Review on IoT Based Real-Time Healthcare Monitoring System

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Abstract. In today's modern medical fields, the emerging trends are wearable's, which are connected to IoT (Internet of things) & thus helps in the process of patients monitoring. The main advantages of wearable devices are continuous tracking of the health status of the patients wearing them. Thereby, ultimately it results in better treatment by having an insight for the doctors about health status of the patient. Also there in the real time approach results in lower cost of operation & increased chances of improvement in patient's health. With the advancement in the field of Cloud, AI (Artificial Intelligence) & IoT, it is now possible to track the health parameters of the patients by the doctors. This has resulted in proactive and timely alerts available to remotely located person by measuring their live record being fed to the cloud server via internet. After systematic analysis of this data with medical history & finding the best possible treatment can be administered using various Machine Learning (ML) techniques. Critical situation can be avoided as forecasted in the beginning is possible. It assists the health workers & family members to monitor & controls the health criterion of patients in an efficient way. This review paper, focused on analysis of IoT based wearable devices used for continuous health monitoring, benefits, challenges, future scope, & applications.

Keywords: Health monitoring · IoT · Wearable devices · ML · Cloud

1 Introduction

In good old times, the sole method to diagnose sickness was through a physical examination of the figure in an exceedingly hospital. This forced the patients to remain physically in hospital for treatment, increasing care and prices. Also the diagnosis of human body can only be possible through physical examination by the doctor. Health care costs increased many folds because the exhaustion of health facilities in rural & remote areas. The technological advances achieved over the years made it attainable to diagnose various diseases & monitor health with miniaturized devices like good watches. The technological progress achieved over these years now permits the identification of varied diseases & health management with miniaturized devices such as smart watches. Various clinical tests (O2 level, blood pressure, glucose level etc.) are allotted and monitored without the assistance of a medical professional. In addition, advanced telecommunication services will facilitate delivery of clinical knowledge and care facilities in remote

areas too. These communication services along with advanced technologies such as ML, data analytic, cloud computing, IoT & wireless sensing has improved the accessibility of medical facilities.

IoT advancements over the past few decades have made healthcare systems accessible even in remote areas and improved the overall health of the individuals. IoT based technology is advancing rapidly in healthcare system. Because the health sector expands, it expects to have direct identification that permits simple observation & management of the knowledge. The futuristic goal is to integrate IoT with emergency services, residential areas & hospitals [1]. With the assistance of artistic movement algorithms & protocols, the IoT has become a crucial contributor to world communication because it connects various wireless sensors, household appliances & electrical devices to the network [2]. The applications of IoT can also be observed in the field of agriculture, automotive, household & healthcare. The growing quality of the IoT is because of its capability of displaying more accurate, lower cost, & AI based data analytics. In addition, better data of package & applications, the advancement of mobile & computing technologies, the easy accessibility of wireless technology & the rise of the digital economy have all contributed to the speedy revolution of the IoT [3]. IoT devices like sensors & actuators are integrated with physical devices to observe & share data through numerous communication protocols like Bluetooth & Wi-Fi etc. Especially in healthcare applications, sensors are mostly employed to collect physiological information such as temperature, heart rate, and pulse rate from the user's body [4]. In addition, outside information such as temperature, humidity is also recorded. This knowledge facilitates to draw meaning & precise conclusions regarding the patient's state of health. The stored data in the IoT system from various sources such as sensors, applications & mobile phone plays crucial role. The information from the detection device is created accessible to doctors, nurses & approved parties. Knowledge with care suppliers via cloud or server permits speedy identification of patients &, if necessary, medical intervention. Continues transmission between the user and medical employees is assisted. However, the most concern in developing an IoT system is embracing the confidentiality of data exchange, security, cost, responsibility & availability. This paper covers IoT-based health systems & provides a scientific summary of the basic technologies, services & applications.
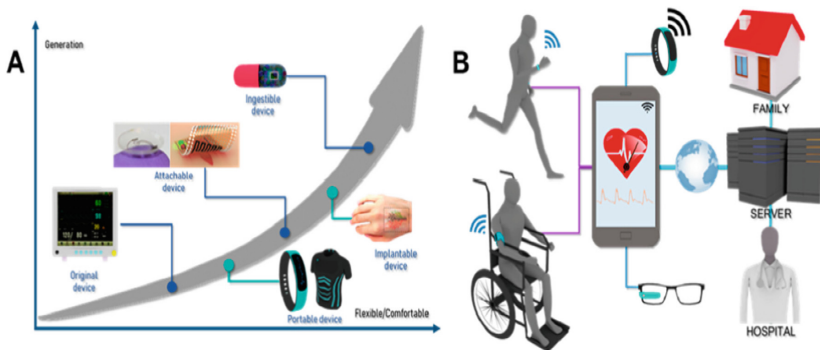

Fig. 1. (A) Wearable gadgets (B) IoT based wearable gadgets used in health monitoring

2   System Analysis

There are various components for the system architecture such as input, information processing, ML, decision making, & output. By using this type of portable system & sensor, healthcare surveillance of a patient living in a remote area can be performed as it would have been not easy for the patients to visit health cares or have regular check-ups. This system will minimize risk of life & improve a person's health. Various types of motion sensors are used for sending the information, which will measure body temperature, blood sugar, pressure & pulse [5].

Wearable technologies such as the wireless Body Area Network (BAN) have been used in health-related research. Real-time condition monitoring by handheld gadgets operate the classification approach for series of time analysis. Previously, Zigbee was used for communication between mobile systems & physiological gadgets. Recent research studies in this area shows that a far-flung of IoT-facilitated gadgets, wearable bracelet sensors, watches & fabric are operated. Many of the research reports achieved using various techniques for routing such as Bluetooth, Wi-Fi, ZigBee, RFID for real/actual-time healthcare surveillance in wearable gadgets. Generally this kind of research uses fitness trackers, smart jacket, shoes & gloves, etc.

2.1   Methodology

Step1: Collection of information & preparation of information
This will include the gathering of measured physiological wave using portable gadgets with motion sensors.
Step2: To Develop a ML Algorithm for healthcare surveillance
A ML algorithm is developed using automatic Artificial Neural Networks (ANN) to calculate judgment with reference to the patient's health status. The ANN is chosen as it has ability to create a vigrious classifier, as the information to be created is in the form of series of time & also has great notion effects that allow it to continuously classify original information.
Step3: Training & Experimenting with information sets
Healthcare surveillance model, which is a ML algorithm, is trained on information set to accurately perform health surveillance & then inform the patient.
Step4: Implementation & analysis in real/actual life scenario

3   Devices

With the onset of 21st century, wearable devices such as wrist mounted devise, head mounted, body cloths & body sensory control devices have made health services personalized. With the development of microelectronics and communication technology the wearable devices are miniaturized and made portable. These portable wearable devices are deeply embedded in our day to day life as shown in Fig. 2 below.

Fig. 2. Wearable healthcare devices

3.1 Portable Gadgets

Wrist-mount gadgets for physiological observation are developed commercially. This helped improvement in battery life and miniaturization and are able to convert signals from human body to real-time communication data. Physiological indicators like BP, heart rate are most important indicators of an individual's health status. Conventional sensors are bulky and ergonomic. With the advancement in technology, devices that can be worn on the wrist have been developed. New age fitness bands & smart watches come loaded with tiny sensors to check pulse rate, blood pressure & various other physiological indicators. With the technological advancement sensors are miniaturised, increasing their scope of usage.

Head-mounted devices such as accelerometers, gyroscopes, altimeters & GPS can be placed in nose pads of a smart glass. Smart goggles are equipped with computer and sensors to continuously monitor & display users health status during activities likes running or riding.

Smart fabrics are being developed which are capable of monitoring human physiological signals, biomechanics & physical activities. This smart fabric generally consists of a conductive devices & clothing materials. An example to smart fabrics are smart clothing, head gear & shoe being developed for defence forces to monitor soldiers physiological traits & biomechanics in real time.

3.2   Attachable Devices

These are considered as next generation portable personal healthcare devices with skin like adaptability features & flexibility thereby offers accurate sensing even without hindering natural movement & comfort. **Wearable Patches** with sweat, cardiovascular & temperature sensors are gaining popularity as ideal wearable's due to their accuracy in sensing data and ease of wearing. Latest advances in sensors technology, micro-electronics & data analysis are enabling manufacturing of cost effective advanced & real time data capturing devices. These smart devices are important components in health monitoring systems. These devices use wide range of sensors such as piezoelectric, resistive & capacitive sensors to gather physiological to BP, heart rate & body temperatures. **Smart contact lenses** enable physiological monitoring of the eyes, non-invasively. These smart contact lenses uses optical an electrical inputs to monitor the eyes. These sensors analyses the chemical nature of tear fluid and reflectivity of primary diffraction light.

3.3   Implantable and Ingestible Devices

MEMS technology fusion with biology and chemistry has made wireless medical measurement possible. These devices are used in diagnosing and treatment of diseases by detecting the possible changes observed in body.

An **implantable electronic device includes** pacemakers, ICDs & deep brain simulators. These devices are made of batteries for power and biocompatible materials embedded as pre-programmable circuitry.

The **ingestible pill contains** sensors that are capable of passing the lumen of digestive track & reach organs around the abdomen. These sensors can monitor enzymes, hormones, electrolytes, microbes and metabolites and delivers biometric information. Figure 3 depicts the application of smart pill and patches.
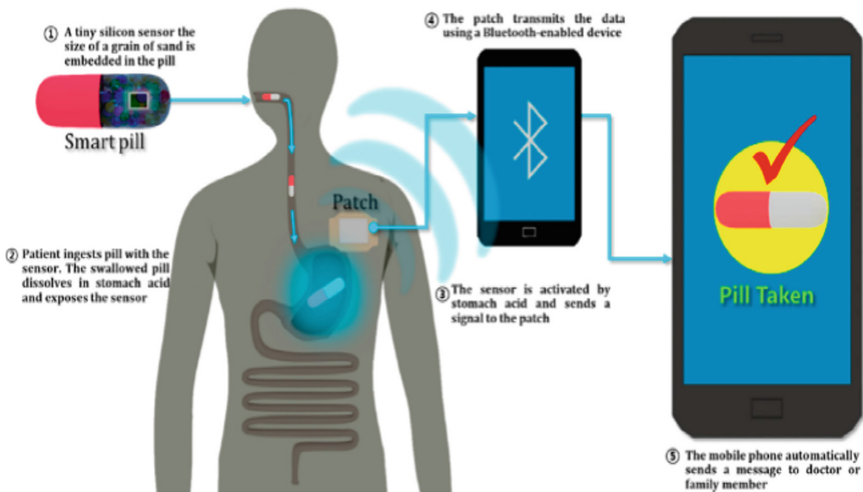

Fig. 3. Ingestible pill system (smart pill & Patch)

4   Benefits of IoT in Healthcare

4.1   Monitoring and Reporting

Connected devices make it simple to draw the attention of professionals to watch patient's heath, conjointly period observance can be rescued the lives during healthcare emergency. Appreciate polygenic disorder attack, heart failure, asthma attack, & so forth by means that of an intelligent healthcare device are connected to apps. Assembling healthcare data & alternative necessary medicative data isn't a challenge if connected properly. IoT devices gather & transmit medicative data such as BP, element & level of glucose, weight & ECG. The info gathered by the devices is stored within the cloud & may be accessed by a certified Individual who can also be doctor, company of insurance, health care company, or outside consultant, no matter location, time, or device used.

4.2   Assortment of Data and Its Analysis

Without application of cloud, it is not possible to deposit massive amounts of knowledge gathered from smartphone devices & health care apps. In addition, it's quite rugged for healthcare employees to gather information from numerous gadgets & sources. In such type of situation, the IoT gadgets will gather, report & data analyzation in actual time [6].

4.3   Tracking and Alerts

The circumstances which are life threatening, timely warnings become very important. For addressing such kind of state, healthcare IoT gadgets & apps can collect critical information & broadcast it to experts & medical staff for monitoring in real or actual time, the critical conditions of the patient regardless of place & time.

4.4   Far-Flung Healthcare Assistance

Reaching a doctor remote is almost not possible for lonely patients in an exceedingly medical emergency, however with the appliance of IoT in tending & alternative connected devices, it's possible. Workers also can monitor patients to observe diseases on the way.

4.5   Reduction in Cost

By exploitation IoT-facilitated gadgets, clinicians will keep an eye on the patients in real or actual time. Therefore, method of period of time observation in numerous locations can facilitate patients scale back supernumerary doctor visits, hospital stays & readmissions.

4.6   Enhanced Treatment

The information collected by IoT gadgets helps doctors & clinicians build informed, proof-based choices & offers total transparency.

4.7 Speedy Diagnosis of Disease

Due to continues patients watching & time period information tracking, doctors will diagnose sickness in the beginning or maybe before disease really evolves supported symptoms.

4.8 Reduction in Error

The information generated by connected gadgets facilitates to form correct & effective selections & conjointly guarantee sleek operation with fewer errors, rejections & costs.

5 Applications

Medical services /concepts are employed to create various IoT based health system. With the advancement of IoT technology, microelectronic & communications, economical and user friendly implantable, ingestible, and wearable sensors and devices have emerged. These systems can be used to gather data, diagnose and track patient's heath. It can also send out alarms in case of any medical emergency. This part will look at some of the most recent commercially available gadgets.

5.1 Monitoring of ECG

Heart muscles atria and ventricles functions in rhythms which are represented on electrocardiogram (ECG). The observed electrical activity, which takes place because to basic heart muscles rhythm will depicts cardiac abnormalities. The IoT technology aids in early detection of cardiac anomalies. The IoT based ECG analysis consists of wireless data acquisition module with a receiving processor. This detects cardiac anomalies in real time. A low-power & portable ECG monitoring system built into fabric has been proposed in [7]. It contains a biopotential chip to gather ECG data & transmit to end users. In [8] the author have attempted to solve the power consumption problem through compression detection [9] using a cloud & mobile application. It is designed to provide real-time monitoring of patients.

5.2 Monitoring the Glucose Level

Diabetes is one among the foremost common human diseases in which blood sugar levels in the body remain high for a long time. Generally there are, three types of diabetes are found (i) type I diabetes, (ii) type 2 diabetes, & (iii) gestational diabetes. These are identified by three tests (i) the random plasma glucose test (ii) the fasting plasma glucose test, & (iii) the oral glucose tolerance test. The IoT technologies uses several handheld blood glucose meters that are non-invasive, comfortable, convenient, & safe instead of widely used diagnostic method i.e., finger prick followed by measuring the blood sugar level. A non-invasive IoT-based glucometer to monitor blood sugar levels in real time was proposed. Here, wearable sensors & healthcare providers are wirelessly connected. In another study the IoT architecture for measuring glucose levels in human body uses optical sensors [10].

5.3 Monitoring of Temperature

Human body maintains a particular temperature. A slight change of body temperature could be considered signal for some diseases hence temperature is one of the most important indicator of human body health. Tracking changes in temperature over time helps clinicians draw conclusions about the patient's health. The traditional method of temperature measurement is to use a thermometer. Comfortability & high risk of infection are always a problem with this method. IoT-based technologies have suggested several solutions to this problem. In [11] an infrared sensor based 3D-printed wearable device is proposed to measure the core temperature of human body. The integrated device can be influenced by environmental factors & other physical activities. In [12] another study used portable & lightweight sensors to measure infant body temperature in real time. You can also warn parents if the temperature rises above a critical level.

5.4 Monitoring of BP

Measuring blood pressure (BP) is one of the mandatory diagnostic procedures. The integration of IoT & sensors has changed the way the BP was monitored previously. In [13], a portable cuff-less device has been proposed that can evaluate systolic as well as diastolic pressure. The data can be saved and retained in the cloud. Also, ECG & PPG is used for the measurement of BP. In [14] microcontroller module is used to calculate BP and cloud storage is used to record the data.

5.5 O_2 Level Monitoring

Saturation of Blood oxygen is considered as an important parameter for health analysis. Previously Pulse oximetry test is used to measure blood oxygen saturation. A non-invasive tissue oximeter resulting from the mixing from IoT based technology has been proposed to measure blood oxygen saturation alongwith pulse rate. The recorded data can be transmitted to medical authorities. In [15] another study patient can be warned regarding their oxygen saturation level by an alarm system. In [16] an inexpensive remote monitoring system for patients with low power consumption has been suggested.

6 Challenges

6.1 Data Privacy and Security

As the IoT gadgets & smartphone apps will gather & send information in real/actual time, there is a risk of privacy of data & protection being compromised. In healthcare, the majority of IoT gadgets lack standards & data protocols. The data is vulnerable to theft, cybercrime & fraud, putting doctors' & patients' personal health information at danger [17].

6.2 Devices and Protocols

Various gadgets surely act as barrier in the deployment of IoT in the healthcare arena. This is because of the absence of standards & networking communication protocols. As a result, regardless of whether gadgets are connected, there will always be a discrepancy in communication protocol, which complicates & inhibits the entire process.

6.3 Data Overload and Accuracy

Data aggregation becomes complicated due to the many standards & protocols. It is challenging for doctors to make timely quality decisions due to massive volume of information acquired by smartphone apps & IoT-facilitated gadgets.

6.4 Price

In many ways, IoT is ahead of the other economical packages, but it is still not as economical for the average person as it is for large healthcare organizations.

6.5 Connectivity

IoT gadgets rely on & run on the internet, a lack of Wi-Fi access in the locations where IoT is desired the most will cause the concept of IoT devices to fail. It is still feasible for hospitals to go without internet access, but there is no guarantee for patients.

6.6 Availability

IoT devices are supposed to work round the clock. It sets the responsibility of healthcare institutions to provide maintenance round-the-clock & if they don't, it will be impossible to receive accurate information from patients on time.

7 Future Scopes

7.1 Home Healing

With the advancement of technology & the development of IoT health monitoring systems, healing at home has become a viable option. Patients do not need to be beneath the hospital's roof because of the collaboration of real/actual time monitoring & numerous specific modules. As a result, the technology has a bright future ahead of it, giving independent & monitoring health by gadgets while minimizing stress of having to see experts & other healthcare professionals.

7.2 Remote Health Monitoring

IoT enables continues monitoring, recording & tracking the changes in various health parameters of remotely located patients. It enhances the access of patient's health data to medical authorities to prevent any emergencies and readmissions. This monitoring minimizes the routine checkup and hospital stays. The accuracy and reliability of the data provides better precision in treatment. The IoT technology comprising of various sensors installed in the house or on the patients collects real time health parameters sending alarms in event of any crisis.

7.3 Taking Medicines at the Appropriate Time

How many times have you forgotten to acquire your medications when they were due? If you answered "many times," you are correct. IoT surveillance gadgets that will maintain track of patient's recommended drug habit has solved this problem. The technology has been shown to be most effective for patients with Alzheimer's or dementia disease. For example, Med Signals' IoT operated solution. A novel solution using a pill cases that lights up when it's time for the patient to take their medicine.

8 Conclusion

In this paper, the role of real time health monitoring wearable devices in medical field & their technological up gradation are studied. The emphasis is on IoT involved in these different medical devices used for sensing & sending patient health conditions to any location connected via server. Overall timely & continuous tracking by medical experts results in lesser fatal cases & better health conditions with overall reduced maintenance health cost. It results in an increase of medical services accessibilities. This paper gives a look on all the advancement going on IoT based medical technologies up to date. Also the concept of HIoT & its various perspectives are also included with their involvements in various applications.

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