MACHINE LEARNING BASED INTERNET OF THINGS (IOT) ENABLED HEALTHCARE SYSTEM

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ABSTRACT: A new coronavirus has prompted countries around the world to emphasize health care. In addition to sensory equipment, technology plays a vital part in healthcare in the form of communication, recording and display devices.Monitoring numerous medical indicators and post-operative days is crucial. This has enabled the most recent IoT-based trend in healthcare communication. In previous ten years, there has been a great deal of technology advancement and healthcare services-related research. More specifically, the Internet of Things (IoT) has demonstrated potential use in connecting different medical equipment, sensors, and healthcare professionals to deliver high-quality clinical services in a remote region.On the other hand Machine Learning (ML) has gain lot of attention in recent times due to its accurate performance. Hence, in this paper Machine learning based IoTenabled healthcare system is presented to detect and monitor the heart disease condition and health condition of a patient.As a result, the healthcare sector will operate more efficiently, lower healthcare costs, boost accessibility to healthcare services, and improve patient safety.In this approach four different ML algorithms namely Decision Tree (DT), K-Nearest Neighbor (K-NN) and Support Vector Machine (SVM) and their performance is assessed in terms of accuracy, precision, F1-score and Recall.

KEYWORDS: Health care system, Machine Learning, Internet of Things (IoT), Corona virus.

I. INTRODUCTION

When humankind advances technologically, health is always a key worry. An example of how health care has taken on critical importance is the recent corona virus onslaught, which has largely destroyed China's economy. The provisionof health care is a basic human right.A tremendous burden is being put on contemporary healthcare systems by constantly aging population and the rise in chronic sickness that results from this. The number of healthrelated problems orcomplications are rising daily, with lung and heart problems topping the list. Wireless technology, which is a contemporary idea, can be used to monitor health.Wearable sensors, mobile remote medical systems, wireless connectivity, and expert systems are just a few of the several technologies employed in wireless health monitoring systems. Even one life is priceless, but people are losing their lives owing to a lack of healthcare facilities, lack of understanding of diseases and unsuitable access to healthcare services. IoT supports illness detection and patient treatment under all conditions.

IoT enables physical items to be connected to the Internet and data can be exchanged or received via Internet [1]. The progress in technology over the years has made it possible to use tiny gadgets like smart watches to diagnose a variety of ailments and track one's health.In addition, technology has changed the healthcare system from being centered around hospitals to being centered around patients. The measurement ofblood pressure (BP), blood glucose level, pO2 (partial pressure of oxygen) level, and other clinical analyses, for instance, can be done at home without a healthcare provider's assistance.With the use of cutting-edge telecommunications systems, remote places can also send clinical data to medical centers. The utilization of these communication services along with quickly developing technology

including ML, big data analysis, IoT, wireless sensing, mobile computing, and cloud computing has increased the availability of medical services [2].

A variety of illnesses that impact your heart are referred to as heart disease. Because of numerous contributing risk factors like diabetes, highBP, high cholesterol, irregular pulse rate and many other factors, it is challenging to diagnose heart disease. Among the most vital parts of the human body, the heart pumps blood to all the body organs. For instance if heart doesn't work properly then the mind and various other organs will quite working which can prompt the demise of individual within couple of minutes. Hence, proper functioning of heart is of great significance.

In an IoT healthcare system, there are wireless systems that allow attachment of various apps and sensors to patients, the collection of data, and the transmission of that data to a physician or other healthcare professional via an expert system. A protected cloud platform is used by the expert system to transport patient data and information, where it is saved and made available for analysis. Connected to the Internet, Medical Devices for the IoT (MD-IoT) allow sensors, actuators, and some other communication systems to check patient health.

In order to identify critical circumstances, IoT and Machine/Deep Learning (ML/DL) based algorithms can gather and analyze data from wearable, ingestible, and embedded sensors as well as information about mobility patterns and device usage.This data can be used to track user behaviors. Numerous deaths currently occur as a result of inaccurate and delayed health information. Through the utilization of sensors, this technology can instantly alert users about any health-related difficulties.

IoT data is a significant source of information that machine learning can detect. Smart use of hybrid technologies has improved decision-making in a variety of fields, including business, security, education, and healthcare. For the best prediction and recommendation systems, ML enables the IoT to demystify the hidden patterns in large amounts of data. IoT and ML have been adopted in healthcare so that automated devices may create medical records, forecast disease diagnoses, andmost importantly it conduct real-time patient monitoring. On various datasets each ML methods functions differently [3].

The term "smart healthcare system" refers to a technology that allows patient treatment and raises general standard of living. The idea of "smart health" also encompasses the idea of "e-health," which has concentrated on several technologiesincludingelectronic record management, smart home facilities, intelligent and clinically connected devices. Sensors, smart gadgets, and expert systems support intelligent medical systems.

The use of remote health monitoring to improve health management calls for reliable monitoring and patient data privacy protection. Additionally, accurate and ongoing monitoring of one's health status may call for professional confirmation in an active learning approach [4]. Hence, in this paper Machine Learning based IoT enabled Healthcare system is presented to detect and monitor the heart condition and health condition of a patient.

The rest of the paper is organized as follows: The relevant research on healthcare systems is described in section II. The section III demonstrates presented health care system and the outcome analysis of the system is shown in section IV. Finally conclusion of the work is presented in SectionV.

II. LITERATURE SURVEY

BrahmajiGodiSangeethaViswanadham, ApppalaSrinuvasuMuttipati, Om prakashsamantray, SauRekhaGadirajuet. al.,[5]provides an IoT-based ML approach to anEHMS. In order to create an advanced automation system, this paper offers a framework for IoT applications called E-Healthcare Monitoring System (EHMS) that integrates ML methods. This system will link, monitor, and enable decision-making for accurate diagnosis.

KashifHameed, Imran SarwarBajwa, ShabanaRamzan, Waheed Anwar, and Akmal Khanet. al., [6]provided using fuzzy neural networks, an intelligent IoT-based medical system. This system is capable of sensing and employing a medical decision support platform to examine patient data.A low-cost alternative for rural dwellers, this approach can help them decide whether they have a serious health problem and then contacting local hospitals for treatment.

Luca Greco, GennaroPercannella, PierluigiRitrovato, Francesco Tortorella, Mario Ventoet.al., [7] has discussed about the Trends in IoT-based health care solutions: Bringing AI (Artificial Intelligence) to the edge. In this article, it offer a succinct overview of the broad application of IoT solutions in healthcare, starting with initial health monitoring options utilizing wearable sensors and concluding with a discussion of the most recent developments in fog/edge computing for smart medical.

Xuejie Yang, Xiaoyu Wang, Xingguo Li, DongxiaoGu, Changyong Liang, Kang Li, Gongrang Zhang and JinhongZhonget. al., [8] it was necessary to build a knowledge graph for inveastigation into the emerging IoT technologies in the field of smart health. Web of Science's core collection is used to investigate 9561 papers published in the field of IoT-based smart health research between 2003 and 2019. This analysis contains the distribution of time, space, literature co-citations, and keywords.

Samaleswari Pr. Nayaka, S.C. Raib, SipaliPradhanc and J.K. Mantri,et. al., [9]introduced a solid authentication method for IoT-based patient monitoring. They describe a reliable Authentication System (RELAS) in which the entire procedure is split into four distinct modes, each of which can have its own set of subtasks that can be carried either locally or on a server. The method comprises the regular collecting of the patient's physical characteristics and environmental informationwhich is then stored in server for forecasting. It also supports both sequential and parallel modes of execution.

Srivardhan Reddy K,Sidaarth R, SaiAneesh Reddy, Dr. RajashreeShettaret. al., [10] a machine Learning IoT-based health monitoring system is demonstrated. In this paper, the suggested project incorporates the ideas of IoT and ML to provide effective patient health monitoring, identify whether the patient has a specific disease or not, and provide an immediate remedy in the event that the patient is experiencing some critical situation that requires instant attention by the physician and an instantrelief through the design of an easy-to-wear device.

M. Sathya, S. Madhan, K. Jayanthiet. al., [11]offers an IoT-based health monitoring system and its problems. Patients might have the cutting-edge sensors implanted or worn on their bodies to continuously check health. It is possible to analyze, aggregate, and mine the data gathered in this way to perform illness early prediction. The use of processing algorithms by doctors aids in the personalization of care and promotes cost-effectiveness in healthcare while also improving results.

SwalehaShaikh, VidyaChitreet. al., [12] demonstrated a "Healthcare Monitoring system using IoT. The suggested system offers a scalable and adaptable personal healthcare system. The system dynamically monitors the health indicators by utilizing embedded wearable sensors. When a severe situation develops, the analysis's findings are then automatically communicated to the doctor.

Mumtaj.S.Y, Umamakeswari.Aet. al., [13] shows an IoT-based healthcare system based on neurofuzzy theory. The suggested method keeps track of the physiological parameters of the patients and helps the medical staff to make the earliest possible diagnoses of diseases. In the event of any anomaly, the system will sound an alarm and send tweets to both the caregivers and the doctors.

B. SobhanBabu, K. Srikanth, T. Ramanjaneyulu, I. Lakshmi Narayana et. al., [14] IoT for Healthcare was presented. The most recent advancements in RFID (Radio Frequency Identification), smart sensors, communication technologies, and Web protocols enable the Internet of Things. The fundamental idea is to create a new class of apps by having smart sensors work together directly without human intervention. The present Internet, mobile, and Machine-to-Machine (M2M) technology boom can be viewed as the beginning of the IoT.

Bhoomika.B.K, Dr. K N Muralidharaet. al., [15]offersSecured Smart IoT-Based Healthcare Monitoring System. The PIC18F46K22 microcontroller serves as a gateway in this project for communication with several sensors, including the temperature sensor and the pulse oximeter sensor. This system is effective because it has low power consumption capabilities, is simple to set up, performs well and responds quickly.

III. MACHINE LEARNING BASED IOT ENABLED HEALTH CARE SYSTEM

In this section ML based IoT enabled healthcare system is explained in detail. IoT has a favorable effect on healthcare, enhancing millions of people's lives. It extensively examines the healthcare system and discovers sickness. For the advantage of the people, it offers personalized attention. IoT technologies can provide a variety of information, including appointment reminders, exercise tracking, calorie count, blood pressure, disease status, heart condition, body temperature, and body position. Figure 1 depicts the design of the suggested healthcare system.

IoT connects machines, tools, and medical equipment to develop intelligent information systems that are customized to the needs of each patient. High-quality medical gadgets that support the customized solution benefit greatly from IoT technologies. Digital data can be captured, saved, and analyzed using these technologies. All clinical records are kept digitally, and with the use of internet resources, patient information and data can be easily transferred in emergency situations and helps doctors work more effectively.

The IoT framework which is used for medical applications helps to merge benefits of cloud computing, ML, IoT technology with domain of medicine. Additionally, it outlines the procedures for sending patient data from various sensors and medical instruments to a particular medical network. The configuration of various IoT healthcare system components which are logically integrated in a healthcare nature is known as an IoT healthcare topology.

Different types of sensors like pulse sensor, Blood Pressure (BP) sensor, Temperature senor, tilt sensors are employed to acquire medical information from patients.Blood pressure, heart rate, temperature, oxygen saturation, ECG (Electro cardiogram), body postures, and other data are included in this information. Wearable sensor-based IoT system that track vital indications like the pulse, body temperature, and blood pressure might be used to monitor the critical health. Sensors are used to perceive, collect and receive the necessary data regarding

patient health and disease. Here, every physical thing is networked (connected to the Internet), and gadgets show real-time process monitoring. Specific doctors are given the necessary medical information in accordance with their needs. Regular measurements can be made, and if any of these parameters deviate from the recognized healthy ranges, the central node can send the data to the cloud so that emergency services are notified.

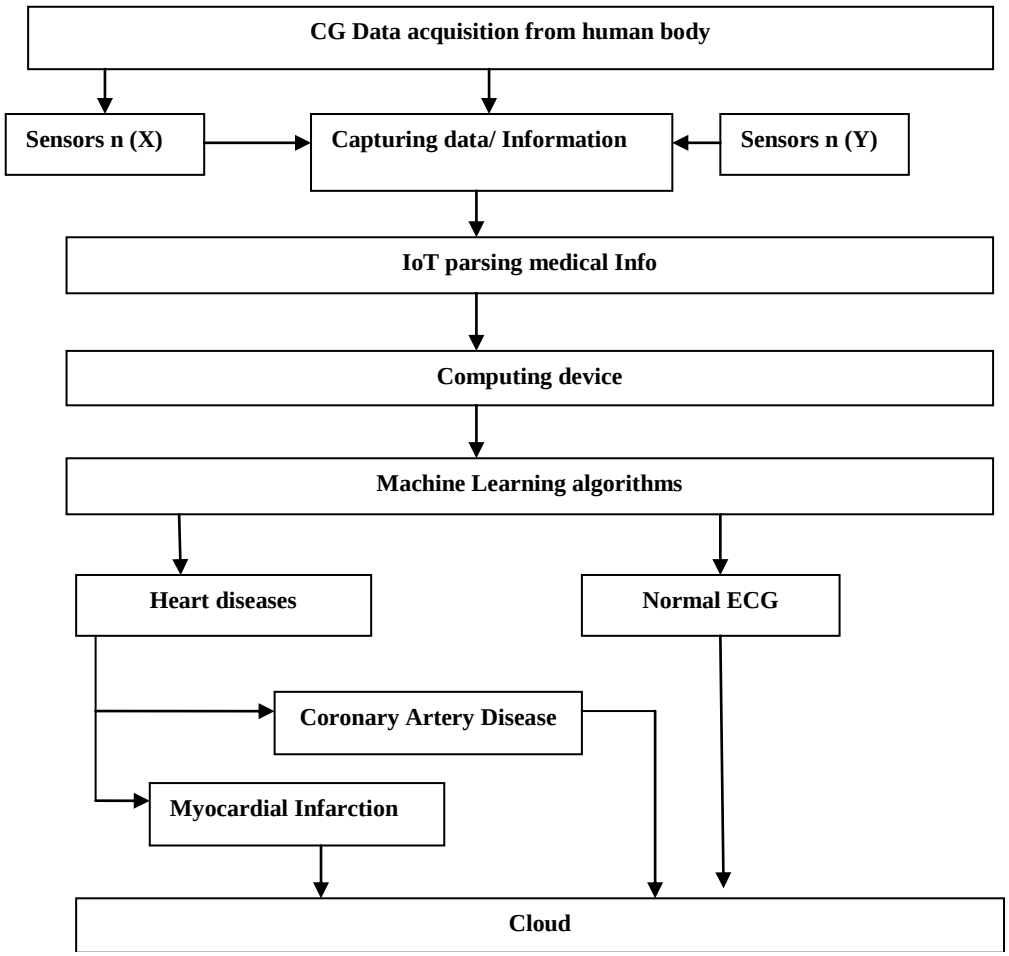

Fig. 1: THE ARCHITECTURE OF ML BASED IOT ENABLED HEALTH CARE SYSTEM

The ECGgives us a series of sinus rhythms that describe the state of the heart. The most used test for detecting cardiac disorders is the ECG because it is inexpensive and effective at detecting certain conditions. The model that developed to forecast outcomes for various illnesses and differentiate among normal and pathological ECG can be utilized to forecast the course of other ailments for which any analysis has not done. The primary goal is also to determine which algorithm produces the best outcomes for forecasting the diseases that is used. Here four different ML algorithms are used which are discussed as follows:

Decision Tree is a supervised learning approach is typically used to address categorization issues. It functions for input and output variables that are categorical or continuous, respectively. When speculating about a target variable's value, model first learns straightforward decision rules based on the characteristics of its data. In other words, the population or sample is divided into two or more homogeneous clusters depending on the most significant discrimination in the input parameters.In K-Nearest Neighbor, theInstances of traininginformation are simply stored in this type of instance-based learning. In essence, an

instance-based training set is used, and the goal is to estimate the label using the training samples that are physically closest to the new location.

In Naive Bayes theMultivariate Bernoulli distributions are used to distribute data, and thisit is a training and categorization algorithm. For linear classification, it is appropriate. Despite the possibility of numerous characteristics, it is presumed that each one has a binary value. As a result, this class requires the decision rule and the representation of samples as binary valued feature vectors. The supervised learning technique SVM is used for outlier detection, regression, and classification. Given labeled training data, the algorithm generates an ideal hyper plane that classifies modern cases. It carries out categorization operations by making hyper-plane in multidimensional environmentwhich divides instances of various label classes. A typical heart beats between 60 and 100 beats per minute in a steady sinus rhythm (specifically 82 bpm). A small modification toPQRST(P-wave QRS-Complex, T-Wave) portionmay result in many forms of cardiac disease.

The P wave, QRS complex, T wave, and U wave that make up a typical ECG tracing of a cardiac cycle are typically detectable in 50% to 75% of ECGs. The area of the ECG trace that comes after T wave, or in some circumstances U wave, comes before subsequent P wave represents the baseline (flat segments). The baseline is almost iso-electric in a healthy, normally beating heart.Based on the ECG report and symptoms this system determines regardless of whether they have heart disease or not.If heart disease is detected then it will be classified to know either it is Coronary Artery disease or myocardial infarction.

For the greatest care and diagnosis in the future, all records are securely kept in the cloud. For continuous use, patient-provided medical information must be securely preserved. In order to attain accuracy and reliability in therapy, heart disease predictionand classification, doctor's and surgeon's performance is improved by the combination of IoT and ML algorithms.

For the depicted healthcare system performance evolution, various performance indicators including Accuracy, Precision, Recall, and F1-score are utilized.

IV. RESULT ANALYSIS

In this section ML based IoT enabled health care system performance is evaluated using different performance metrics likeAccuracy score, Precision (P), Recall (R) and F-measure. These measurements are employed to assess the performance analysisof different ML algorithms like SVM, DT, K-NN and NB. These metrics are measured based the predictedvalues of TP, TN, FP and FN from the presented approach are given as

i) TP (True Positive):The patient has been diagnosed with Heart Disease and the prediction is positive.

ii) FP (False Positive): Patient has no heart disease, but is predicted to be positive

iii) TN (True Negative): The patient does not have cardiac disease, and the outcome is expected to be negative.

iv) FN (False Negative):The patient was diagnosed with heart illnessbut predicted as negative.

Accuracy:Accuracy is defined as the ratio of predictions made by model correctly to the total number predictions in the problem classification.

$$Accuracy = \frac{(TP + TN)}{(TP + TN + FP + FN)}$$

Recall:The recall can be described as the number of predicted true positives to actual heart diseases (i.e., TP '+' FN) and is given as

$$Recall = \frac{TP}{TP + FN}$$

Precision:The precision can be described as the number of TPs to total positive predictions (i.e. TP+FP).

$$Precision = \frac{TP}{(TP + FP)}$$

F1 - Score:Precision and recall are components of F1. When there is an unequal class distribution and want to find a balance among precision and recall, it require the F1 Score (more number of actual negatives).

$$F1 - Score = 2 \times \frac{Precision * Recall}{Precision + Recall}$$

The performance of different ML algorithms is represented in Table 1.

Table 1: PERFORMANCE METRICS OF DIFFERENT ML ALGORITHMS

ML Algorithms	**Accuracy**	**Recall**	**precision**	**F1-score**
DT	84.5	82.8	85.2	83.2
KNN	82.3	81	83.4	82.2
SVM	89.8	90	91.2	90.5
NB	94.6	93.6	94.1	93.4

Out of these ML algorithms the Naïve Bayes algorithm has better results in termsof accuracy, precision, recall and F1-score. After NB algorithm SVM has better results. The performance comparison between these 4 algorithms is shown in Fig. 2.

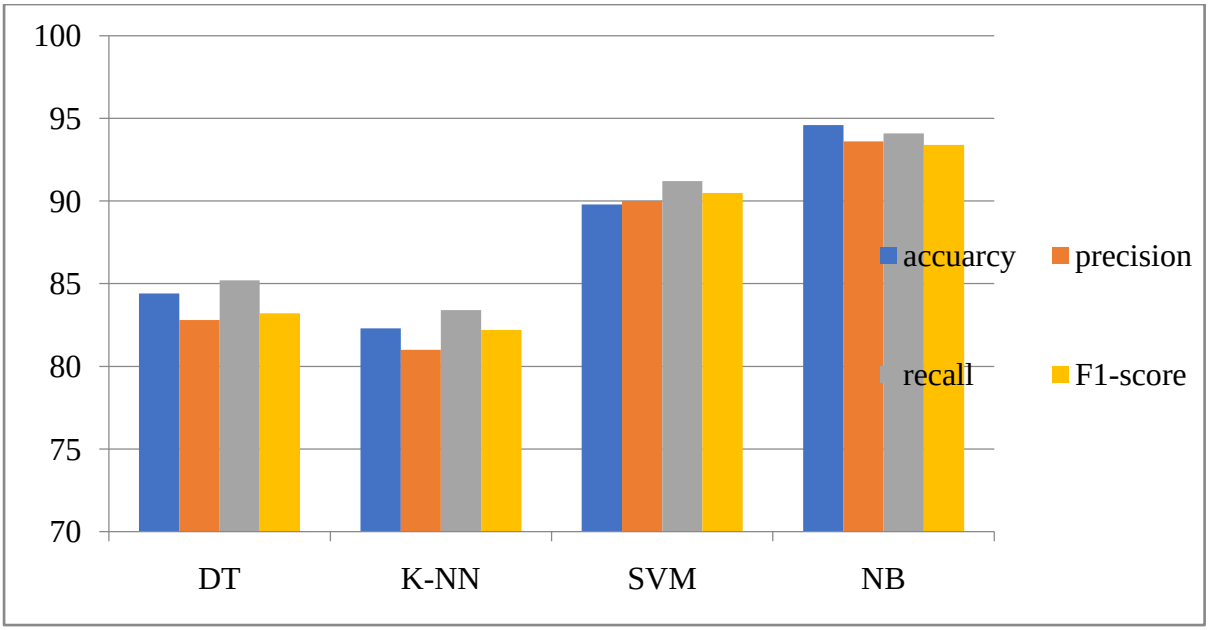

Fig. 2: PERFORMANCE COMPARISON BETWEEN ML ALGORITHMS

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and classification and gives accurate results in less amount of time compared to traditional approaches. In addition cost of the presented system is less compared to other systems. The comparison of presented and traditional systems in terms of cost and time is shown in below Fig. 3.

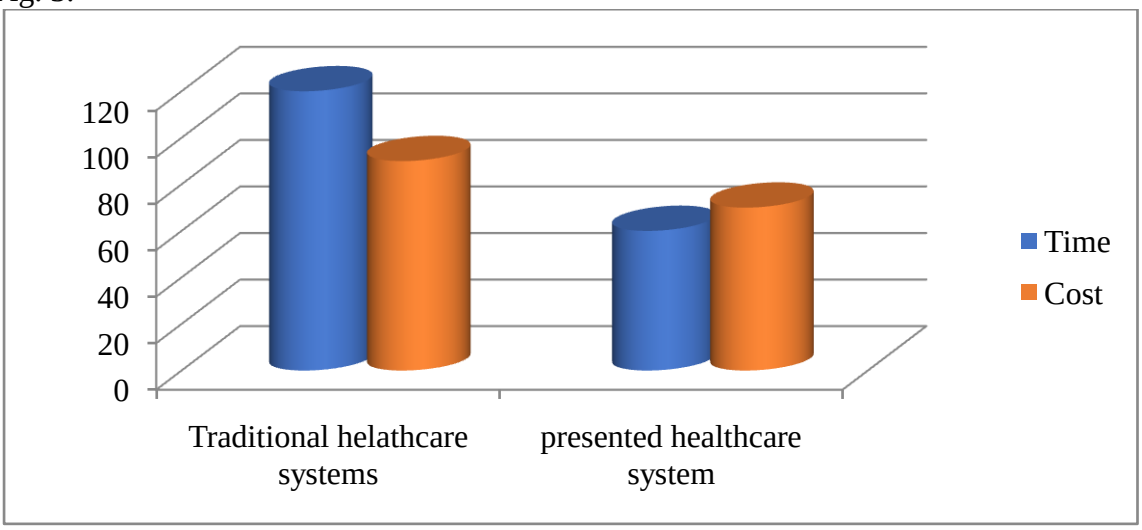

Fig. 3: COST AND TIME COMPARISON BETWEEN TRADITIONAL AND PRESENTED HEALTHCARE SYSTEMS

V. CONCLUSION

In this paper Machine Learning based Internet of Things Enabled Healthcare system is presented to detect and monitor the heart disease condition of a patient. In this approach four different ML algorithms are used namely SVM, DT, K-NN and NB. Out of these 4 classifiers the Naïve Bayes has better results in forms of accuracy, precision, recall and F1-score. This system effectively detects the heath condition of a patient as well as heart disease condition of patient. In addition, it securely stores patient health report information in the cloud for future diagnosis purpose. Moreover it takes less time to give results than traditional systems. The cost of the presented system is also less compared to traditional healthcare systems.

Finally it is concluded that ML based IoT enabled healthcare system accurately predicts the health condition of patient in less time with least cost.

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