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Review on the Heart Disease Detection Using IoT Framework

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Abstract- IOT is the trending technology which may affect the networking, communication and business. Among the various applications of Internet of Things, healthcare is one of the important one. Heart disease is the leading cause of death worldwide, therefore in order to reduce this there is a need for efficient heart disease detection system. Remote health monitoring system is emerging as an essential part in one's life. Various wearable sensors either worn or attached to the body of the patients helps in the collection of various health metrics. These sensor devices generate the data at a very high speed and it is difficult to manage and store the huge amount of data. In this paper the review on an IOT framework is given for the prediction of the heart disease. The first part focuses on the acquisition of the data using various sensors, second part focus on the data storage using cloud technologies, and third part is about the analysis of the data using various machine learning algorithms.

Keyword- ZigBee, Bluetooth, Sensors, Cloud, Data mining, wearable devices

I. INTRODUCTION

Have you ever wondered what will happen if one day all of your electronic devices starts talking to each other and to you as well. Assume that your wakeup alarm is connected to your water heater which is connected to your bread toaster and music system and all are connected to the internet working in coordination with each other for your comfort so that as you wake up in the morning you will get a warm shower and soon after that a hot meal while listening to your favorite music. So basically IOT is a system of systems that means all the electronic devices will be connected to each other in a local area forming a system and further these systems will be connected to each other forming a bigger network system. Internet of things (IOT) is sometimes also known as internet of everything in which exists all the web enabled devices which sense and collect the data [3], send the data and act upon the data which is acquired from the nearby environment with the help of the sensors, processors and communication hardware. These devices are sometimes called "connected" or "smart devices" which can talk to each other and the process is called 'machine to machine (M2M)' communication. The concept of IOT dates back to 1982 when internet was connected to the coke machine through which the drinks it contained and whether it is hot or cold is reported [1]. In this the human beings can interrelate with the devices to set them up, give them instructions or access the data. [2] The various types of sensors can be used in IOT such as RFID, wi-fi, Bluetooth, ZigBee etc in addition to wide area connectivity with the help of GSM, GPRS, 3G, LTE etc. The survival of these devices has been made feasible by all the tiny components that are available these days. Connected devices also generate massive amounts of Internet traffic, including loads of data that can be used to make the devices useful, but can also be mined for other purposes. All this new data, and the Internet-accessible nature of the devices, raises both privacy and security concerns. But this technology allows for a level of real-time information that we've never had before. We can monitor our homes and families remotely to keep them safe. Businesses can improve processes to increase productivity and reduce material waste and unforeseen downtime. Sensors in city infrastructure can help reduce road congestion and warn us when infrastructure is in danger of crumbling. Gadgets out in the open can monitor for changing environmental conditions and warn us of impending disasters.

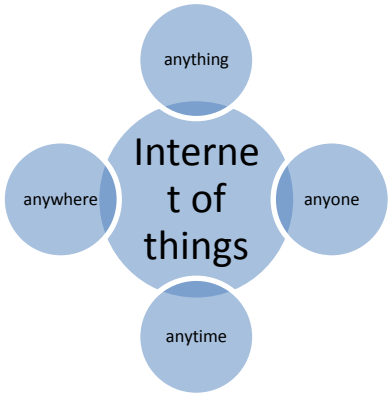

Figure 1. Shows the block diagram of IOT concept.

In the recent years with the advancement in the IoT technologies number of wearable devices has been used and developed for monitoring the patients' health. These wearable devices when attached to the human body can measure the various health metrics like blood pressure, heart rate, body temperature etc. The data collected from these devices need to be stored and processed. The traditional methods now are not able to handle such a huge amount of data generated therefore the cloud technologies and big data management plays a very important role in this. For data analysis [14] data mining and machine learning algorithms give the maximum accuracy for the prediction of the heart disease. In this paper, a detailed review is given about the data collection phase, data transmission and storage phase, data analysis phase. Rest of the paper is organized as follows: Section II presents the related work which is done on the prediction of heart disease. Section III presents the parameters which are required for the detection of heart disease. Section IV presents the IoT framework in which data collection, data storage and data analysis is discussed. Section V concludes the paper.

II. RELATED WORK

The use of IoT in healthcare system is increasing day by day and much research is being done on this. A sample prototype [11] is implemented where pervasive monitoring system is proposed in which patients physical signs like blood pressure, ECG, SpO2, heart rate are collected using the wearable sensors attached to the patient's body and then transmitted to the android smart phone application using Bluetooth, GSM and GPRS technologies. A system has been proposed [6] which monitors the HRV parameters of the hypertensive patients. HRV is the heart rate variability which is the variation in the time interval between the heartbeats. In this system Zigbee is used to derive the HRV parameters. Then the data is transmitted to the server using Arduino microcontroller and a short message is sent to the doctor if there is any kind of emergency. ECG monitoring system which is widely being studied by the researchers is one of the vital approaches to diagnose the heart disease. A body-mounted, persistent diagnostic system [12] is developed in which the biochemical marker related to the happening of myocardial infarction are identified. Myocardial infarction is a type of heart attack that occurs when one or more coronary arteries are blocked. In this system a microneedle is used which collect 20-30 micro liter of blood sample and is pretreated to remove the blood cells.
The monitoring system [5] for reading the ECG (electrocardiographic) signals and temperature signals are presented in. There is a Bluetooth transmission mode in which data is sent via (GPRS or Wi-Fi) to the database with the hardware module and the displaying Module like LED or mobile phones.

[9] All the systems used for ECG monitoring cannot work without mobile application for data collection and display but the new method of ECG monitoring has been proposed in which data is gathered using the wearable sensors and transmitted directly to the IOT cloud using wifi. Visualization of the ECG data and storage of the data is done by the IOT cloud.

[13] An IoT based architecture with machine learning algorithms has been proposed for the prediction of heart disease. In this the data from the wearable sensor is collected and transferred to the Amazon s3 bucket using 5g mobile network. Then from Amazon s3 bucket the data is transferred for storage to apache HBase. And further the prediction model is build using logistic regression.

Various researchers have used MATLAB tool for the prediction of heart disease as in [20] different classification algorithms like J48, REPTREE and simple CART is used on various parameters. In [19] also MATLAB is used with hybrid Artificial Neural network and Grey Wolf Optimizer for predicting the heart disease and it has been concluded that performance of ANN- GWO is better than alone ANN.
Machine learning algorithm optimized by particle swarm optimization [18] has been used in WEKA for prediction of heart disease. The results are predicted in terms of effectiveness, accuracy and confusion matrix is made. The algorithms like Naïve Bayes, SMO, C4.5 decision tree and K-Nearest neighbor has been used in [17] with WEKA and performance is evaluated in terms of correct classification rate and mis-classification rate. In this naïve bayes classifier is considered as the best.

Particle Swarm intelligence algorithm has been used for prediction of heart disease [16] and results are calculated in terms of accuracy, sensitivity and specificity. In [15] prediction system using naïve bayes and PSO is designed and achieved an accuracy of 87.91%. Moreover the survey [14] on various machine learning algorithms has been done.
Nowadays one thing that has become inevitable for e-health field is designing and developing the wearable devices which could detect much type of diseases. Many researchers use the internet of things to do the same. The work has been proposed [8] to track the human body troubles using IOT. Main aim of this system is to decrease the overall cost of the users. Performance of the system is based on WSN which connect all the system nodes. This is an outdoor system which uses LTE support to connect the data using internet on smart phones.

III. PARAMETERS IDENTIFIED

- **Blood Pressure:** Blood pressure is the

Circulation of the blood through the blood vessels. It's recorded as two readings: Systolic pressure (higher reading) – this records the pressure within the blood vessels as the

heart contracts and forces blood out into the arteries. Diastolic pressure (lower reading) – this records the pressure when the heart fills up with blood again. Normal range of blood pressure in an adult is approximately 120 millimeter of mercury systolic and 80 millimeter of mercury diastolic abbreviated as "120/80 mmHg". Traditionally it is measured by a device called Sphygmomanometer which is considered to be the gold standard of accuracy and various other automated devices are also in development. Low blood pressure below 120/80 mmHg is called hypotension and above 120/80 mmHg is called hypertension. Long term hypertension is a basic risk factor for heart disease. Low BP is also a risk factor or other diseases. Risk of cardiovascular disease is when BP is above 115/75 mmHg. A pervasive heart disease monitoring system has been proposed [11] in which various multiple physical signs like blood pressure , ECG etc is been checked. Though there are various sensors for measuring BP but still no system has been developed [4] for accurate measurement of BP using comfortable wearable device.

- **Heart rate:** heart rate measures the number of contractions (beats) of the heart per minute. It is usually equal to the pulse measured at any point. Normal heart rate of an adult according to the American heart association is 60-100 bpm. Above 100 bpm it is Tachycardia and below 60 it is Bradycardia. But a heart rate lower than 60 is not necessarily a sign of medical problem. It could be the result of taking drugs. A lower heart rate is also common for people who get a lot of physical activity or are very athletic. During sleep the heart rate is 40-50 bpm and it is considered normal. Irregularities in heart rate are arrhythmia and also lead to heart disease. In [11] it is considered as the one of the important parameter for heart attack detection.

- **Respiration rate:** Respiration rate is the Number of breaths taken by a human body per minute i.e. how many times the chest rises. Normal respiration rate of an adult is 12 to 20 breaths per minute. Various automated sensors are in development for measuring the respiration rate. Abnormal respiration rate can also lead to various health problems but in various earlier studies this parameter is seen as the neglected but still it is used for various medical purposes.

In [10] IoT architecture sensing with cloud based processing is build in which respiration rate is measured. In [7] also monitoring system has been developed based on WSN and telemedicine to measure the respiration rate. Respiration rate monitoring can help in diagnosis of various conditions like hyperventilation, asthma attacks, heart attacks etc. and various respiration rate sensors has been discussed in [4].

- **Blood Sugar:** Blood sugar level or the Blood glucose level is the amount of glucose present in the human body. Glucose is a simple sugar present in the body which provides energy to the body. The high level of sugar level is called Hyperglycemia and low level of sugar in the body is called Hypoglycemia. Normal value of blood sugar level in human body should be between 70- 130 mg/dL. The long term hyperglycemia is also one of the risk factor for heart disease. Blood sugar level above 300 can lead to fatal reaction. This parameter is not so accurate for the detection of the heart disease but still it is one of the vital parameter recommended by the doctors for medical purpose.

In [11] monitoring system has been proposed has been proposed for detecting the heart diseases by measuring blood sugar level. Table 1. Shows the normal and above range of all the parameters used to detect the heart problems.

Table 1. Normal and high range of the different Parameters.

Parameters	**Normal range**	**Risk of heart disease**
Respiration rate	12-20 per minute	<12 and >25 per minute
BP (systolic)	120 mm/Hg	140 – 159 mm/Hg
BP (diastolic)	80 mm/Hg	90 – 99 mm/Hg
Heart rate	60-100 bpm	>100 bpm
Blood sugar/ blood glucose	100 mg/dl	>300 mg/dl
Cholesterol level	< 200 mg/dl	>240 mg/dl88

- **Cholesterol level:** It is a waxy like Substance which is naturally present in all the parts of the human body. It will narrow the arteries and even block them completely which can lead to heart attack. High cholesterol level in the blood is one of the major causes of the heart disease. Normal level of cholesterol in blood should be less than 200 mg/dL. 200-239 mg/dL is borderline and above 2409 mg/dL is high risk. Low density lipoprotein (LDL) is 'bad' kind of cholesterol which builds up in the arteries and forms the fatty waxy deposits called plaques.

IV. IoT FRAMEWORK

With the advancement in the technology, remote health monitoring system has achieved the great heights and with the use of IoT framework into these systems it can further increases the accuracy, flexibility and interoperatebility. The IoT framework must be able to monitor the various

parameters which may improve the healthcare systems. Basically IoT framework consists of three parts data acquisition, data storage and data analysis. In this paper review on all these parts is given.

a) Data acquistion

In recent years there has been increase in the number of wearable devices for monitoring the health of the patients. To monitor the health of the heart patients, there are various sensors which can monitor the identified parameters. Multiple wearable sensors can sense the physical signs of the human body when they come in contact with the human body. Various types of sensors to measure the heart rate, respiration arte, blood pressure blood glucose level have been discussed [4].

There are sensors like Pulse sensor, respiratory rate sensor, pulse oximetry sensor etc. Then these sensors are connected to the network through any kind of gateway which can be one's smart phone also. The data collected from the various devices is transmitted for the storage. In this various short range communication standards [4] are used and many of them are discussed.

Moreover when the values measured by the sensing device exceed the normal value of the parameters then an alert message is also sent to the doctor or the caretaker. For this data acquisition part there exist many short range communication standards. Most commonly used communication standards by many researchers are Bluetooth (BLE) [11, 7] and ZigBee [10, 6]. Table 2. Shows the comparison between BLE and ZigBee.

Table 2. Comparison of BLE and ZigBee

	BLE	**ZigBee**
Band of operation	2.4 GHz	2.4 GHz
Topology	star	Mesh
Coverage	150m	30m
Data rates	3-24 Mbps	10-250 Mbps
Protocol	IEEE802.15.1	IEEE802.15.4
Stability for healthcare	High-Often supported by smartphones	Low- only supported by specific devices.

Bluetooth is very well suited to the healthcare applications as it is secure and robust. It has low power consumption. ZigBee is also preferred by some researchers but the major drawback of using ZigBee is that key exchange can be compromised unless implemented extremely well by the manufacturer. Zigbee is not till now implemented in smart phones but BLE is compatible for the use in healthcare. Now, as the range of Bluetooth and ZigBee is low, there are certain long-range communication standards also which are highly suitable for IoT applications.

Data from the sensors is transmitted to the smart phones or laptops through ZigBee or Bluetooth but the weakness is that battery life of phones and laptops may run out therefore solution to this problem is long range communication standards [4] like NB-IoT or 5g technologies through which data can be directly transmitted to the cloud. NB-IoT operates on licensed bands of GSM and LTE and provides long range and low power consumption. Due to a high receiver sensitivity its range is upto 15 km and its data rate is 250 kbps. It can also support a minimum of 52,547 nodes per base station. These various advantages of NB-IoT makes it suitable for healthcare applications.

b) Data storage

Data storage is the second step in IoT framework as the wearable sensing devices produce the data at a very high speed and huge amount of data is generated everyday which is very difficult to store and process. The traditional data storage and processing methods like SQL database could not compete with the huge amount of data generated everyday therefore non structured query language database [13] has been used for IoT health monitoring systems.

Cloud technologies virtually provide unlimited storage space, many useful services and also enable accessibility for patients as well as doctors. Due to these benefits cloud technologies in big data management, processing and analytics it has been very widely used in the various researchers. In this way patients can have their full control on their healthcare and also enables doctors to provide the suitable treatment to the patients. The aggregated data collected from the sensors needs to be transformed to the cloud for the long term storage. Communication between the sensors and the cloud is done using wi-fi interface [10]. Table 3. Illustrates the storage used with the parameters and technologies in earlier research.

Table 3. Parameters, technologies and storage used in healthcare systems.

Author	**Year**	**Parameters**	**Technologies**	**Storage**
Moeen Hassanalieragh *Et al.*	2015	ECG, Temp, Respiration rate	Zigbee, Bluetooth	Cloud
Zhe Yang *et al*.	2016	ECG signals	Wifi, Bluetooth, zigbee	IoT cloud
Chao Li *et al.*	2017	Heart rate, BP, SpO2, Pulse rate	Bluetooth, GSM, GPRS	Android app impleme

				nted in JAVA
R.N Kirtana *et al.*	2017	HRV parameters	ZigBee, Wifi	My Sql 5.5 database

Benefits of cloud technologies for bigdata management are that it virtually provides unlimited storage space. So, overall big data is very much essential in the IoT healthcare system for the future work.

c) Data Analytics

Now, after the data acquisition and data storage next thing is data analytics for the prediction of heart disease. Data mining and machine learning algorithms plays a very important role in this which potentially recognizes correlation between sensor observations and clinical diagnosis. In this field of IoT healthcare pattern recognition and machine learning promise the improved accuracy for diagnosis of heart disease. When the machine learning algorithms are applied on the large data sets it gives the meaningful information from such a raw data.

Moreover cloud storage allows machine learning algorithms to perform rapidly and effectively. Table 4. Shows the comparison of various algorithms used in previous research. The comprehensive view of machine learning techniques has been discussed [14] with the tools used and their accuracy but still it cannot be said that specific algorithm is best for the prediction of heart disease as with the different parameters and conditions accuracy of different algorithms may vary.

Table 4. Comparison of various algorithms used for data analytics

Author	**Year**	**Tool**	**Parameters**	**Algorithms**
Haudi Daniel Masethe *et al.*	2014	MATLAB	Heart rate, Cholesterol,BP, Blood sugar.	J48, Naïve Bayes, CART,REPTREE
Hamza Turabieh	2016	MATLAB	Heart rate, cholesterol, BP, Blood sugar	Hybrid ANN & Gray Wolf optimizer
Sanjay Kumar Sen	2017	WEKA	Heart rate, cholesterol, BP, Blood suagr.	Naïve Bayes, SMO, C4.5, K-Nearest neighbor
Priyan Malarvizhi Kumar *et al.*	2017	Apache Mahout	Respiration rate, BP, temp, blood sugar	Logistic regression with ROC curve
Youness Khourdifi et al.	2018	WEKA	Respiration rate, BP, blood sugar,temp	PSO & colony optimizer

V. CONCLUSION

In this paper, an IoT framework is reviewed for the prediction of the heart disease. Wearable sensing devices which are used to collect the data from the body of the patients and then storage and processing of data using communication standards. Among the communication standards which transfer the data collected to the storage devices, Bluetooth (BLE) hs been well suited for the healthcare application. Next, for the storage of the huge amount of data generated by the wearable sensor cloud storage and big data management is considered as the best. Finally, for the analysis of the data to predict a model data miming tools and machine learning algorithms are used to get the accurate results but the accuracy of all the algorithms vary according to the parameters and data collected. The future work can be done to analyze that which algorithm can accurately predict the heart disease.

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