats are often associated with an increased risk of heart-related disorders. Traditional diagnostic methods such as electrocardiograms (ECG), stress tests, and laboratory examinations provide accurate results but are costly, time-consuming, and not suitable for continuous monitoring in daily life.

Recent advancements in embedded systems, biomedical sensors, and machine learning have enabled the development of intelligent and portable health monitoring devices. Pulse sensors based on

photoplethysmography (PPG) offer a non-invasive and cost-effective way to measure heart rate in real time. When combined with machine learning algorithms, these sensors can be used not only for monitoring but also for predicting potential heart attack risks.
This project proposes a Heart Attack Prediction System using Machine Learning, implemented as a hardware-based device capable of measuring human pulse rate in real time. The system processes pulse data, extracts relevant features, and applies trained machine learning models to predict the likelihood of a heart attack. The objective of this project is to develop a low-cost, portable, and efficient solution that can assist in early detection of cardiac risk, thereby enabling timely medical intervention.

1. Literature Survey

Heart attack prediction has become a critical research domain due to the rising need for continuous and intelligent cardiac monitoring. IoT assisted frameworks use wearable sensors to collect real-time physiological signals such as heart rate, ECG, blood pressure, and stress indicators, enabling early detection of cardiovascular abnormalities. Many approaches leverage sensor networks for remote monitoring in home and outdoor environments, supporting timely risk assessment outside clinical settings. Machine learning integration with ECG systems has shown effectiveness in analysing cardiac activity and classifying high-risk conditions, often enhanced by motion-based heart activity analytics.
Deep learning models applied to ECG and bio signal amplifiers demonstrate high sensitivity toward abnormal cardiac patterns, making them suitable for early heart attack risk detection. Hybrid feature fusion models combine multiple wearable inputs—ECG, pulse rate, oxygen saturation, and BP—to improve predictive accuracy by incorporating diverse medical and lifestyle parameters.
Despite promising advancements, challenges remain, including sensor drift affecting long term measurement reliability, environmental noise distorting ECG and BP readings, missing or delayed data packets during wireless transmission, and high-power dependency due to frequent charging requirements. Signal artifacts and noise sensitivity further reduce classification robustness, especially in real-time IoT-based deployments.
Cardiovascular diseases (CVDs), particularly heart attacks, are one of the leading causes of mortality worldwide. Early detection and continuous monitoring of heart-related parameters play a crucial role in reducing fatal outcomes. In recent years, researchers have focused on integrating biomedical sensors, embedded systems, and machine learning techniques to develop intelligent heart monitoring and prediction systems.
Several studies highlight the importance of heart rate and pulse signals as key indicators of cardiac health. Pulse rate variability and abnormal heart rate patterns are strongly associated with cardiovascular risks. Traditional diagnostic methods such as ECG and angiography are accurate but expensive, time-consuming, and not suitable for continuous monitoring. This limitation has motivated researchers to develop non-invasive, low-cost pulse-based monitoring systems.
Machine Learning has significantly improved the predictive capability of heart disease detection systems. Various algorithms such as Logistic Regression, Decision Trees, Random Forests, Support Vector Machines (SVM), and K-Nearest Neighbours (KNN) have been used in previous works. Comparative studies indicate that ensemble models like Random Forest often achieve higher accuracy due to their ability to handle non-linear relationships and noisy medical data.
Some existing systems rely solely on clinical datasets containing parameters like cholesterol, blood pressure, and ECG results. However, these systems are not suitable for real-time monitoring. To address this issue, recent research has shifted toward sensor-based real-time health monitoring devices that combine physiological signals with machine learning models. Pulse-based systems offer portability and continuous monitoring, making them suitable for early warning systems.
Overall, existing studies highlight that combining IoT sensing with ML and deep learning enhances early heart attack prediction, but improving signal stability, noise handling, and energy-efficient transmission remains an open research gap, motivating the development of more reliable and low-power intelligent cardiac risk prediction systems.

2. Proposed System

The proposed system is a hardware–software integrated medical prediction device that measures a human's pulse rate in real time and predicts the likelihood of a heart attack using Machine Learning techniques. The methodology is divided into sequential phases as described below.
1. System Overview
The system consists of:

- A pulse sensing module to capture real-time heart rate signals

- A microcontroller unit for signal processing
- A machine learning model for heart attack risk prediction
- A display/interface module to show results

The device works by acquiring pulse data from the user, processing it, and predicting the risk level (Low / High).

2. Pulse Data Acquisition (Hardware Layer)

A pulse sensor is used to measure the user's heart rate non-invasively through the fingertip.

- The sensor detects changes in blood volume using photoplethysmography (PPG).
- Analog pulse signals are generated corresponding to heartbeats.
- The user places their finger on the sensor for a fixed duration (e.g., 30–60 seconds).

This enables accurate pulse rate measurement in beats per minute (BPM).

3. Signal Conditioning and Processing

The raw pulse signal may contain noise due to motion or external light. Therefore:

- Signal filtering techniques are applied to remove noise.
- Peak detection algorithms are used to calculate BPM.
- Abnormal pulse patterns are identified.

The processed pulse values are forwarded to the prediction module.

4. Feature Extraction

From the pulse signal, meaningful features are extracted such as:

- Average heart rate
- Maximum and minimum pulse rate
- Pulse variability
- Irregular heartbeat indicators

These extracted features form the input vector for the machine learning model.

5. Dataset Preparation

A dataset is created by combining:

- Real-time pulse data collected from users
- Labelled medical heart disease datasets (for training)

Data preprocessing includes:

- Normalization of pulse values
- Removal of outliers
- Label encoding (risk / no risk)

6. Machine Learning Model Development

The processed dataset is used to train Machine Learning classifiers such as:

- Logistic Regression
- Decision Tree
- Random Forest
- Support Vector Machine (SVM)

The dataset is split into training and testing sets to ensure unbiased evaluation.

7. Model Training and Optimization

- Models are trained using extracted pulse-based features.
- Hyperparameter tuning is performed using cross-validation.
- The best-performing model is selected based on evaluation metrics.

8. Prediction and Decision Making

When real-time pulse data is received:

1. Features are extracted
2. The trained ML model predicts heart attack risk
3. The result is classified as:
    - Low Risk
    - High Risk

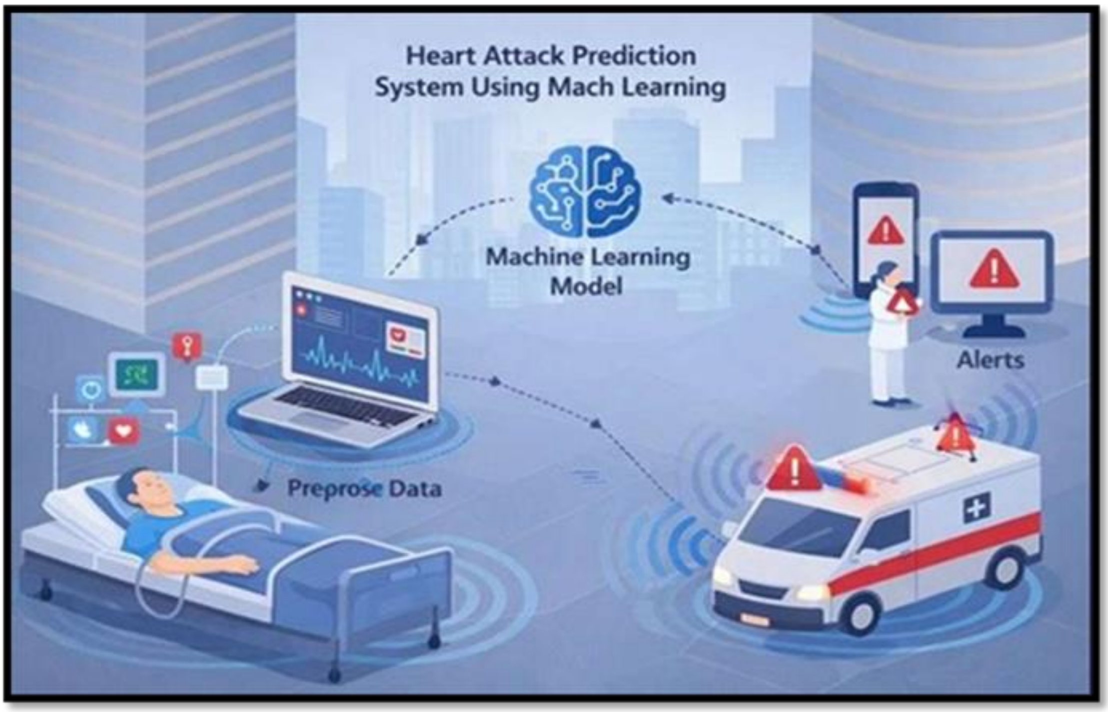

Figure.1. Real-Time Heart Attack Monitoring and Prediction System

- Continuous IoT-based acquisition of ECG signals and vital health parameters
- Machine learning–based cardiac risk classification for early heart attack prediction
- Effective noise reduction and missing data/packet handling during signal preprocessing
- Real-time alert generation and instant notification to caregivers and medical services
- Remote monitoring and visualization through a real-time dashboard.

3. Methodology

The heart attack prediction system is focused on achieving early and accurate detection of heart-related risks in patients while minimizing false alarms and delays in medical intervention. The system uses machine learning models to analyse patient data and predict potential heart attacks before symptoms become critical.

1. Early Detection of Heart Attack Risk

The primary objective of the system is to identify high-risk patients early using various health parameters such as blood pressure, cholesterol levels, ECG readings, heart rate, and lifestyle factors. By applying machine learning algorithms (like Logistic Regression, SVM, or Random Forest), the system can detect hidden patterns in patient data, which may not be visible during routine checkups. This ensures timely medical advice and preventive measures, reducing the chances of severe cardiac events.

2. Prioritizing Critical Patients

In emergency situations, the system can prioritize high-risk patients for immediate medical attention. For example, real-time monitoring through wearable devices or hospital sensors sends patient data to the system. If the prediction model identifies an imminent heart attack, doctors are alerted immediately, allowing them to respond faster. This reduces response time, potentially saving lives.

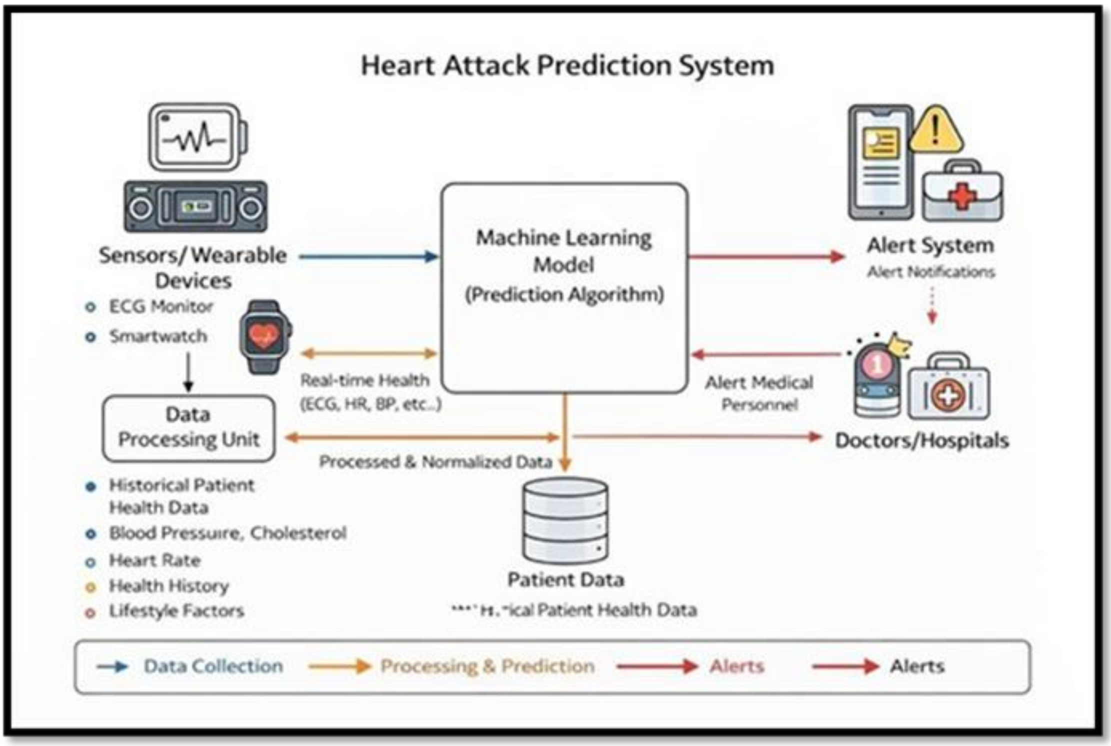

Fig.2: Heart Attack Prediction System

3. Core Components of the System

- Machine Learning Model: The heart of the system, trained on historical patient data, to predict the risk of heart attacks.
- Sensors and Wearables: Devices like ECG monitors, blood pressure sensors, and smartwatches continuously gather patient health data.
- Data Processing Unit: Preprocesses collected data (cleaning, normalization) before feeding it to the IoT model.
- Alert System: Sends notifications to doctors, hospitals, or patients if the model predicts a high risk of heart attack.

Fig.3: Hardware

- ESP32 Microcontroller
  A 32-bit controller that acts as the main processing unit of the system.
- Power Supply (5V via USB)
  Provides required power to the ESP32 and other components.
- Voltage Regulator IC
  Maintains a stable voltage and protects the circuit from fluctuations.

- Display (LCD/OLED)
  Used to show output such as system status or finger detection.
- Sensor (IR/Finger Sensor)
  Detects the presence of a finger using light emission and reception.
- LED Indicator
  Shows system status (ON/OFF or initialization).

4.Results

The embedded system monitors critical physiological parameters including heart rate and body temperature for heart attack risk assessment. Abnormal pulse conditions are detected by continuously analysing heart rate variations. Body temperature is monitored to identify fever and hypothermia conditions, which may indicate health abnormalities. The system processes sensor data using the ESP32 microcontroller in real time. Based on predefined threshold values, the system classifies the patient's condition as normal or high risk. During normal conditions, the system maintains LED indication with buzzer turned OFF. When high-risk conditions are detected, the LED is turned OFF and the buzzer is activated. The alert mechanism is triggered within 2 seconds, ensuring timely notification. Experimental results show that the system correctly identifies abnormal conditions. Minimal false alerts were observed during testing, indicating reliable system performance. The proposed embedded system demonstrates stable, accurate, and continuous operation. The compact and low-cost design makes the system suitable for real-time and continuous cardiac health monitoring.

5.Conclusions

The Heart Attack Prediction System using Machine Learning represents a powerful, modern approach to preventive healthcare. By using patient health parameters such as blood pressure, cholesterol levels, ECG readings, glucose levels, age, and lifestyle habits, IoT algorithms provide fast, accurate, and reliable predictions of heart attack risk. The system plays a critical role in reducing mortality rates by enabling early diagnosis and timely treatment.

This technology is low-cost, user-friendly, and capable of integrating with mobile applications, wearable devices, and hospital systems. Although challenges such as dataset quality, privacy issues, and model limitations exist, continuous advancements in AI, deep learning, and healthcare analytics are rapidly improving accuracy and usability.

Figure 3: Embedded Systems

Machine learning algorithms such as Logistic Regression, Decision Trees, Random Forest, Support Vector Machine (SVM), and Neural Networks enhance predictive performance by identifying complex relationships within medical data. This enables healthcare professionals to make informed decisions, prioritize high-risk patients, and implement preventive measures at an early stage.

However, the model's effectiveness depends on the quality and size of the dataset, proper feature selection, and regular model updates. Ethical considerations such as data privacy, security, and fairness must also be addressed to ensure responsible deployment in real-world healthcare environments.

In conclusion, the Heart Attack Prediction System highlights the transformative role of machine learning in modern healthcare. With continuous improvement and integration into clinical workflows, such systems can significantly contribute to reducing mortality rates and improving patient outcomes through early diagnosis and preventive care.

Overall, the project offers a promising solution for global cardiac health improvement, empowering doctors with better tools, supporting patients through early alerts, and ultimately contributing to a healthier society.

References

1. Sharma, R., & Patel, K. (2024). IoT-Assisted Early Heart Attack Monitoring System Using ECG and BP Sensors.
2. Verma, A., Khan, S., & Thomas, L. (2023). Wearable IoT-Driven Heart Disease Detection Framework Using Smart ECG and Pulse Sensors.
3. Roy, M., & Banerjee, D. (2023). IoT Sensor Network for Cardiovascular Risk Assessment Using Multi-Sensor Health Data.
4. Mehra, J., & Gupta, P. (2023). Real-Time Heart Attack Prediction Using IoT-Enabled Continuous ECG and Bio signal Monitoring.

5. Kulkarni, S., & Deshmukh, H. (2024). IoT-Enabled Smart Cardiac Alert System Using ECG, Heart-Rate, and BP Sensors.
6. Menon, R., & Sinha, P. (2021). IoT-Based ECG Abnormality Detection Framework Using Deep Learning and Bio-Signal Sensors.
7. Choudhary, L., & Fernandes, M. (2021). Multi-Sensor IoT Architecture for Heart Attack Prediction Using Wearable ECG, BP, and SpO_2 Sensors.
8. Borkar, S., & Rawat, T. (2022). Cloud-Connected IoT Healthcare System for Cardiac Risk Prediction Using ECG and Heartbeat Sensors.
9. Das, A., & Kamat, F. (2020). IoT-Based Medical Data Streaming System for Real-Time Heart Attack Risk Analysis.
10. Shetty, D., & Nair, V. (2020). Ensemble IoT Sensor Network for Large-Scale Cardiovascular Disease Prediction Using ECG, HR, and BP Nodes.