

Internet of Things for Smart Healthcare

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ABSTRACT:

The Internet of Things (IoT) is predicted to be the single most important factor that has the power to change our world .The internet of things, or IoT, is a system of interconnected computing devices, mechanical and digital machines ,home appliances ,vehicles which has the capability to collect and exchange data over a network without requiring human-to-human or human-to-computer interaction. It has gained much attention in recent years due to its different scope of use in various sectors. The Internet of Things (IoT) has opened up a world of possibilities in health care and medicine from remote monitoring to smart sensors and medical device integration which allows medical centres to function more competently and patients to acquire better treatment. IoT-based healthcare services are expected to reduce costs, increase the quality of life, and enrich the user's experience .This papers presents impact of IoT in health care system and reviews various IoT based health care technologies that benefit patients, physicians and hospitals.

KEYWORDS: Internet of things ,healthcare ,applications ,wearable technology ,benefits.

I. **INTRODUCTION:** The Internet of Things (IoT) has an crucial technical, social and economic significance. IoT is a network of interconnected 'smart' devices, allowing collecting information and managing physical objects[9].It is the use of electronic devices that capture or monitor data and are connected to a cloud, enabling them to automatically trigger certain events. It has an extensive applicability in numerous areas, including healthcare. The full application of this model in healthcare area is a mutual hope because it allows medical centres to function more proficiently and patients to obtain better treatment. With the use of this technology-based healthcare method, there are incomparable benefits which could

improve the quality and efficiency of treatments and accordingly improve the health of the patients. Combining the capabilities of the Internet of Things with medical devices can create and provide better conditions for patients who need constant medical and healthcare supervision and preventive intervention. IoT provides numerous advantages to the medical area for example; intelligent IoT wearable devices, in combination with mobile medical applications that allow patients to capture their health data remotely. The IoT has the potential to give growth to many medical applications such as remote health monitoring, fitness programs, chronic diseases, and elderly care.

II. INTERNET OF THINGS AND HEALTHCARE

There has been an increasing demand in developing efficient and cost-effective healthcare solutions which facilitate hospitals and healthcare providers an ease in performing diagnosis and also facilitating patients. The Internet of Things (IoT) has introduced a world of possibilities in health care and medical area: when connected to the internet, ordinary medical devices can collect invaluable additional data, give extra intuition into symptoms and trends. It also enable remote care, and generally give patients more control over their lives and treatment. With IoT, the vital functions of a person are observed using different sensors and complex algorithms are used to examine the data. A communication is then established between the person and the caregiver who can access the valuable medical data and perform diagnosis and make suitable treatment recommendations.

A. APPLICATIONS OF IoT IN HEALTHCARE



Figure1.healthcare trends[2]

There are various applications of IoT in the healthcare industry. Some of the applications are:

- a. **Real Time Location Services:** Through IoT ,doctors and physicians can use real time location services and track the machines and

devices used for treating patients. Medical staff may sometimes keep the devices in out-of-sight areas which makes them difficult to find when another medical staff comes instead. Medical apparatus and devices like wheelchairs, scales, defibrillators, nebulizers, pumps or monitoring equipment can be combined with sensors and located easily through IoT. Apart from real time location services, there are IoT devices that help in environmental observing as well.

- b. **Predicting the Arrival of Patients in PACU:** With the intervention of Internet of Things, clinicians can predict the arrival of patients who are recuperating in the Post-Anesthesia Care Unit (PACU). They can also observe the status of patients in real time.

- c. **Monitoring hand hygiene:** There are hand hygiene monitoring systems that would detect the degree of cleanliness in a healthcare worker. According to the Center for Disease Control and Prevention in the United States, about one patient out of every 20 gets infections from deficiency of proper hand hygiene in hospitals. Many patients lose their lives as result of hospital acquired infections. The interactions in the hand hygiene monitoring systems are done in real time. If a clinician or doctor comes near a patient's bed without washing his hands, the device would start buzzing and the information about the healthcare worker, his ID, location and time will all be entered into a database and this information would be forwarded to the concerned authorities.

- d. **Remote Health Monitoring:** Remote health monitoring is an important application of Internet Of Things. Through monitoring, you can give adequate healthcare to people who are in need of help. Every day, lots of people die because they do not get well timed medical attention. With IoT, devices connected with sensors notify the concerned healthcare providers when there is any change in the vital functions of a person.

These devices would be capable of applying complex algorithms and examining or analyzing them so the patient could receive and experience the proper attention and medical care. The collected information about the patient would be stored in cloud. Through remote monitoring, patients can significantly reduce the span of hospital stay and possibly, even hospital re-admission. If there is any interruption in the routine activity of a person, alerts would be sent to concerned health providers and family members. This kind of intervention is an advantage to people living alone, especially seniors. These monitoring devices are available in the form of wearable devices also.

III. IOT TECHNOLOGIES FOR HEALTHCARE

IoT-based healthcare systems involve a number of technologies that allow IoT devices to obtain data from the physical world; such as Radio-Frequency Identification (RFID) wireless medical sensors, Wi-Fi, ZigBee, Bluetooth, Near-Field Communication (NFC), Big data, -dimensional code equipment, and so on [5].

1. Medical Sensors: Rapidly evolving new applications for healthcare field are based on knowing the conditions of objects (e.g., temperature, stress, strain, pressure, trace, shock). Even though RFID is a major technology in the recognition of a smooth link between medical, physical objects and their digital representations, it cannot give the condition information that healthcare applications require. A sensor is a very broad term used to describe an object that can acquire data [6]. Sensor technologies are important part of IoT in healthcare. It has gained a relatively recent reputation due to their capability to gather contextual and medical data such as temperature, location, humidity, SpO2, ECG, EMG, and EEG and then transmitting the data to a gateway via a specific communication protocol such as

Wi-Fi, Bluetooth, ZigBee or 6LoWPAN. Some of the medical sensors are;

- Heart Rate: To detect the heart rate (and consequently heart rate variability).
- ECG (Electrocardiography): To measure the electrical activity of the heart, this conveys essential information about the status of heart and the function of its muscular contractions.
- EEG (Electroencephalography): To capture the electrical voltages which represent the brain activity.
- EMG (Electromyography) To measure the electrical signal causes by muscular activity for gesture detection of neuromuscular diseases, etc..
- Blood Pressure (BP): measure systolic and diastolic pressure Respiration Rate To measure the rate of breathing.

2. Radio-Frequency Identification (RFID):

RFID facilitates helps in improving the applications of IoT healthcare. Radio Frequency Identification (RFID) is a technology which uses electronic chips embedded on tags to transfer radio waves. These tags can identify products, medical records, assets, and even individuals with embedded security cards or wristbands. It has the potential to help healthcare facilities improve patient safety and reduce costs. It reduces the caregiver's loads in home monitoring, and helps them to monitor the patients suffering from chronic diseases [11]. The RFID system in healthcare consist of two main components ; radio signal transponder (tag) attached to an object (patient or medical devices) and the reader. The tag consists of two components: a chip to keep the unique identity of the object and an antenna to allow the chip to communicate with the reader using the wireless medium. The reader produces a radio frequency field to identify objects through reflected radio waves of the tag. RFID works by sending the number of tags to the reader using radio waves. At last the reader passes that number to a specific application called the Object-

Naming Services (ONS). An ONS looks up the tag's details from a database such as when and where it was manufactured [12].

3. **Cloud Computing:** Cloud computing is the concept of internet based technology, which offers a variety of remote services over the internet such as infrastructure, data storage, servers, networking software, and hardware. The combination of IoT-based healthcare technologies and cloud computing should provide facilities via access to shared resources, delivering services over the internet and allowing users to accomplish normal tasks.
4. **Big data:** . Big data is more than high-volume, high-velocity data that has the potential to be mined for information, patterns, trends, and associations. Medical sensors collect large amounts of essential health data .Big data provides tools for analyzing these data and increasing the effectiveness of relevant health diagnosis and monitoring methods.
5. **NFC(Near-Field communication):** It is a protocol that enables smartphones and other gadgets to establish radio communication with each other by close proximity. Near Field Communication makes the process of connecting devices easy and intuitive. There is no lengthy handshaking or data entry requirements. Just tap and go.

A. WEARABLE TECHNOLOGY AND DEVICES: One of the biggest IoT applications in the healthcare is wearable devices that provide individuals with the information they need to gain better control over their health outcomes. These devices allow remote monitoring of different vital signs and health status. Wearable healthcare devices allow providers and facilities to stay attached to patients and consumers to gain sophisticated visibility into their health. One of the greatest assets of IoT-enabled healthcare wearable devices is that they

provide individuals with the information they need to gain better control over their health outcomes. Wearable gadgets offer individuals greater visibility into their health status and allowing them to make more informed and precise judgment about their health. IoT has introduced several wearables and devices which has made lives of patients comfortable. They could be smart wristbands, smart watches, shoes, shirts, caps, headbands, eyeglasses, etc. These smart devices contain some sort of sensors that help in gathering raw data and relaying it into a database or software. Using this software, we can gather insights and analyze our health. Some of these devices are as follows:

- **Smart watches:** A smart watch is a wearable computer in the form of a wrist watch. Smart watches are being used as a platform for numerous healthcare applications. The most common healthcare applications using smart watches focused on health monitoring or smart home environment for the old age people. They also work as a good fitness tracker; It can count steps, distance, calories, heart rate, pulse rate, sleep and some even go beyond this to calculate other important metrics you may need.
- **Glucose monitors:** Continuous and steady glucose monitors (CGMs) are becoming increasingly popular with diabetic patients. They can wear the gadgets day and night to continuously check their glucose levels. The devices becomes popular because of the facts that a patient can view their glucose levels with a quick look and they only have to use a finger prick blood test twice a day to analysis that the readings on both devices are similar. Real-time glucose levels help patients make more informed choices about the physical activities types of food, and medication they require throughout the day. These monitors work by using a small sensor inserted under a patient's skin which tests interstitial glucose levels every few minutes and sends this information to a monitor or smartphone. Patients gets alerts

when their glucose levels need to be adjusted. Devices like the DexcomG6 are widely accepted because they claim to negate the need for patients to use finger sticks.

- **Smart cloths:** Today Clothes are embedded with sensors which are connected to smartphones, and relay all types of information to the user about their fitness and health. A socks launched by sensoria can track your runs much better than a fitness tracker. It consist of three pressure sensors embedded into the socks to track pace, distance, and time. Sensoria is able to analyse the data and give tips on how to improve your runs and avoid injury.
- **Ingestible sensors:** One of the most interesting aspect of internet of things in the field of medical industry is ingestible sensors. They induce an entirely new possibilities of remote monitoring of patients they are ingestible electronic devices composed of controller sensors etc. Sensors in ingestible sensors mostly measure pH, temperature and pressure and adherence to medication. They transmits information about a patient to medical professionals. These sensors are used to reflect lifestyle choices and entire medication-taking patterns.
- **Hearables:** Hearables are generally the devices for deaf, however the role is not confined to that much. With the help of ear buds it helps in exposing biometric data and fitness metric. The application can also used for tracking vitals including heart rate, blood pressure, and other internal factors
- **Moodables:** These devices will help in providing relaxation to people those who having stress disorders. Moodables can study the brain waves and provide low intensity currents to the brain accordingly. This device would be beneficial on both healthy and stressed brain. The device will also be helpful to study human brains and elevation of mood swings.

IV. IMPACTS AND BENEFITS OF HEALTHCARE IOT

With the IoT Innovation, amazing benefits in healthcare are possible which includes Mobile Health Applications, Wearable and Implantable gadgets. There are tremendous ways by which IoT is making impact in healthcare and lots of benefits through the Internet of things in Healthcare;

1. **Patient accessibility:** The development and availability of Mobile Health applications has become a important achievement which can effectively change the medical industry. Mobile health applications are a efficient way to keep patients engaged in ongoing treatment plans. Some of the various advantages being offered by the medical apps are:[2]
 - Flexibility to both patient and doctor: Mobile health apps are helpful in monitoring patients incurable diseases and notify doctors of emergency medical conditions by providing GPS location for instant healp
 - Electronic Health records: The bulky clinical software used previously is now made available in the form of mobile applications thereby helping doctors quickly and correctly examine and diagnose patients.
 - communications: In case of emergency, patient has the flexibility to instantly message the doctor ensuring quick and timely support. There are social networks which takes healthcare professionals together to discuss and decide on best possible diagnosis.
 - Costs Reduction: Visiting doctors regularly are expensive, but these apps are changing the scenario significantly by establishing remote connections thereby reducing costs.
2. **Remote Monitoring devices:** In Implantable Medical Devices (IMD) is electronic gadgets which are embedded on the human body for monitoring, diagnosing and other purposes. IMDs like artificial pacemakers, implantable cardiac defibrillators, neuro-stimulators and implantable drug delivery systems have implanted computers which are of miniature size which can perform monitoring tasks and therapeutic functions automatically. The

following are the benefits being offered by the remote monitoring devices:

- **Continuous Monitoring:** There are scenarios where the patients require long time monitoring for ex: patient with a chronic disease. Therefore, constant monitoring becomes vital which is being facilitated through these devices.
 - **Patient compliance:** The treatment regimen associated with implantable devices is generally less burdensome than the conventional ways. Early detection of possible problems: Many of the diseases become fatal if they are not acted upon at the right time. These devices could alarm the patients of any such abnormal activity thus preventing from any such severe damage.
 - **Improvement in Quality of life:** The ease of access to medical data of the patient is advantageous in leading a healthy lifestyle. These devices have the potential for tremendous life enhancing capabilities.
3. **Self management with wearable devices:** Wearable devices provides different functions including data collection from sensors, data preprocessing, data storage, and data transfer to internet-connected devices such as mobile phones or to a remote web server. Wearable health devices offer amazing potential in transitioning the health care system from hospital based environment to personal-centered environment. The following are some of the benefits through these kinds of gadgets:
- **Patient friendly Interactive Interface:** Consumer usability has transformed the design of wearable devices, user friendly interfaces and abstraction of information presented to the users.
 - **Personalization of Treatment:** These equipment plays an essential role in treatment and management for chronic diseases. Also, medication adherence monitoring is another aspect being considered.
 - **Interaction between patient and doctor:** Wearables facilitates both patient and the

doctor to establish efficient and productive communication beyond the physical boundaries of the hospitals. Therefore, clinical guidelines are being offered in real time.

- **Management and maintenance of Wearable devices:** Management of these devices on daily basis is an fundamental issue. However, new technologies such as inductive fast charging and intelligent sampling of sensors may also be helpful in prolonging the battery life.

V. CONCLUSION

There has been an increasing demand in developing efficient and cost-effective healthcare solutions which facilitate patients and also healthcare providers an ease in performing diagnosis. IoT technology smart health applications have become a fast growing sector. As the world population is aging and chronic diseases are on the rise, the healthcare industry is quickly delivering high-tech solutions. The growth of advanced medical electronic devices and wearable gadgets is greatly improving patient outcomes and reducing healthcare costs. IoT technologies enable new opportunities by Integrating sensors, devices and people into a single network for interaction between a person and a machine, software and equipment which improves the quality of lives. Lots of technologies of IoT in healthcare is growing rapidly as well as the solutions for numerous applications such as monitoring patients, medical assets, collecting patient data, automated treatment devices, remote monitoring and so on. The performance

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