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Development of Internet of Things (IoT) and Its Impact on the Healthcare Industry

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Abstract

The Internet of Things (IoT) has the potential to modernize healthcare through remote patient monitoring, disease management, and improved health outcomes. IoT devices, such as wearables and sensors, can collect and transmit data in real time, enabling healthcare providers to make informed and timely decisions. This paper examines the current state of the Internet of Things in healthcare, the opportunities presented by the Internet of Things, and the challenges faced during implementation. This paper first describes the benefits of IoT in healthcare, including improving patient outcomes, reducing healthcare costs, and increasing access to care. We look at a variety of IoT devices used in healthcare, including wearables, smart implants, and medical sensors.

This paper also outlines the challenges facing the use of IoT in healthcare, including data security, privacy issues, and regulatory issues. The paper concludes with a discussion of the future of IoT in healthcare and its potential impact on the healthcare industry.

Keywords: Internet of Things (IoT), smart implants, remote patient monitoring, artificial intelligence

Introduction

The Internet of Things is the interconnectedness of devices, apps, sensors, and network connectivity that empowers these entities to collect and exchange data. A distinguishing feature of the Internet of Things in the healthcare system is the continuous monitoring of the patient by checking various parameters and also drawing good results from the history of such continuous monitoring. Many such devices equipped with medical sensors are present in the ICU today. There may be cases when, despite 24-hour monitoring, the doctor could not warn in time when there is an emergency. There may also be barriers to sharing data and information with specialist doctors and concerned family members and relatives. The technology that powers these features is already available, but not accessible to most people in developing countries like India [1]. Therefore, solutions to these problems can be simple extensions to current devices that do not have these facilities. This paper demonstrates a remote health monitoring system controlled by Raspberry pi. The Raspberry Pi is a small payment card-sized single-board microcontroller designed to improve basic computer science education in colleges and developing countries. In this work, the system is designed to continuously

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monitor important parameters such as heart rate, blood pressure, and body temperature.

The information is stored in a cloud server database and can be viewed online through the website or mobile application only by authorized personnel. The idea may not be very new, but we offer a complete and cheap method for the system using Raspberry pi. The main purpose of this system is to update the data online and send an alert to the doctors about any pathology and also predict whether the patient has any disease or not. The former is achieved by using the MySQL Db module to connect the Raspberry pi to the database, while the latter is achieved by combining the Raspberry Pi with the GSM module and the web interface. This system has future scope because the data collected through monitoring is so valuable and can be used by the medical community for any type of research.

The main objective of the paper can be summarized as follows:

• Obtaining real-time medical information about the patient through IoT.

• Processing and classification of information collected about the patient.

• Interpreting and predicting any disease or disorder at an early stage using data mining techniques, which also provides a favorable approach to decision making.

• Provide IoT-based healthcare solutions anytime, anywhere.

Despite the slower pace of IoT (Internet of Things) adoption in healthcare compared to other industries, IoT in medicine is set to keep people safe and healthy, most importantly reducing healthcare costs in the coming years. A smart healthcare system built on the Internet of Things, equipped with a smart medicine box, is becoming available. Connected sensors and servers enable continuous health monitoring. Patients can receive consistent medical treatment without having to meet the patient in person because of the link to the smart medicine box connected to the Internet. A suggested medicine box helps the patient take the right dose at the right time and contains instructions to help the sufferer. In today's world, people often miss important daily details due to busy schedules. The degree to which a patient properly complies with medical instructions is known as medication adherence. Medication nonadherence is defined as carelessness and delay in taking your medication, failure to follow your prescription, or even skipping a dose due to cultural and racial influences. Additionally, unscripted polypharmacy, prescription changes, and taking multiple medications are examples of medical nonadherence. According to studies, medical coverage in rich countries is only about 50%. The situation is significantly worse in developing countries.

The healthcare industry is undergoing significant transformation with the advent of advanced technologies, and one technology that is gaining attention is the Internet of Things (IoT). The Internet of Things refers to a network of connected devices, sensors, and objects that can collect, exchange, and analyze data. In recent years, the healthcare

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sector has explored the potential impact of IoT in transforming healthcare delivery, improving patient outcomes and increasing overall operational efficiency.

Fig. 1. Internet of Things connected to many physical things and objects

This paper aims to explore and analyze the various ways in which the Internet of Things is changing the healthcare industry. By harnessing the power of IoT, healthcare organizations can enhance patient monitoring, enable telemedicine, improve disease management, streamline workflows, and optimize resource allocation.

Through extensive research, data analysis, and case studies, the work demonstrates the tangible benefits of IoT for healthcare providers, patients, and other stakeholders. It also discusses the challenges and considerations of implementing IoT in healthcare, including data security, privacy concerns, interoperability and regulatory compliance.

Ultimately, the outcome of this paper is how IoT is changing the healthcare industry, informing decision-making in healthcare organizations, improving patient care, increasing efficiency and transforming healthcare delivery. This will contribute to a deeper understanding of how to pave the way for more flexible solutions for the digital age.

IoT-based healthcare architecture

Healthcare architectures based on the Internet of Things (IoT) typically consist of three layers: the understanding layer, the network layer, and the application layer. The sensing layer includes a diverse range of sensors and devices designed to collect health-related data from patients. These devices include wearable gadgets, smart watches, blood pressure monitors, glucose meters and similar technologies. They capture vital signs, activity level, heart rate and other relevant information, passing it to the network layer for further processing.

The network layer establishes the necessary connectivity and communication infrastructure to facilitate data transfer between the sensing and application layers. IoT primarily emphasizes high-frequency device communication, although low and medium frequencies are also possible. Communication technologies used in this

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layer include Bluetooth, Zigbee, wireless sensor networks, RFID, low-power Wi-Fi, and global mobile communication systems.

The application layer takes responsibility for processing and analyzing the data received from the perception layer. It includes a number of software applications and algorithms that can monitor the collected data and provide valuable information to healthcare providers. Applications at this layer differ from simple mobile applications that allow patients to track their health data. and end up with sophisticated machine learning algorithms that can predict health outcomes and identify potential risks.

Overall, an IoT-based healthcare architecture empowers healthcare providers with real-time access to actionable data, allowing them to improve patient outcomes, improve care delivery, and reduce costs. However, privacy and security issues are critical to protect patient data and ensure the ethical and safe use of these technologies [1].

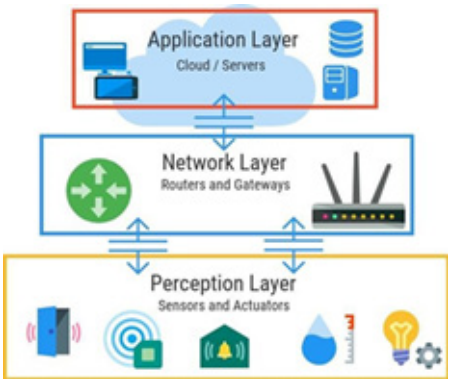

Fig. 2. Three-level IoT architecture [7]

The architecture of the Internet of Things consists of several functions, which can be divided into three main components. The first component is the sensor layer, which consists of sensors, actuators and end devices that interact with the environment. The second component is the sensor layer. It is the network that works with the application layer to facilitate the discovery, connectivity, and movement of network devices, and finally the application layer, which manages and stores data and special services and plays a key role in providing functionality to users (as in Figure 2).

Digital Devices and the Internet of Things

Digital devices and the Internet of Things (IoT) are becoming increasingly important in our daily lives, with interconnected concepts that are changing various aspects of society. Digital devices include electronic devices that can store, process and transmit data. On the other hand, IoT refers to the networking of physical devices, objects and machines, which is embedded with sensors, software and network connectivity that enables data collection and exchange. In healthcare, the widespread use of digital devices and IoT technology has led to significant progress.

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IoT devices collect data and use algorithms for analysis, allowing healthcare professionals to create alerts or recommend further treatment based on the insights gained. Additionally, IoT facilitates remote monitoring of patients' vital signs and health metrics. In addition, smart homes equipped with IoT technology offer support for the independent living of the elderly and disabled through remote monitoring and control of household appliances. In conclusion, the combination of digital devices and IoT technology has enormous potential. To revolutionize healthcare delivery, resulting in improved patient outcomes, increased efficiency and reduced costs. However, it is critical to carefully consider privacy and security issues to ensure that the benefits of these technologies are realized in a safe and ethical manner.

Global statistics for IoT-based healthcare

Forecasts show that the global Internet of Things (IoT) market in the healthcare sector will experience significant growth. The market value, which was $180.5 billion in 2021, is expected to grow to $662.3 billion in 2028, representing a CAGR of 25.9%.

Currently, the market value is estimated at about 60 billion dollars. IoT-based healthcare solutions are expected to achieve annual growth of 25%, reaching over $300 billion by 2025. The expected increase in the number of Internet-connected healthcare devices is significant, approximately 3.7 billion. The devices will be used by 2025.

The adoption of IoT in healthcare has enormous potential. It is expected that the introduction of IoT devices, including wearable devices, can lead to significant cost reductions, Such as a potential 30% reduction in hospital costs, 40% reduction in emergency department visits, 50% reduction in hospital readmissions, and 33% less average hospital stay. These advances are particularly important in the management of chronic diseases such as diabetes and heart disease, where IoT-enabled solutions have the potential to improve patient outcomes and reduce healthcare costs. These statistics highlight the growing importance of IoT-based healthcare solutions and their significant impact on the industry in the near future .

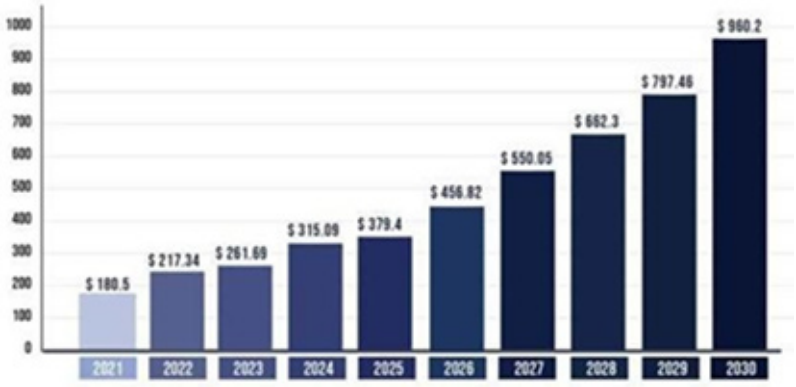

Fig. 3. IoT market, from 2021 to 2030 (USD billion)

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The figure represents the Internet of Things (IoT) market share from 2021 to 2030 and shows the market size in billions of dollars. In 2021, the service sector will account for 59% of revenue, and the hospital sector will account for 35%. In 2021, North America is expected to hold the largest revenue share at over 40.3%. Asia Pacific is forecast to grow at a CAGR of 18.50% for research, software and documentation processes from 2022 to 2030. The market has experienced significant growth due to increasing demand for medical equipment, active patient population and focus on efficient equipment. Improved digitization, government support, and technological advancements will also drive market growth during the forecast period (as shown in Figure 3). [2]

Implementation of the System

In this paper, we proposed a system in which the patient's body temperature, heart rate, body movements, and blood pressure results are monitored in the system. Various sensors are placed on the patient's body and they receive the data and send the corresponding signal to the Raspberry Pi. Various sensors are used to measure the patient's body temperature, heart rate, blood pressure and their respective results are sent to the database via Raspberry Pi and can be monitored from anywhere in the world via the internet via a GSM module.

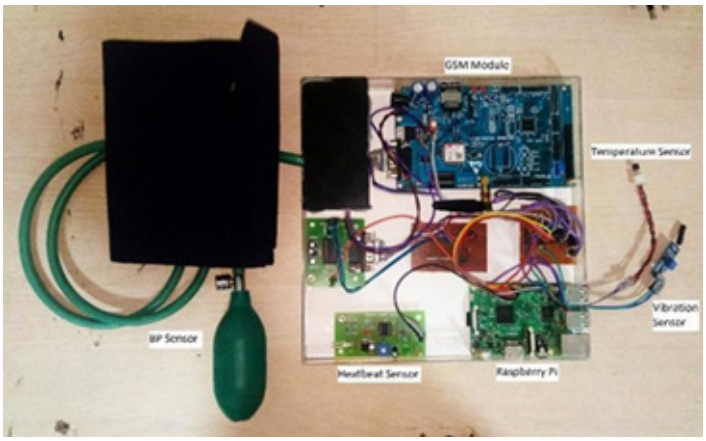

Fig. 4. Experimental setup

The Raspberry Pi is programmed in the Python language, and it sends patients' health-related data to a server connected to the Internet. Details can be easily accessed online with proper authentication and patient health status can be monitored.

The various components used in the system are:

A. Raspberry Pi

The Raspberry Pi is a bank card-sized microcontroller with the features of a small computer and is very popular for development purposes because it offers an entire Linux server and peripheral on a single chip and is very efficient.

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Fig. 5. Raspberry Pi

B. Temperature sensor

LM35 sensor is used to measure temperature which is an IC sensor used to measure temperature with the help of analog output proportional to temperature.

Fig. 6. Temperature sensor

C. Heart rate sensor

The heart rate is measured using a pair of LEDs and an LDR and a microcontroller and works on the basics of optoelectronics. Infrared radiation is emitted by an IR LED and the infrared light is reflected off the surface. The radiation intensity produces an electron-hole pair, which in turn produces a leakage current. The current thus generated is sent through a resistor to obtain a proportional voltage. Thus, the greater the intensity of the intensity beam, the greater will be the value of the voltage that flows through the resistor.

Fig. 7. Heart rate sensor

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D. Vibration sensor

The vibration sensor used here senses the vibration of the environment and hence we use it here to observe whether the patient is shaking or not so that proper care can be given.

Fig. 8. Vibration sensor

E. BP sensor

We used a manual blood pressure monitor instead of a digital blood pressure monitor because it is cheaper. It is commonly known as a sphygmomanometer and the kit consists of an arm cuff, an inflation bulb, a stethoscope and a pressure sensor. Blood pressure is measured using an air pressure sensor. Indications are in the form of electrical signals. These readings are also converted to digital form to be read by the Raspberry Pi.

Fig. 9. BP sensor

F. ADC

The MCP3008 is a low-cost 8-channel 10-bit analog-to-digital converter. This chip is a great option if you need to read simple analog signals, such as from a temperature or light sensor.

Fig. 10. MCP3008

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G. GSM module

GPRS/GSM Quadband Module (SIM900) provides GPRS connectivity to our system and includes the SIM900 communication module from SIMCom. This module can accept any type of SIM card that has its own unique number. The same can be used to send messages, make calls or create sockets to provide internet access.

Fig. 11. GSM module

Using AI and ML for designing IoT-based healthcare systems

The use of artificial intelligence (AI) and machine learning (ML) in combination with the Internet of Things (IoT) has attracted much attention in the healthcare industry. By analyzing data captured by IoT devices, AI and ML algorithms offer valuable insights into patient health, enabling personalized treatment and optimizing device operations. This integration holds tremendous potential to improve patient outcomes, reduce healthcare costs, and improve the overall quality of care. Moreover, the study of smart city concepts specifically focuses on revolutionizing healthcare by increasing efficiency and cost effectiveness. One notable use of IoT in healthcare is remote healthcare monitoring systems that rely heavily on AI and ML to analyze various records and data sets. In addition, ML methods are used to create analytical representations in clinical decision support systems.

Security and Privacy of Patient Data

Ensuring the security and privacy of patient data has become a major concern in IoT-based healthcare. The growing use of IoT devices in the healthcare sector has raised concerns that patient data is vulnerable to cyber-attacks and unauthorized access. Therefore, it becomes imperative to establish adequate security measures to protect patient data and privacy. This requires the implementation of encryption techniques, access control and secure communication protocols. In addition, it is essential to educate patients and healthcare professionals about potential risks and data

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protection best practices. Patients should be well informed about data collection, use and sharing procedures, and ensure their informed consent before data sharing. Healthcare providers need comprehensive training to handle patient data securely, recognize security threats, and respond effectively. Additionally, a strong regulatory framework that outlines clear data protection and security standards in IoT-based healthcare is needed. Such a framework promotes trust, inspires trust, and ensures the responsible and ethical use of patient data within IoT-based healthcare systems.

Wearable sensor network

The inclusion of a wireless sensor network is a critical component in healthcare solutions, as it enables continuous and real-time measurement of physiological signals, minimizing information overload and effort. Vital signs such as heart rate, heart rate variability, body temperature, skin conductance, lung respiration, blood pressure, blood sugar, Oxygen saturation and other vital signs can be measured using appropriate equipment that can easily be worn over clothing or clothing. . It was effectively identified and acknowledged. Can be attached directly to the body. In the clinical setting, assessment of the four key indicators (namely body temperature, heart rate, respiratory rate, and blood pressure) is usually limited to physical examinations or medical prescriptions, often using limited equipment. However, more accurate and continuous monitoring of these vital signs and other related parameters is needed. The primary goal of medical and precision medicine devices is to provide optimal information to healthcare professionals and patients, which provides high precision longitudinal measurement. Each subject has two types of wearable sensor nodes, a safe node to monitor the environment and a health node to measure the body. The health node consists of a BLE module that facilitates WBAN communication, a PPG sensor for heart rate monitoring, and a body temperature sensor. In addition, the system includes four environmental standards and two radio modules: BLE for indoor WBAN communication and LoRa for LPWAN transmission. In a secure environment, the Bluetooth Low Energy component (BLE) plays an important role in receiving sensor data from the WBAN medical line. This data is then transmitted to distant locations on the LoRa network. BLE can transmit data efficiently with low power consumption, but the transmission range is limited. On the other hand, LoRa has a lower data rate and consumes more power, but it can transmit data over long distances. Therefore, the proposed hybrid network design uses LoRa for long-range data transmission and BLE for data transmission in WBAN.

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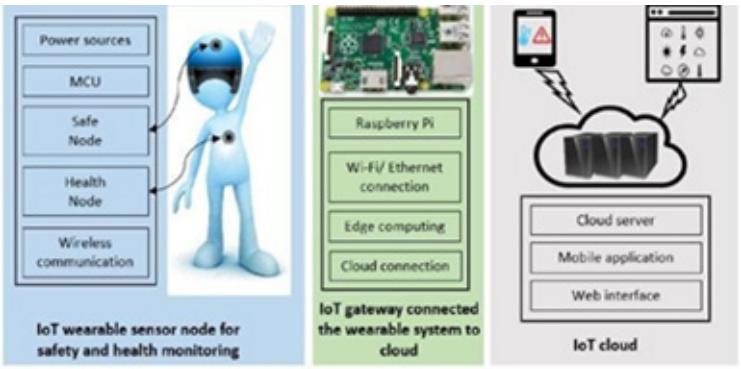

Fig. 12. Design of wearable sensor networks for environmental and health monitoring

Recommendation

IoT-based healthcare has the potential to benefit various sectors such as hospitals, clinics, home healthcare, telemedicine, remote patient monitoring, and public health agencies. This technology can be used to deliver personalized care, improve patient outcomes, optimize resource allocation, reduce healthcare costs, and improve the overall healthcare experience. In addition, wearable devices and smart sensors can be used to monitor health biometrics and alert patients and healthcare providers to potential health problems. which facilitates early intervention and better management of chronic diseases.

The paper has various limitations, which are explained below:

- Security Concerns: With the increased use of connected devices, the risk of cyber-attacks and data breaches increases. The sensitive nature of healthcare data makes it an attractive target for hackers.
- Interoperability: There is a lack of standardization and interoperability among IoT devices, which can lead to difficulties in integrating different devices and systems.
- Reliability: The reliability of IoT devices and the accuracy of the data they collect can be a concern. Technical problems with devices or connectivity can result in inaccurate or incomplete data, affecting patient care
- Privacy concerns: The collection and use of personal health data raises concerns about privacy and data ownership. Patients need to be confident that their data is secure and that they have control over who can access it.
- Cost: The cost of implementing and maintaining IoT-based healthcare systems can be high, especially for smaller healthcare providers. This can limit their ability to adopt new technologies and provide the best possible care to patients. [3]

Conclusion

The impact of the Internet of Things (IoT) on the healthcare project has provided valuable insight into the transformative potential of IoT in healthcare. The findings of this project highlight the many benefits

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and opportunities IoT brings to healthcare organizations, patients, and stakeholders. Through the integration of IoT devices, healthcare providers can enhance patient monitoring, enable remote care and improve disease management. Real-time data collection and analysis enables proactive and personalized healthcare interventions that lead to improved patient outcomes. Seamless connectivity and interoperability of IoT devices and wearables facilitates efficient information sharing, facilitates collaboration and streamlines work processes. However, the challenges and considerations associated with implementing IoT in healthcare are critical. Data security, privacy concerns, interoperability and regulatory compliance must be carefully considered, to ensure the safe and responsible use of IoT technologies in healthcare settings.

Going forward, the future of IoT in healthcare has enormous potential. Further research and development in areas such as smart medicine, sensors, software frameworks, AI integration, and overcoming systemic barriers will help realize the full benefits of IoT in healthcare. By embracing and leveraging IoT, the healthcare industry can embrace the future of connected care, improved efficiency, and enhanced patient well-being.

References:

Journal of emerjing technologies and innovative research (JETIR) (ISSN-2349-5162).An international Scholarly Open Access, Peer-reviewed Refereed Journal (2022). www.jetir.org

International Journal of Applied Engineering Research. ISSN 0973-4562. Volume 13, Number 15 (2018) pp. 11984-11989. http://www.ripublication.com

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056. Volume: 09 Issue: 12 | Dec 2022 www.irjet.net