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RESEARCH

Identification and alertness of cardiovascular disease using MATLAB with IoT

J. A. Sandhiya[1], S. Preetha[1], A. Sarumathi[1], D. Umadevi[1], G. Yogeshwari[1] and Kirubanandan Shanmugam[2]*

[1]Gnanamani College of Technology, Anna University of Chennai, Namakkal, India
[2]Department of Biotechnology, Sree Sastha Institute of Engineering and Technology, Chennai, Tamil Nadu, India

***Correspondence:**
Kirubanandan Shanmugam,
kirubanandan.shanmugam@gmail.com

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The last several decades have seen cardiovascular illnesses become the leading cause of mortality globally, in both industrialized and developing nations alike. Clinical staff monitoring and early diagnosis of heart disorders can both lower death rates. However, because it takes more intelligence, time, and skill, precise cardiac disease identification in every case and 24-h patient consultation by a doctor are not yet possible. With the use of machine learning techniques, a preliminary concept for a cloud-based system to predict heart disease has been put out in this study. An effective machine-learning strategy should be applied for the precise identification of cardiac illness. This method was created after a thorough comparison of many machine learning methods in MATLAB coding. The application may thus be utilized by the medical professionals to monitor the patient's real-time sensor data and begin live video streaming if urgent care is necessary. The ability of the suggested method to notify both parties right away when the patient checks the stage while the doctor isn't there was a crucial component.

Keywords: detection of heart disease, cloud-based predication, MATLAB coding, alert message

Introduction

The body's circulatory system, which also comprises the lungs, is controlled by the heart, a kind of muscle organ. The heart serves as the body's main blood pump. The cardiovascular system is a network of blood vessels that includes capillaries, veins, and arteries. All across the body, these blood vessels distribute blood. Cardiovascular disorders, often known as heart diseases, are characterized by deviations from the heart's normal blood flow (CVD). The leading causes of death globally are heart disorders. The World Health Organization (WHO) study estimates that heart attacks and strokes are responsible for 17.5 million of all global fatalities. Most cardiovascular disease deaths—more than 75%—occur in low- and middle-income nations. Additionally, heart attacks and strokes account for 80% of mortality caused by CVDs (1).

As a consequence, by identifying cardiac anomalies early on and developing tools for heart disease prediction, the death rate from cardiovascular illnesses can be decreased. Early diagnosis of cardiac anomalies and methods for forecasting heart illness can therefore save many lives and aid in the development of successful treatment plans, which in turn lowers the death rate from cardiovascular problems. The healthcare industry nowadays produces a huge amount of data about patients, illnesses, and other subjects. There are several techniques available for extracting hidden patterns or similarities from data through data mining (2). This study suggests using machine learning to create a system that can anticipate cardiac disease. This algorithm's capacity to forecast heart illness was evaluated using two open-access datasets.

This work also presents a system for monitoring cardiac patients using MATLAB, several physiological signal sensors, and the Internet of Things (IoT). Currently, information is collected, analyzed, and sent between nodes in sensor networks utilizing IoT technologies. A multitude of sensors and data collectors may detect, share, and communicate via private, public, or internet protocol (IP) networks thanks to the IoT, a relatively new and rapidly evolving technology.

The sensors gather the data after a predetermined amount of time, analyze it, and use it to carry out the appropriate action, in addition to providing an intelligent cloud-based network for planning, analysis, and decision-making. Due to IoT products like embedded technology, which allow for data transfer between nodes or the Internet, it is predicted that between 8 and 50 billion things will be connected by 2020 (3).

Objectives and background

Several study findings addressed the applicability and benefits of utilizing machine learning to detect and predict cardiac disease. The use of MATLAB IoT to enhance sickness detection systems, especially those for cardiac ailment performance, is similar to other well-known models now in use, such as the American Heart Association (AHA) and American College of Cardiology (ACC) models, in the identification and prognostication of CVD (4). In addition to analyzing the potential and associated issues of delivering enhanced services of a human health management system, Wang, Zhao, and Nakahira provided a research route for medical technology on the IoT in 2011 (5). They looked into a variety of sensors and health-related technology. They identified a few issues that needed to be resolved. The decision-support and home monitoring system was created in 2014 by Chiuchisan and Geman (6). It has been observed that alternative machine-learning approaches and weighted associative classifiers perform better for diagnosing cardiac abnormalities (7).

An in-the-moment mobile healthcare system in Rincon et al. (3) has shown the capability to monitor elderly people from indoor or outdoor areas. The two main parts of the system were a signal sensor and a smartphone. Delivering data to a smart server over the GPRS/UMTS network is how the bio-signal sensor collects data. Using the apparatus, it is possible to remotely monitor the status, location, and vital signs of an elderly patient. Wireless body area network (WBAN) technology has been defended by (8) in favor of its use. In order to gather physiological data from sensors, the design of the system uses medical bands. To lessen interference between sensors and already-in-use equipment, the author has selected appropriate medical bands. In this process, a wireless medical gateway board was employed to apply the multi-hopping approach and extend the operational range.

Using fuzzy cognitive mapping and structural equation modeling (SEM), Manpreet Singh et al. (9) created a method for predicting cardiac illness (FCI). They looked at the results of the 2012 Canadian Community Health Survey (CCHS). Twenty fundamental traits were applied. Using SEM, which also forecasted the likelihood of cardiovascular disorders, the weight matrix for the FCM model was produced. Together with the variable CCC 121, which indicates if the responder has heart disease, a SEM model is created using 20 attributes. An intelligent system for heart attack prediction utilizing large data sets was studied by Prajakta Ghadge et al. (10). Due to the high occurrence of heart attacks, prompt and accurate diagnosis is required. This study's major goal was to identify a working prototype of a big data and data mining modeling-based system that can forecast heart attacks. A provided heart illness database might be used by this technology to extract hidden information about heart disease.

With support vector machines, a data mining approach that outperforms naive Bayes, random forest, simple logistic regression, and artificial neural networks (ANN) in terms of accuracy and performance, the aim of this work is to develop a decision support system for the early diagnosis of heart disease. Blood pressure, sex, blood sugar, age, and electrocardiography (ECG) readings are a few characteristics of the cardiovascular system that may be used to determine a person's risk of acquiring heart disease (11). For the purpose of selecting the algorithm that would accurately diagnose and forecast heart illness, a comparison of a few chosen machine-learning algorithms has been shown.

The suggested system consists of the structure and layout of an Android web application that effectively detects heart disease using machine learning. It can be a very helpful tool for diagnosing cardiac problems for doctors, patients, and medical students. After being discharged from the hospital and moving into their home, patients need to have their health monitored for 24 h in order to diagnose deadly physiological disorders and symptoms like heart attacks.

Anywhere on the application interface where the patient enters their current heart disease parameters will allow them to view their risk of getting heart disease. Some criteria, such as the kind of chest pain and exercise-induced angina, require the patient to self-measure them on a regular basis and manually enter the data on the application interface. All of the non-real-time information, such as serum cholesterol, blood sugar, and ECG results, will be included in the doctor's recommended report. The patient can video contact any licensed physician who specializes in treating heart disease in the event that the program detects a potentially deadly problem. To find the doctor's phone number, use the search bar.

Heart patients who require critical care can be continuously monitored in hospitals, but once they are discharged, they are often no longer under direct observation. For at least a week or so, these patients require constant observation of their medical status to lower the danger of unintended sequelae. Through the Wi-Fi module, the sensor data may be transferred to the server and saved in the server database. Due to the sensor data being updated on the server every 10 s, clinicians may use this application to get their patients' most recent health status from any location. A notice is sent to both their phones and the software when they check the patient's or doctor's physical status. The program allows families and carers to view the patient's current data.

Methodology and data analysis

In this study, a large dataset was utilized to identify an efficient machine learning algorithm from among the options using the Java-based open access data mining platform dataset (WEKA).

The following lists the proposed system's step-by-step design processes and its workflow as a whole: Figure 1 shows the steps in the processing of conversion images.

- Collecting and picking distinctive machine learning datasets related to heart disease.
- The effectiveness and accuracy of several data mining algorithms in predicting cardiac disease are compared.
- Choosing the optimal algorithm from the model performance traits to create a mobile application that uses the cloud to forecast heart disease.
- Storing medical records on a cloud-based server for analysis after doctors and patients have registered individually through the program.
- The analysis and results section includes a full-fledged design for a preliminary Android application with the appropriate requirements.
- The patient may manually enter all heart disease-related parameters and sensor data, such as heartbeat, using the application interfaces. They can thus anticipate whether or not they develop cardiac disease.
- When a doctor has joined the service, the patient may use the search tool to transmit the results to them in report format. A live video call with the doctor might also be made in a situation where life is in danger.
- The doctor will connect to the program after getting an alert message with the current sensor data on his phone in order to review the patient's prior physiological data and receive guidance on the best course of therapy through live video streaming (Table 1).

Proposed system

The proposed system's overview is shown in this section, along with an explanation of all the many parts, methods, and resources that were used to create the whole thing.

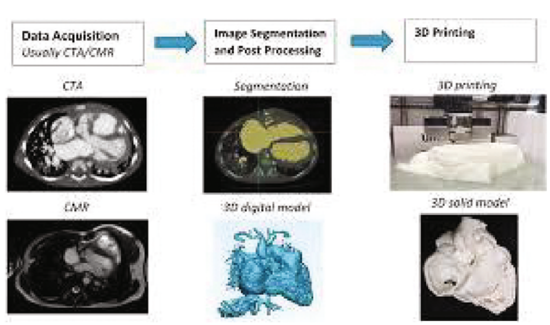

FIGURE 1 | Process of conversion image.

TABLE 1 | Table of data collected on the symptoms and causes of various forms of heart disease.

S. No.	Types of disease	Symptoms	Prevention
1.	Coronary artery disease (CAD)	Damage/disease in blood vessels (chest pain, heart attack)	Eat heart-healthy die, reduce the high pressure, avoid sweets, fried food and processed meats, take teaspoon of salt per day.
2.	High blood pressure (Hbp)	Blurry/double version, headache, fatigue, nosebleeds, shortness of breath, nausa/vomiting	Physical exercise, stress manage, home bp monitor, low sodium diet, quiet smoking, low weighted jewellery used.
3.	Cardiac arrest	Collapse, no	Eat healthy diet, exercise

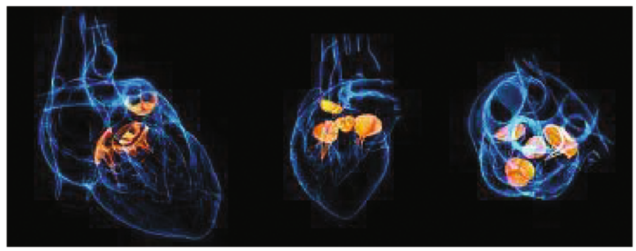

FIGURE 2 | 3D image of heart valves.

An effective software solution is required to train big datasets and compare several machine-learning algorithms in order to create a clever and user-friendly system for heart disease prediction.

Using the robust algorithm that has been shown to have the highest accuracy and performance metrics, smartphone-based software for identifying and forecasting heart disease risk levels will be created. The continuous patient monitoring system must be built using hardware components, including MATLAB, several biological sensors, a display monitor, and an EPS32 IoT kit (Figure 2).

Required software and hardware MATLAB IoT

You can build, prototype, and deploy IoT applications like supervisory control, predictive maintenance, and more with the aid of MATLAB§ and Simulink®.

With built-in interfaces to relational and non-relational databases, cloud storage, and protocols like REST, MQTT, and OPC UA, you can access and preprocess streaming and archived data.

By picking from hundreds of tried-and-true prebuilt functions for subjects like data erasure, machine and deep learning, computer vision, controls, and optimization, you may create new IoT analytics and algorithms rapidly. Take advantage of current features, modify them, or create your own.

Create digital twins utilizing data-driven and physics-based models to comprehend, manage, and optimize your linked items.

Simulink models and automatically generated MATLAB analytics may be sent to any asset, edge, or cloud in the form of C/C++, HDL, PLC, or GPU software elements that are based on Java® or NET.

Design and operationalize smaller-scale systems using ThingSpeak™, an IoT platform with ready-to-use MATLAB analytics.

Access streaming and archived data

Your algorithms are built with MATLAB and big data. Data that has been time-stamped and is unstructured can come from a variety of sources, including databases, cloud storage options (such as AWS S3, Azure Blob, OPC UA, and RESTful web services), and cloud storage providers (like AWS S3 and Azure Blob). Utilize streaming protocols like Kafka and message brokers like MQTT by connecting MATLAB with linked assets to work with real-time data.

By replacing missing or incorrect values, smoothing out data, and aligning data sets with various timestamp formats, you can quickly do data munging and cleaning by utilizing built-in capabilities (**Figures 3–6**).

Develop analytics, control, and optimization algorithms

The dozens of functions available in MATLAB, including those for signal and image processing, feedback and supervisory control, optimization, and machine learning, may be utilized to create IoT applications.

By altering or generating pre-existing functions, you may develop algorithms considerably more quickly using MATLAB than with typical programming languages. Many common IoT settings, such as huge data or streaming, may employ the same method.

Automate deployment to the edge, asset, or cloud

You can use the edge, an asset, or the cloud to deliver Simulink models or MATLAB programs. The ability to create run-time executables, components, or containers is available for desktop, server, on-premises, and cloud applications. You may produce GPU, Verilog/VHDL, or C/C++ code for embedded devices automatically. Examine and test the appropriate locations for your IoT system's algorithms, such as the asset or edge for time-sensitive control loops, the on-premises data center for big data analytics, or the cloud for Monte Carlo simulations.

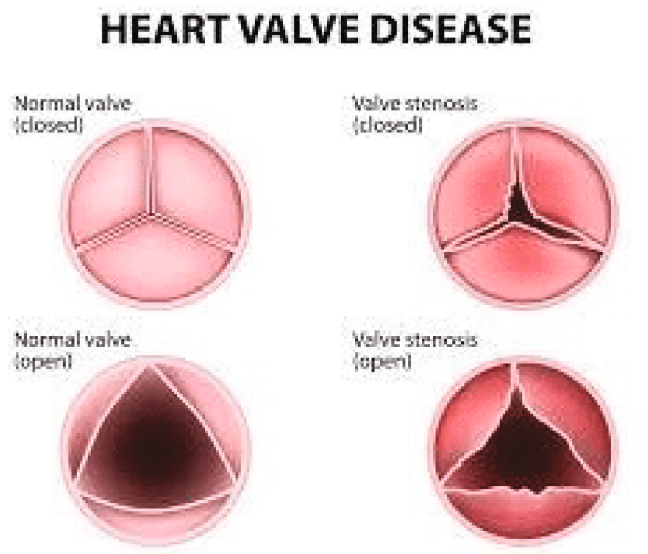

FIGURE 3 | Normal and abnormal heart valves.

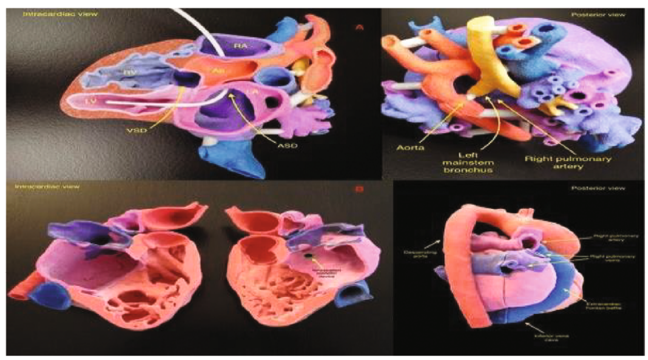

FIGURE 4 | 3D printing bolsters care for CHD.

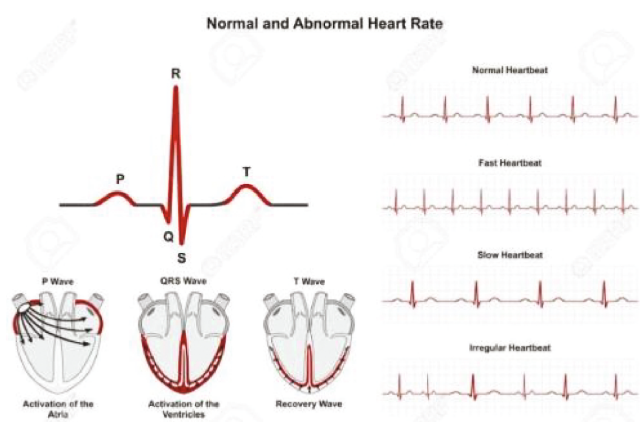

FIGURE 5 | Normal and abnormal heart rate.

ThingSpeak: A MATLAB-enabled-IoT platform

ThingSpeak is a pleasant cloud-based platform that is ideal for IoT prototypes and small-scale production applications.

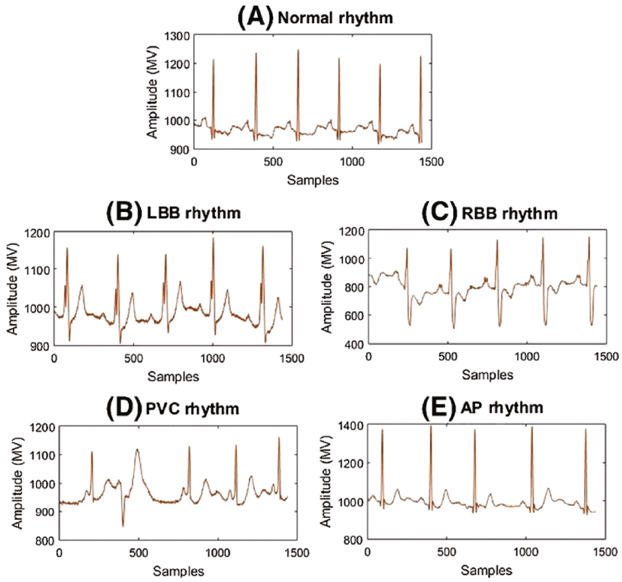

FIGURE 6 | Graphical waveform of heart rhythm.

From your devices, use the MQTT or REST APIs to send data to ThingSpeak. From any web browser with an internet connection, instantly visualize your real-time data. You can use MATLAB code to do live analysis and visualizations when fresh data is received via ThingSpeak. Utilize your data by generating alerts and initiating responses.

Result and conclusion

This research made an effort to suggest cardiovascular disease detection and prevention using MATLAB and IoT. Information for the suggested model was acquired from a variety of hardware items. It is possible to enhance the proposed model by using more sophisticated feature selection algorithms, optimization methods, and classification methods.

The discussed algorithms can be used to increase the prediction system's effectiveness in making a heart disease diagnosis. Additionally, this approach may be used in real-time applications. We can accurately diagnose the stage of a disease and its treatment using this approach. The capability as an alert message to a certain individual along the webpage is included in this article. While the patient is checking his or her body, an alarm message is received. No unwanted communication is ever received at an unfavorable moment. So, the patient won't likely find it irritating.

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