Section A-Research paper
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A STUDY ON INTERNET OF THINGS BASED ON BIOMEDICAL APPLICATIONS

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ABSTRACT

Applications based on the Internet of Things (IoT) are utilised in biological sensors and data, diagnosis, therapy, and other biological processes like healthcare/telecare. IoT applications in the areas of health and medicine are important research topics. Some IoT applications include the hospital administration system, remote patient monitoring, medical waste management, robotic nursing assistants, depression monitoring via smart watches, Parkinson patient monitoring via GPS smart soles, and hand hygiene tracking via smart watches. All healthcare-related data, including treatment, diagnosis, recovery, inventory, and medication, may be effectively gathered, processed, and shared using IoT-based systems with worldwide connectivity. Due to their wireless interfaces and internet connections, IoT-based healthcare services offer mobility. The research flow for the IoT applications study offers a current overview of potential applications for IoT-based technologies in healthcare. In this case, a variety of interconnected idioms and linguistic conventions make it evident how the input and each node's likelihood of becoming a CH relate to one another. During the data transmission phase, a network coding technique will compress the data before sending it to the following level.

Keywords: Internet of Things, biomedical systems, healthcare, hand hygiene monitoring, mobility.

INTRODUCTION

The Internet of Things (IoT) has generated a lot of interest in the healthcare software industry during the last several years. The healthcare industry is extremely practical, and IoT offers a wide range of options to improve it. A wide range of modern medical sensors and gadgets may

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communicate through different networks, giving access to crucial data regarding patients' ailments. [1] Then, by gaining more insight into the symptoms, this information can be used to anticipate disease and recovery, monitor patients from a distance, and generally enhance the diagnosis and treatment process by increasing automation and portability.

Modern biological sensors and information networks are revolutionizing traditional health care. Healthcare costs are decreasing, early diagnoses are made, and people who may not be in the immediate vicinity of the medical staff can now get distributed medical treatment. The development of the medical internet of things (m-IoT) would pave the way for several applications, such as remote health monitoring via medical-grade wearables to provide elderly people with in-home care, virtual doctor-patient interaction to give patients access to health experts whenever and wherever they are, wireless endoscopic analysis, and remotely controlled surgical methods to improve access to highly qualified surgeons. The relationship between IoT and other network devices is shown in Figure 1. There are connections between patients, doctors, and the rest of the networking system. All digital records that are maintained in databases are accessible to clinical personnel and physicians. Thanks to this mobile health service [2], we can easily access the quality of medical treatment and the calibre of pharmaceuticals in accordance with patient needs. The IoT-based system, which can adjust to the patient's circumstances and enable its settings to be changed in accordance with the patient's disease, manages the patient's whole care. Using this technique, we can precisely forecast the patient's present and future health conditions.

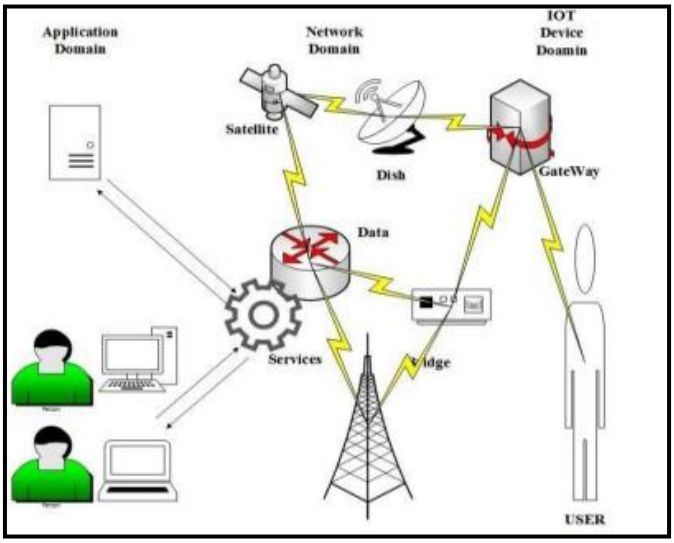

Fig 1 Communication of IOT [2]

In this study paper, we will largely look at the uses, benefits, and upcoming issues of the internet of things (IoT) based on the research done by numerous researchers in the field. This essay's main objective is to give readers a basic grasp of what the Internet of Things is, the range of

applications it has taken, and how it is assisting in resolving problems in the worldwide health care industry. [3].

INTERNET OF THINGS

The purpose of the rapidly expanding internet is to link people, things, and experiences through connections. The internet of things began to exist when there were more objects online than people. Every element of our life is being impacted by the Internet of Things, including our reactions and actions. The air conditioner can be controlled with a smart phone, and smart autos provide the quickest route. Our everyday actions are also monitored through the smart watches we wear. IoT refers to a vast network of connected items. These devices gather and share data on their use and environment of operation. Every physical object has a sensor, and sensors are utilised for everything. Nearly every device we use on a regular basis, including cars, traffic lights, barcode sensors, and mobile phones, might be impacted. What matters most is how they share this vast amount of data and how we can use it to our advantage. These sensors produce data and information about the devices' operations on a continuous basis. IoT offers these devices a standard data storage platform and a language to communicate with one another. Data is released from numerous sensors and submitted to an IoT platform's security. The IoT platform combines the data collected from many sources and does additional analysis on the data to extract the relevant information that is required. The result is then shared with other devices in order to improve user experience, automate procedures, and boost efficiency.

KEY FEATURES (COMPONENTS) OF IOT

The Internet of Things (IoT) is now understood to be more than just a collection of consumer devices. The technology behind the Internet of Things (IoT) actually develops systems that can independently detect and respond to environmental stimuli without the aid of a human. As a result, we must develop a process flow for a particular framework that serves as the foundation for an IoT solution. The route the IoT data takes is both lengthy and exciting. The IoT platforms get data upstream from the field sensors through wireless communication. The platforms also offer data mash-up capabilities that let us take advantage of Big Data potential. Last but not least, there is a data downstream from the platforms to the actuators in the field or some lovely frontends on our computer or mobile device.

BLOCKCHAIN WITH IOT

In an HIoT network, data exchange between various medical equipment and medical providers is essential. However, data splitting is one of the main problems with secure data communication. Due to data fragmentation, healthcare practitioners caring for the same patient may have information gaps. The course of treatment could become more challenging due to ignorance. Healthcare organisations can connect the network's data repositories using blockchain

technology, which is utilised to address the problem of data fragmentation. [4]. This increases communication between doctors and patients and ensures that sensitive medical information is transmitted in a secure and secured manner. Additionally, blockchain technology fosters qualitative research collaboration between healthcare companies and practitioners (Figure 2). Three things may contribute to the secure transmission in blockchain technology.

It has an immutable "ledger" that individuals can access and manage as a start. It guarantees that a record cannot be changed once it has been added to the ledger. Additionally, each transaction in the ledger is subject to a set of preset regulations. Second, blockchain is a distributed system that runs concurrently from numerous computers, devices, etc. Third, blockchain relies on a smart contract approach to follow the rules of agreements and data sharing regulations. Access privileges to the electronic medical records (EMRs) kept on the blockchainare set by the smart contract, which also controls identities. Meaning that doctors can only view the EMRs to which they have been granted access. For the management of electronic medical records (EMR), prescriptions for pharmaceuticals, and treatment pathways, a number of blockchain efforts have been launched in the healthcare sector in recent years [6–8]. The Yue et al.-developed Healthcare Data Gateway (HDG) app leverages blockchain technology to get patients' consent before sharing their data. Without violating the privacy policy, the patient can manage and share their data here. [9].

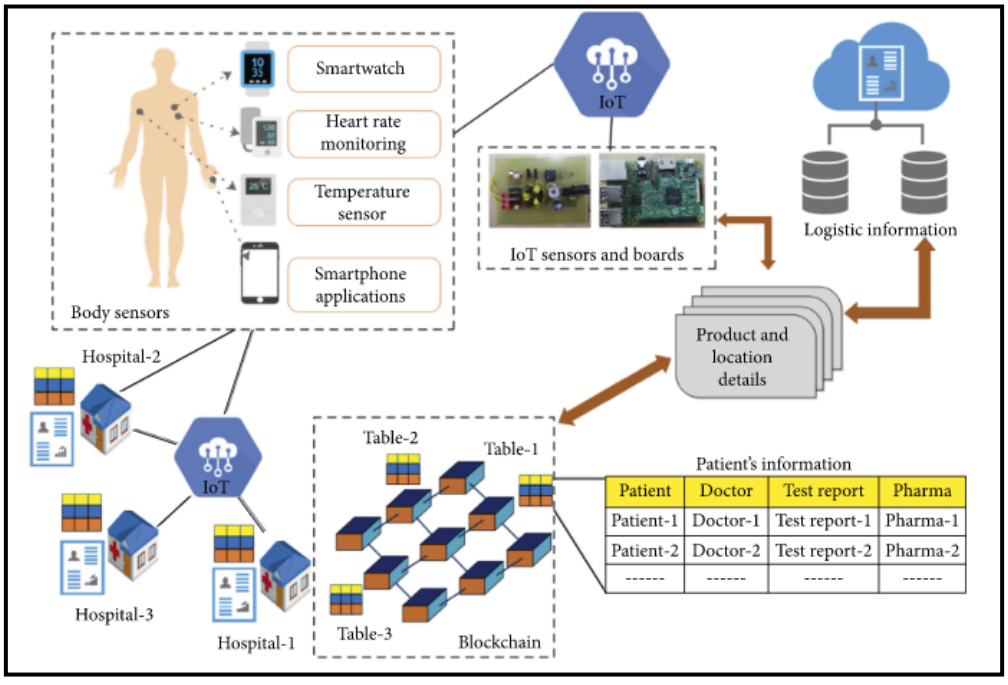

Fig 2 A blockchain-based health monitoring system [5]

RELATED WORK

The effect of the GDPR on linked medical technologies is examined in K. Ider et al. [10] examination of study findings. The components that result in the lawful and responsible processing of personal data are identified based on these findings. According to M. Moutaib et al [11], collisions between connected devices are one of the primary sources of energy loss. An IoT-based real-time monitoring system was created by L. Chuquimarca et al. [12] that detects aberrant heart activity and notifies the patient when the heart rate exceeds 60-100 beats per minute. A key factor in an IoT system is the security and privacy of the user and their personal data.

The method is presented by T. Veeramanikandasamy et al. [13] and minimises the danger of infection by allowing doctors to evaluate COVID-19 patients without the requirement for physical contact. The vital signs of COVID-19 patients are gathered and displayed via an embedded hardware device with internet access, and the data is then sent to an IoT platform. H. Huang et al. [14] provide a novel indoor localization system that makes use of a PSO (Particle Swarm Optimization)-based approach to integrate RSS fingerprinting with IMU sensing. We develop a new platform with WiFi capabilities that can gather RSS from wireless messages that are captured in the WiFi flow.

For mobility services, R. Cossu et al. [15] suggest a Blockchain-based data notarization solution. We begin by outlining a crowd monitoring system that uses the Internet of Things (IoT) to count the number of people in a certain region and gather data on dwell duration and people mobility (i.e., how people move across cities) (i.e., the time people stayed at specific places).In response to the COVID-19 pandemic, C. P. Tan et al. [16] examine some examples of these breakthroughs in digital healthcare and suggest a quantitative grading system for practical factors to support data-driven decision making throughout the implementation of these technologies.

S. K. UmaMaheswaran as well as associates [17] by using machine learning to find hidden patterns in massive amounts of data, the Internet of Things can improve forecasting and recommendation engines. For pathogenesis, target discovery and verification, pharmaceutical product development, disease evaluation, and therapy predictions, machine learning is used in the healthcare industry.

SERVICES OF IOT IN MEDICAL FIELD

IoT technology has recently advanced, making it possible for medical equipment to perform real-time analyses that were previously impossible for doctors to perform. Additionally, it has enabled healthcare facilities to provide low-cost care to a broader population at once. The dependability and ease of doctor-patient communication have both improved with the use of big data and cloud computing. As a result, the patient's financial burden was lessened and their participation in the healing process increased. The main effect of IoT that has been noticed in recent years is supporting the development of HIoT services, which include managing health and

fitness, managing health and disease, and tracking chronic illnesses. It has been split into the two crucial areas of operations and applications in order to help understand these applications. While the second explores applications in healthcare for either detecting a particular ailment or tracking certain health factors, the first explores the ideas behind creating an HIoT device.

Ambient Assisted Living

The ambient assisted living (AAL) branch of artificial intelligence, which is connected to the Internet of Things, offers age-related help. AAL's main objective is to make it possible for elderly persons to live independently in safe and comfortable environments at home. AAL offers a mechanism to keep track of these patients in the case of a medical emergency and ensure they would receive support on par with that offered by human services. This is made feasible by the healthcare sector's use of cutting-edge AI technology, big data analysis, and machine learning. The concentration of the researchers has often focused on these three crucial AAL domains: activity recognition, environment recognition, and vital monitoring.However, activity recognition has drawn the greatest attention since it focuses on identifying potential dangers or urgent medical issues that could influence the wellbeing of older individuals.[18]

Mobile IoT

Using netbooks, sensors, modern connectivity, and cloud services, the "mobile Internet of Things," or "m-IoT," monitors patient health data and other physiological indicators. In order to provide an effective Internet-based healthcare service, it primarily acts as a communication link between personal area networks and mobile networks (such as 4G and 5G). [19]. Medical personnel now have easier access to HIoT services thanks to the widespread use of mobile devices, which allows them to quickly diagnose patients and deliver therapy by accessing their data. There have been several research published on the usage of mobile computers in healthcare.

Wearable Devices

Wearable technology helps individuals and healthcare professionals manage a variety of health issues more affordably. By combining various sensors with human wearable accoutrements, like watches, wristbands, necklaces, shirts, handbags, shoes, and hats, among others, these non-invasive gadgets can be produced. [20, 21]. Information about the patient's health and the environment is gathered using the attached sensor. The server/databases are then updated with this information. Through health apps, certain wearables are also linked to mobile devices.

Cognitive Computing

Investigating a subject in a way akin to how the human brain does it is known as cognitive computing. IoT devices now incorporate sensors that can mimic the human brain's ability to solve problems thanks to recent advancements in artificial intelligence and sensor technologies. An IoT system's large volume of data has hidden patterns that can be studied with the help of

cognitive computing. This technique also improves a sensor's capacity to process medical data and automatically adjust to its surroundings. To provide efficient health services, all sensors collaborate with other intelligent devices in a cognitive Internet of Things network. Medical practitioners can efficiently monitor patient data and provide appropriate care thanks to the integration of cognitive computing into an IoT system.

Adverse Drug Reaction

One negative effect of taking medication is having an adverse drug reaction (ADR). One dose or multiple doses of the drug may be responsible for the reaction. This may also be the case because it may be harmful to take two different medications at the same time. ADR varies from person to person and is unrelated to a health condition or particular medication. Each medicine in an IoT-based ADR system can be identified at the patient's terminal by a special code or barcode. An intelligent information system for the pharmaceutical sector can be used to check data regarding the drug's compatibility with the patient's body. Using electronic health records, the information system saves each patient's allergy profile. An assessment of the patient's suitability for the drug is made after taking into account the patient's allergy history and other relevant medical data.

Child Health Information

A concept known as child health information (CHI) aims to increase public awareness of children's health. The primary objective of CHI is to educate parents and children about a child's entire health, which includes dietary practises, emotional and mental well-being, and behaviour. Researchers were more successful in attaining this objective because to the development of a platform that can employ IoT applications to monitor and manage a child's health.

Glucose Level Monitoring

When the body's blood sugar levels are abnormally high, it develops diabetes. One of the ailments that affect the most people is this one. Type I diabetes, type 2 diabetes, and gestational diabetes are the three main forms of diabetes that are typically present. Three tests—the random plasma glucose test, the fasting plasma glucose test, and the oral glucose tolerance test—can be used to determine the illness. However, the technique most usually used to identify diabetes is "fingerpicking," which is followed by measuring blood glucose levels. A range of noninvasive, cosy, useful, and secure wearable blood glucose monitoring devices have been created with the aid of recent advancements in IoT technology. [22]

Oxygen Saturation Monitoring

Studies in medicine can benefit greatly from pulse oximetry, a non-invasive technique for determining oxygen saturation. The old method's limitations are eliminated while the noninvasive technique provides real-time monitoring. Pulse oximetry has been improved because to IoT-based technology, which could have uses in the healthcare industry. In [23], a non-

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invasive tissue oximeter that could measure heart rate, pulse, and blood oxygen saturation level was proposed. Furthermore, the collected data may be transferred to the server via various connection protocols as Zigbee or Wi-Fi. In light of the documented information, a choice to receive medical treatment was made.

Asthma Monitoring

Chronic asthma can clog the airways and make it difficult to breathe. The airways narrow more as a result of the asthma-related airway edoema. This happens after a variety of medical problems, including wheezing, coughing, chest pain, and shortness of breath. The only thing that can save you from an asthma attack is an inhaler or nebulizer because there is never a good time for one to happen. As a result, it could be necessary to monitor this situation in real time. In recent years, a variety of IoT-based asthma monitoring methods have been created. [24] described a smart HIoT asthma treatment that used a smart sensor to assess breathing rate. Maintaining the patient's medical records on a cloud server so that caretakers can access them for monitoring and diagnosis

Medication Management

Adherence to medication is a major problem in the healthcare sector. Patients' bad health consequences may become more severe if their pharmaceutical regimen is not followed. Because clinical disorders like dementia and cognitive decline occur as people age, elderly people are more prone to suffer drug non-adherence. As a result, it is difficult for them to strictly follow the doctor's instructions. Numerous researches have previously examined the use of IoT to monitor patient medication compliance.

Rehabilitation System

A patient with a disability can regain their functional abilities with the help of physical medicine and rehabilitation. Identifying the issue and assisting people in getting back to their normal lives are both parts of rehabilitation. IoT has several uses in rehabilitation, including the treatment of strokes, cancer, sports injuries, and other physical afflictions.

GROWTH OF IOT

Internet usage has become ingrained in the lives of the social animal. It is a vast area filled with people and information. The "internet of computers" was the original form of the internet. It is a worldwide platform that might support the implementation of numerous services, including the World Wide Web. It was an era of information exchange. As the days went on, more and more people began to use the "Internet of people." Many social media platforms entered the picture and kept individuals in constant contact. Due of this, there are now more people online than information. However, at the same time that technology was developing quickly, the

"MobiComp" (mobile computing) era had already started. Mobile enabled man to access the internet while on the move at all times.

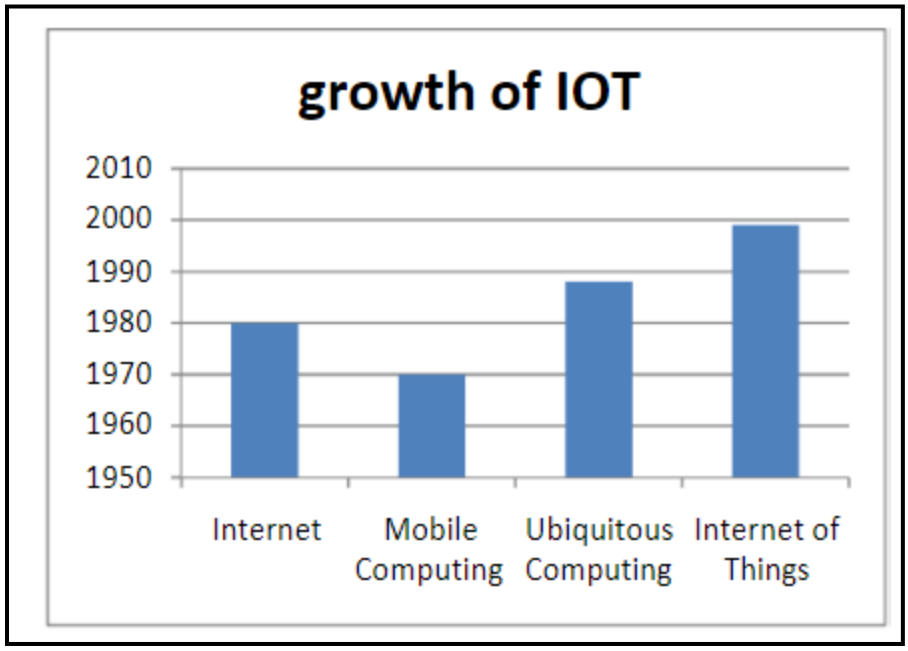

Fig 3 Growth of IOT

IOT AND MACHINE LEARNING APPLICATIONS IN HEALTHCARE SYSTEMS TO PREDICT FUTURE TRENDS

Thanks to the Internet of Things and machine learning, patients can now wear devices like posh jackets and smart bands that monitor their health and regularly upload data to a database inspected by doctors and medical specialists. While simultaneously monitoring a patient's organs and vital signs, the devices may send a report on that patient's progress to a particular database. Additionally, the system monitors and reports symptoms and pathogen presence. Applying best practises is now possible in the healthcare industry thanks to this significant advancement. Smart medications, sensors, and wearable monitoring solutions are now available, which is beneficial for the healthcare industry. These tools assist in identifying, predicting, and monitoring sickness trends as well as their propensities in the future. Automating the patient and illness monitoring activities saves time and fills in when all the doctors are busy, like in an emergency. [25].

The goal of saving lives during pandemics like COVID-19 requires the application of intelligent technologies in this field. The doctors can analyse the data collected by the wearable monitoring equipment, diagnose the patient, and then write a prescription by transferring it to a database. In order to track and gather precise data during pandemics to feed a database, patients can be equipped with IoT devices like smart tablets and smart bands. These tools give healthcare professionals the opportunity to comprehend symptoms and analyse them in order to create quick and secure diagnoses. They also assist other machines (machine learning) in understanding

illness patterns and symptoms. Such tactics can improve patient and healthcare provider safety during quarantines because machine learning technology eliminates physical contact with patients who have fatal airborne viruses. The IoT industry includes the effective technology of cloud computing. Connecting a variety of machine learning AI devices is useful for gaining a better understanding of data through analysis and storage. The capacity of cloud computing to meet the requirements of the health service by supporting enormous volumes of data storage is another key component of it. Numerous devices can access the data because to cloud computing's capacity to share data.

On the other hand, some issues with cloud computing need to be resolved immediately now. For academics and researchers wanting to increase the value of ML and IoT in the healthcare sector, these issues may present new research opportunities. One of these issues is the security and privacy of personal data. Because they include people's protected health information, medical records in the healthcare industry must be handled with extreme care and sensitivity (PHI). To control who can access and examine this data, tough laws like the Health Insurance Portability and Accountability Act (HIPAA) have been put in place.This poses a substantial obstacle to modern data mining and ML techniques like deep learning, which frequently need a large amount of training data. If this sensitive information is shared in an effort to improve the delivery of care, patient privacy may be put in danger. Utilizing machine learning technology, there are numerous ways to safeguard patient privacy.

One remedy is federated learning (FL). With the help of deep learning, this new ML paradigm trains servers and mobile devices to create a single, strong ML model without exchanging any data. Researchers can solve important concerns including data security, data access rights, and heterogeneous data access thanks to FL. ML faces additional challenges when storing data in centralised cloud computing since the use of a single server to compile input from many sources and maintain a generic model leaves the server open to bias and malfunction. This might result in a model that has been incorrectly trained, which would lower the accuracy of outcome prediction. Decentralized data storage is therefore now one of the best choices. Blockchain technology allows decentralised data storage.

APPLICATION OF INTERNET OF THINGS IN OTHER FIELDS

There are many different IoT applications, ranging from local networks like home automation to huge networks like cloud-based business applications. The main objective of the Internet of Things (IOT) will always be to enhance the quality of human life by integrating smart cities, intelligent construction, intelligent agriculture, clever cars, smart health care services, intelligent environmental monitoring and control, intelligent grids, intelligent transportation and logistics, intelligent water supply management, intelligent parking, and so forth into lifespan. Table 1 provides a quick summary of several IoT applications and their associated fields.

S.No	Field	Application
1	Smart Cities	Parking Areas Monitoring, Bridges, Monitoring In Buildings, Android Devices, iPhone Detection, Energy Radiated Measure
2	Smart Environment	Smart Earth Forest fire detection, Air pollution, Catastrophic early detection
3	Security & Emergencies	Revolution and Hazardous Gas Detection, Radiation Level Detection, Liquid Monitor Data Centers, People Detection and Control in Non-Authorized and Restricted Areas
4	Industrial Control	Oxygen Levels and Toxic Gases are Monitored Within Chemical Plants Monitoring, Ozone Tracking, Temperature Monitoring, and Monitoring of the water level.
5	Home Automation	Appliances with remote control.
6	Smart Agriculture	Soil Moisture Monitoring, Greenhouse Monitoring, Controlling Humidity and Temperature Levels, And Studying Weather Conditions
7	Traffic Management	Real-time traffic and path optimization are used in smart transportation.
8	IoT in Education Applications	Smart Classrooms, Assists Special Children, Task-Based IoT Learning, Foreign Language Guidance
9	IoT in Government Applications	City Planning and Management, National Defense
10	Smart Animal Farming	Animal Tracking, Toxic Gas Levels, Toxic Gas Levels

SIGNIFICANCE AND THE LIMITATIONS OF THE IOT IN THE MEDICAL FIELD

The medical sector is embracing the internet of things. IOT primarily provides "material management visualisation, medical information digitalization, and medical process digitization" in the healthcare industry. The development, delivery, and tracking of medications and medical equipment are made possible by the internet of things and radio frequency identifiers, enabling the avoidance of health care issues while also improving treatment quality and lowering administrative expenses. A multitude of benefits, including pharmaceutical anti-counterfeiting, medical waste and emergency management, drug recognition, medical record IDs, medical device identifiers, drug storage, etc., would be provided by the integration of RFID and the internet of things. Doctors may now track a patient's disease in real time and advise them on preventative measures thanks to the application of IOT in the medical field [26]. It also makes it possible for the doctor to get patient data more rapidly.

We can have a better, healthier environment with remote real-time monitoring thanks to the internet of things. The IOT enabled in the medical imaging systems has the ability to affect both the diagnostic procedures and the clinicians by enabling patients to follow changes in their health in real time[27]. Even while the IOT-enabled medical industry is crucial, particularly for medical imaging, real-time monitoring is difficult. There are still several restrictions. The management of node mobility, data completeness, data compression, and data security are some of the "complications in large scale dynamic networking" that they are dealing with. The best compression and encryption techniques must be used in conjunction with "appropriate network mobility management methodologies and the network topology management structure" in order to maximise administration, data compression, and privacy.

CHALLENGES OF IOT IN HEALTHCARE

Following some quick study, we compiled a list of key pressing issues related to IoT. We think that if these issues are resolved in the IoT space, we can raise the bar for IoT in the medical profession. In the area of medical and health care, IoT can offer more dependable and superior services. IoT has brought about revolutionary change in the area of internet connection, which has greatly aided the development of many difficult fields, but particularly that of medical products. This is a key factor in bridging the gap between medical professionals, patients, and healthcare services thanks to its simplicity, precision, and adaptability. IoT enables medical professionals to work more effectively and actively with less effort and brainpower. These challenges were chosen based on the contributions of several IoT researchers from a variety of sources.

BENEFITS OF IOT IN HEALTHCARE

IoT offers several benefits to people, society, the environment, customers, and businesses, but it also has some negatives, just like any other technology. The following table lists the top advantages of the Internet of Things. IoT is, nevertheless, particularly helpful in the medical and healthcare industries. IoT-based systems and apps have changed the world into an idealised version of what people thought of in the 1990s. The world of internet communication has undergone revolutionary change as a result of IoT; this has greatly contributed to the expansion of many difficult fields, but particularly in the field of medical items. This is a key factor in bridging the gap between medical professionals, patients, and healthcare services thanks to its simplicity, precision, and adaptability. IoT enables medical professionals to perform more effectively and actively with less effort and brainpower. IoT is relatively simple to use, and its integration into the medical profession has given patients amazing benefits.

CONCLUSION

We gave a general review of IoT services and technology in healthcare in this article. Research issues that have been identified are anticipated to develop into significant research trends

throughout the coming years. Numerous advantages of usage research have been noted, and the most pertinent application domains have been highlighted. In order to help researchers and practitioners in the area comprehend the enormous potential of IoT in the medical domain and identify important difficulties in IOT, we believe that this study will be helpful. Additionally, this research will aid scientists in their understanding of IOT applications in the healthcare industry.The healthcare industry now has a wide range of options thanks to the Internet of Things (IoT), which also holds the potential to solve a number of issues. There will be many opportunities for telemedicine, remote patient monitoring, and other uses by utilising the medical IoT. Thanks to ML models, this might be doable. In this study, we looked at IoT and machine learning in the healthcare industry to estimate future trends.

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