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Research Article

A Survey on IoT-Based Healthcare Systems: Innovations, Challenges, and Future Directions

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Abstract

One of the most admirable uses of IoT is in healthcare. Doctors can use the Internet to help people because to IoT. The distance between the patient and the physician can be greatly decreased with portable Internet of Things-based health monitoring equipment. may approach each patient separately, assess their current state of health, and determine the best course of action for them thanks to IoT. Healthcare is fast changing thanks to the Internet of Things (IoT), which promises individualized treatment and eases systemic stress. Devices whispering updates to physicians, tablets reminding patients to take them, and remote monitoring for the elderly are all possible with the development of networked systems. IoT is growing in the developing world because to a number of issues, including a lack of access to healthcare, an increase in chronic illnesses, high healthcare costs, and a growing need for telemedicine. There are suggestions for future research directions along with a presentation of the security, privacy, wearability, and low-power operation challenges that the healthcare IoT faces and conduct a thorough literature assessment of current research on IoT-based healthcare monitoring systems. review. The effectiveness, efficiency, data protection, privacy, security, and monitoring of various systems are compared in the literature study. The report concludes with recommendations and ideas for IoT healthcare applications as well as future directions pertaining to a number of current technological advancements.

Keywords: *Internet of Things (IoT), Healthcare System, Healthcare system architecture, IoT technologies, Remote Healthcare.*

Introduction

The IoT is a network that links people, things, data, and processes. It is changing our lives, businesses, and everything else. Scientists say that by 2025, 75 billion devices will be online. Of those, only 33 billion will be computers, smartphones, tablets, and smartwatches. The last two thirds will be made up of more "devices" that have never been connected to the Internet before [1]. Sensing devices, computers, city structures, TVs, thermostats, home appliances, cars, and many other things are examples of "things." In the near future, the IoT will change how people talk to each other in big ways. People could connect to the Internet and each other through mobile devices, which were the next step up from the World Wide Web. The IoT, on the other hand, looks like it will connect machines, virtual objects, environments, people, and devices in ways that only science fiction writers could have imagined.

A lot of people believe that AI, cloud computing, fog computing, edge computing, cognitive computing, and other advanced technologies will make healthcare perfect [2].

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The medical data that a person has looked at may be linked to their age, gender, and where they live. Smart health care systems can look at and summarise huge amounts of data. One example is RHMS systems, which allow for remote healthcare tracking. There are three levels to these methods. At the first stage, intelligent wearable monitoring [2] is used to gather information about the body. Most companies that make wearable monitors use Bluetooth low energy (BLE) interfaces for their sensing devices. Because of this, a number of remote healthcare tracking systems have gotten better. They now send BLE communication interfaces to collect physiological data from patients.

The study of the IoT is still pretty new, as are the ideas behind how it might be used in healthcare. This part talks about the IoT and stresses how well it works for the healthcare business. Several creative attempts to make IoT solutions for healthcare are being talked about[3]. A general and standardized paradigm for future end-to-end IoT healthcare systems is suggested, building on the themes that have come up in these efforts. This will help guide the development of these kinds of systems in the future.

The IoT is clearly becoming a bigger part of our lives all over the world. IoT generally includes a wide range of smart system platforms, sensors, and smart devices[4]. Quantum and nanotechnology are also used in the IoT to make working faster, storage space bigger, and sensing better than ever before. Many research projects have been done to show that IoT transformations work and are useful.

Edge computing is also becoming more important in IoT settings, which is an interesting trend. Edge computing shortens wait times and speeds up response times by putting computer power closer to the source of the data [5]. By managing data at the edge, IoT devices can improve system speed, save bandwidth, and work more efficiently. For the foreseeable future, security will remain very important in the IoT. Protecting the safety and security of data sent between devices is very important as the number of connected devices grows. Improvements in encryption, authentication, and secure communication techniques are needed to keep IoT ecosystems safe from cyber threats.

Overview Of Iot-Based Healthcare Systems

IoT stands for "Internet of Things." Things like cars, homes, and other places that can send, receive, and use data over the internet are known as "internet objects" [6]. Making a service that can be used for more than one thing is one way to get the most out of the IoT. "Services involved in device modelling, device control, data publishing, data analysis, and device detection" are some of the different things that the writers say the IoT is. Because the IoT has such a bright future and can help with research and study in so many areas, other technologies like it have been pushed to the back burner.

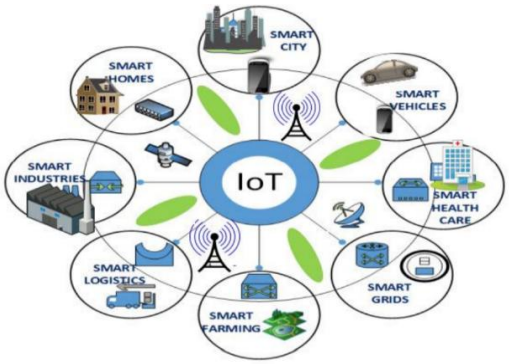

Fig.1 Definition of IOT

This maintains that if IoT is to become a well-known technology in the medium term, several neuralgic features of its continuous growth must be examined [7]. "An internet-based interconnection of machines and devices, enabling the creation of data that can shed light on analytic performance and support new technologies" is a description of a thing. This argument says that the IoT is a group of fixed or moving devices that are all linked to the internet and have actuator, sensor, and communication units. A "network of physical things" that can talk to each other on their own is also known as "the IoT."

IoT based Healthcare system

Every day, many people in India lose their lives because they don't get the care they need quickly and properly. It was the main goal to make a reliable patient tracking system that would let doctors keep an eye on patients who were in the hospital or living their normal lives. A traditional method to health care is being replaced by a more modern, patient-centered one [8]. In the traditional method, doctors play the most important part. They have to see the patients in person in order to give the right diagnosis and advice. Modern healthcare systems say that everyone, everywhere, at any time should be able to get better healthcare services that are easy to get, don't cost much, and are patient-friendly [6]. Our method is meant to be used in hospitals to track and measure things like temperature, pulse rate, and heart rate.

Benefits of IOT based healthcare system

Remote Patient Monitoring

Where healthcare centers or specialists, general doctors, medical caretakers, and patient watchmen will probably have a continuous perceivability of patient action and condition. The timely data access is a key factor for the success of remote patient monitoring solutions with IoT enabling technologies in healthcare. As a matter of fact, that some applications for remote patient monitoring already existed and proved its electiveness, particularly, with elderly patients or dependents deteriorates or patients with exhibits abnormal behavior [13]

Remote Patient Monitoring: General practitioners, medical workers, patient watchmen, and healthcare centres or experts will probably always be able to see what patients are doing and how they are doing. Fast data access is necessary for remote patient monitoring systems that use IoT technologies to work in healthcare [9].

Better Patient Experience: IoT healthcare solutions and apps stress proactive therapies, accurate diagnostics, quick doctor intervention, and better treatment outcomes. All of these things will lead to a better patient experience and happiness.

Fig.2 Monitoring system in Healthcare systems

Better Ways of Delivering Drugs: IoT-enabled technology will have a huge impact on the drug distribution system. This will allow medicines to be given more accurately and with less risk to the patient. Wireless networks can be used to connect smart devices or add IoT-enabled devices to them.

Better Management of Clinical Infrastructure: Technology that makes the IoT possible can help make managing clinical chores more efficient. Sensors can keep track of who is where and what is going on, and the information can be used to update an online schedule that everyone in the medical centre stack can see. This should be possible in a non-stop way, which is a little better than having someone physically write something on a whiteboard again.

IoT Technologies for Healthcare systems

Biosensors: were made in the 1960s by Clark and Lyons. It is generally thought that biosensors started to be made in the late 20th century. Using oxidase to find glucose electrochemically was the most common way that biosensors were used in the first part. A lot of people were interested in making quick, sensitive, and cheap gadgets for natural systems in the 1990s. A biosensor has three parts: the transducers, the signal processor, and the substance that does the identification.

Immunosensors: are widely used to find specific antibodies or antigens. This is how most immunosensors that are used by a lot of people are made. In the medical field, immunosensors can be used. Immunosensors are very selective and aware because they only bind to germs and work with harmful substances in the host's body. How well an immunosensor works is based on three rule0073:

1- The binding parts' preferences
2- The size and ease of access of the bond should stay the same after immobilization.
3- The number of particles that stick to the immunosensor's surface.

It's important to note that different methods can lead to various outcomes. Besides that, there are different types of immunosensors [10]. The materials used for each type can change depending on the needs. Some of these different types of immunosensors are optical, electrical, piezoelectric, direct, and indirect immunosensors.

Iot Based Healthcare System Architecture

The information we were given says that our system should be set up in three steps, with a strong cloud system at the base and a data-gathering layer based on the IoT at the top. With this set-up, we can look at a lot of data from hospitals and individual patients to find trends and predict diseases [11]. Lastly, mobile app technology will improve real-time data sharing and care by analysing data in fun ways that make keeping track of patients easier. Healthcare devices are used in the sensing layer of the system to gather biological data. It can keep an eye on temperature, blood pressure, SpO2, ECG, and other things. People can keep track of a number of their vital signs with these smart techs. The Node MCU ESP8266 processor gets data from things that can sense. Node MCU is a free tool that can be used to make both hardware and software. It is built on top of the ESP8266. To get the most up-to-date results when gathering healthcare data, you need IoT choices that are based on medicine.

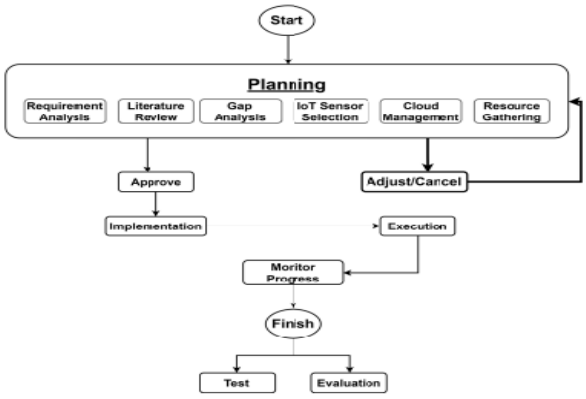

Fig.3 Methodology of Proposed system

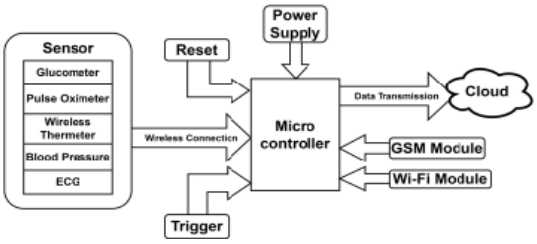

Fig.4 Sensors, setup and components connection block diagram

An IoT-Cloud-based healthcare system should have grouping algorithms because they make it easier to organise and see the data that is created by multiple devices that are connected [12]. Healthcare workers wouldn't be able to find trends and correlations in the data if they couldn't sort and combine pieces of data that are related [13]. Healthcare workers can also benefit from seeing the results of a clustering algorithm. This helps them understand the data better and see how it fits with what they already know. They make it easy to look at data, assign resources, and make decisions, all of which lead to better healthcare service. Clustering algorithms are a key part of an IoT-

Cloud-based healthcare system.

In the healthcare field, HCA can be used to look at and rate data that is kept in a continuous-time domain. The suggested system can be expanded as needed and can be put into place with either a public cloud or private cloud-like technology on-premise, Figure 5 shows the layer of clouds.

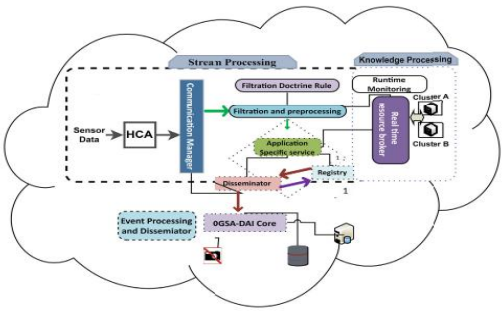

Fig.5 Cloud Management

HCA works by putting together data into a framework that looks like a tree [14]. It uses a hierarchical clustering method that doesn't need to know how many groups to use ahead of time. The input space holds the data that came from IoT devices in the first place. When the DAN gets health data that hasn't been labelled or organised, it stores it. This leads to a lot of unique traits that need to be thought about.

Challenges And Innovation In Implementing Iot-Based Healthcare Systems

IoT-based healthcare systems need to get past some problems to make sure the technology works right and gives the expected benefits [15].

Challenges in implementing IoT based healthcare systems

IoT has been used in many areas and can help the healthcare system in many ways, such as by tracking patients and providing smart home systems for people with diabetes [16]. Here is a list of the most important problems the healthcare system is having[17]:

The IoT makes things very flexible. For example, a patient who needs care around the clock can live at home instead of in a hospital and get regular tracking through IoT. Sensors and other external tech can be painful for the patient's body.

There will be noise in the data as it travels from the sensor to the control device and then to the tracking center. A better design makes it easier to send data without changing what the data is about. Noise removal methods can also be used to make the data signal better.

Most of the present methods for monitoring an ECG involve guided signal analysis. This could cause a detection mistake and raises the price. Using machine learning [18], the signal can be analysed, which raises output and lowers costs.

More sensors and devices are required to handle more energy, and more power is being lost and used. Use of less energy can be lowered by using an optimization method.

Keeping track of a lot of IoT users requires more storing space and a mainframe. If you store your data in the cloud, you don't have to worry about this. But things get more complicated when the cloud and IoT are used together.

Privacy is another big problem with the IoT because strangers can get into more gadgets. Because these devices don't have as many tools, it's hard to use encryption methods on them.

Innovations In IoT-Based Healthcare Systems

A lot of things are better for people when they use IoT to run their healthcare systems, like [19]:

Remote healthcare: Wireless Healthcare can come to patients thanks to IoT tools [20]. IoT devices collect data safely. Following a short procedure, the data is sent to medical professionals to get advice.

Real-time monitoring: IoT-enabled monitors that don't stand out collect a lot of psychological data. To keep track of data storage, gateways and cloud-based research are used.

Preventive care: The information from sensors is used by IoT healthcare systems to let family members know about problems and help find emergencies quickly. The IoT method lets computers learn to track health trends and find problems early on [21].

E-Health: E-health, which provides personalised medical services, meets people's needs when it comes to health care. IoT is a big step forward in the age of big data, and it uses a lot of useful tech tools to make things better [22][23]. IoT data analytics is now used by the medical system as a user data source to learn more about patients, find diseases early, and rate the importance of problems for better quality of life.

Future Directions Of Iot In Healthcare

The plan for the future is very important for the design system to get smarter. Adding more sensors to the internet would make the designed systems better because they could measure other health factors and help with patient tracking. This would mean connecting the whole thing to the internet so it is easy to get to . Putting in place Wi-Fi mesh networks to make ways of communicating wider.

The (IoT) has a lot of promise for the future in healthcare. A lot of new technologies and trends could completely change how we treat people. IoT is already making a difference because it gives us info in real time, makes us more efficient, and helps patients do better.

Advances in IoT technologies

Medical and healthcare: IoT technology is changing the way patients are cared for by making it easier to keep an eye on them, tailor their treatment, and get better health results. Fitness trackers and smartwatches are examples of wearable tech that has biosensors that can track vital signs, levels of physical exercise, and even early signs of diseases. Medical costs and hospital readmissions can be cut by using remote patient monitoring systems to handle long-term illnesses, keep

an eye on patients' health from afar, and act quickly in an emergency. Adherence-tracking systems and smart drug dispensers can help patients better handle their medications and stick to their treatment plans. This is especially important for people who have complicated drug plans. IoT in healthcare generally makes it easier to switch to proactive, patient-centered, and customized care models, which improve patients' results and quality of life over time.

AI and Machine Learning in IoT Healthcare

A big use in the real world was using AI-enhanced IoT wearables in a remote patient tracking system to keep an eye on people who have long-term illnesses. By analysing sensor data in real time, this technology showed how AI systems could predict health declines and let doctors know right away what to do. Another interesting example is how AI is being used in imaging diagnostic tools. In this case, imaging devices that are connected to the IoT and AI algorithms showed better detection accuracy, especially when it came to finding diseases like cancer early. We also came up with made-up situations, such as a senior care smart home that uses AI and IoT to keep track of daily activities and spot problems like falls, and a situation where AI analyses data from various IoT medical devices to create personalised treatment plans.

Blockchain for Healthcare Data Security

Blockchain is a public, decentralized digital ledger that keeps track of events across many computers. It is impossible to change a record from the past without also changing blocks that come after it. Blockchain builds a long chain by verifying and linking each "block" to the one before it. After all, blockchain is the name of the record. Blockchain provides a high level of responsibility because every transaction is made public and checked. The information that is put into the Blockchain can't be changed by anyone. It shows that the data is correct and has not been changed. By storing data on networks instead of a central computer, blockchain makes it more stable and shows how easy it is to hack.

Literature Review

This paper gives a complete review of the latest technologies for watching patients from afar. These technologies use AI and the IOT to find both emergencies and low-risk illnesses. It also talks about This project uses an IoMT-based system to track the health of crisis rescuers and use their ability to move around to come up with new ways to quickly fix broken paths. Last but not least, we talk about three possible future sites for IoMTs. Most of the changes in the IoMT happen when users move around and change places. This makes it harder to plan how to divide up resources and routes. This research looks at how the IoMT can be used to keep track of people's and groups' health. These networks let the people who are being watched move around as they please. Wearable tech is being used more and more in medical and emergency settings to keep people safe and healthy, which helps the Internet of Medical Things (IoMT) grow [28].the problems with collecting data, analysing it, and keeping an eye on things in the current health tracking systems. This helps figure out the scope and direction of future research in cutting-edge medical technology and remote health tracking systems [24].

The main focus of this study is on personalised health care services. While using the IoT in modern healthcare, make a list of the most important things that must be in place for full personalised healthcare services (CPHS). Among other things, you should talk about change and give an example of a use case scenario that shows how modern HIoT works. Next, an easy three-level plan for AI and non-AI IoT healthcare systems was looked at. We thought about what CPHS needs in order to do its job before looking at the pros and cons of personalised health care [25].

The aim of this paper is to look at the most up-to-date smart healthcare systems that are currently in use. It will focus on some of the most important areas, such as using machine learning to diagnose diseases, using wearable and smartphone devices to track health, and creating assistive systems like social robots for assisted living environments. The study also shows how to easily add software interface designs that are necessary for creating smart healthcare systems that can easily include AI and data analytics [26].

The basics of the IoT in the medical area are talked about in this essay. It also talks about the privacy and data security problems that come up with machine learning and H-IoT devices. The story makes it clear how important it is to keep an eye on all of the different parts of healthcare IoT, such as awareness, network, cloud, and application. To find and fix problems, different types of cyberattacks and methods are needed. The H-IoT, which is also known as "Digital Healthcare," would not be possible without smart sensors like blood pressure and temperature monitors. This method is based on data, which speeds up response times, diagnosis, and treatment [27].

This research examines all the current medical IoT technologies, their uses, their benefits, and their issues. Additionally, it reads all studies that look at the different methods and technologies used in these areas. Although things have gotten better recently, medical IoT is still not widely used. Regulations, technology, and moral concerns about biological devices are slowing the development of the medical IoT. IoT is still being used in more and more medical situations. The following are two examples: biomedical tools and data that show body levels, electrical signals, vital signs, glucose levels, cancer markers, and other levels. It is expected that medical IoT will replace old healthcare systems in the coming years. The differences between our study and other surveys on the topic are that ours looks at all the most important standards and technologies for medical IoT, as well as the problems that come up [10].

Table 1 Summary of IoT-Based Healthcare Systems

Ref.	Study On	Approach	Key Findings	Challenges	Limitations
[24]	IoT and AI-based remote patient monitoring systems	Comprehensive study	Low-risk chances of illness and emergencies through remote monitoring	Data collection, monitoring issues	Scope for future research and advancements
[25]	Personalised treatment services based on IoT	A look at three-layer building	Pros and cons of using AI versus other ways	Personalization complexity	Limited scope in real-world applications
[26]	Smart healthcare systems	Discussion of ML, wearable devices, and assistive frameworks	Integration of AI tools in healthcare	Software integration complexity	Practical deployment issues
[27]	Healthcare IoT privacy and security challenges	Review of security challenges in HIoT	Importance of anomaly detection and cyber-attack responses	Privacy and data security	Vulnerabilities in HIoT layers
[10]	Technologies and protocols in medical IoT	Literature review	Growth potential and expected replacement of old healthcare systems	Ethical, regulatory, and technological challenges	Limited biomedical hardware advancement
[28]	Routing repair in IoMT-based health monitoring	Study on topology changes in IoMT	Mobility-based routing solutions for disaster rescue	Resource allocation and routing difficulties	Frequent topology changes affect reliability

Conclusion and Future Work

Healthcare is one of the most interesting fields where IoT-enabled apps can be used. People from all over the world have been looking into how the IoT could be used to make healthcare better lately. In lots of ways, the IoT could make health care better. These include lower prices and faster, more accurate, and better performance. Thanks to the benefits of IoT use, healthcare systems can now be managed as well as they can be. This book is meant to be an introduction for people who want to work in healthcare tracking systems or the IoT in general.

In the future, study into IoT-based healthcare systems will focus on fixing important problems and making these technologies work better. More and more, businesses are starting to use IoT apps. A lot of business options are available for keeping an eye on someone's health.

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