Chapter 7
Modern Healthcare Systems: Unveiling the Possibility of AIoT for Remote Patient Monitoring

Kunal
ABES Engineering College, Ghaziabad, India

Ayushi Prakash
Ajay Kumar Garg Engineering College, Ghaziabad, India

Sandhya Avasthi
https://orcid.org/0000-0003-3828-0813
ABES Engineering College, Ghaziabad, India

Kadambri Agarwal
ABES Engineering College, Ghaziabad, India

Mohammad Hussain
Islamic University of Madinah, Saudi Arabia

ABSTRACT

Patient care is transformed when AIOT is included into contemporary healthcare. The influence of AIOT on remote patient monitoring is examined in this chapter, with a focus on how it may improve healthcare outcomes. Real-time monitoring of vital signs, activities, and mental health is made possible by wearable AIOT devices. Data on blood oxygenation, temperature, respiration, and heartbeat are analyzed using sensor nodes and machine learning. Using RPM, the AIOT architecture gathers a variety of biological data and sends it to the IoT cloud for extensive patient monitoring. Examined for their contributions to patient care are a variety of AIOT healthcare products, including wearables, robotic surgical equipment,

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blood clotting testing devices, linked inhalers, depression monitoring wristwatch applications, and IoT-connected contact lenses. The chapter demonstrates AIOT's potential to improve patient outcomes and support a more efficient and accessible healthcare system by highlighting its role in early identification, particularly for life-threatening disorders.

1. INTRODUCTION

The aim of this remote patient monitoring system is to construct healthcare that is more efficient, effective, successful, and easily accessible to a larger population. With the help of AI and the Internet of Things, a patient can be monitored with accurate disease prediction, and illness can be detected within seconds. The aim to start this remote patient monitoring with AIOT is to provide accurate predictions for many life-threatening diseases like cancer and heart disease at early stages so that they can be cured. In some developing countries, there is a shortage of doctors, due to which treatment is not being provided properly due to a lack of time. In such a condition, it is really challenging for patients and elderly people to take appointments and get proper treatment. Another problem is the restriction on visiting doctors during the pandemic. To address this issue, we are developing an intelligent remote health monitoring system for patients based on artificial intelligence, which will allow patients to consult with a doctor and receive treatment via digital mode. An intelligent remote patient activity tracking system helps monitor patient activities and check those activities based on the attached sensors. An artificial Internet of Things (IoT) enabled health monitoring device is implemented and designed using various machine learning models to keep a record of the patient's activities, such as sleeping, walking, running, and exercising, the necessities during those activities, such as body temperature and heart rate, and the patient's breathing pattern during such activities(Talukder & Haas, 2021).

Machine learning models are used for the identification of different activities of the patient and for detecting the patient's breathing, respiratory health, and vitals during various activities. Recently, various AI and machine learning models have been used to detect cough and breathing problems.

1.1 Artificial Intelligence of Things

Artificial intelligence of things (AIOT) is defined as the blend or combination of artificial intelligence technologies along with the Internet of Things framework. The main goal of AIOT is to implement and perform more efficient IoT functionalities

and operations, as well as to improve human and machine interactions and enhance management of data and its analysis with ease. AI is the simulation of human intelligence processes by machines, especially computer systems, and is typically used in natural language processing (NLP), speech recognition, and machine learning vision. IoT consists of many interconnected things with built-in sensors and has the power to generate and collect a huge amount of data. This data can be easily analyzed and utilized with artificial intelligence for solving problems based on decision-making. AI can enhance the value of IoT (Janaki & Sravanthi, 2022). For instance, machine learning is one of the most utilized key technologies to be used for AIOT.

AI implementation in the field of healthcare aids in enhancing and improving the quality and effectiveness of patients' decision-making processes. Its implementation along with the IoT helps in treating patients remotely with accurate and complete health information about the patient and providing real-time data. The remote patient monitoring system can present an effective solution to control and monitor a vast number of patients and maintain their data. Artificial intelligence and the Internet of Things (IoT) are the cutting-edge technologies that allow electronic devices to perform tasks like human beings. These tasks include understanding abilities, thinking, implementing, making decisions, and solving problems (De Michele & Furini, 2019). Machine learning, deep learning, ambient intelligence, smart objects, big data, data analytics, embedded systems, blockchain, and other techniques are used to implement AIOT.

Overall, AIOT has the potential to transform healthcare by improving patient outcomes, increasing efficiency, and reducing costs (Dhaka et al., 2022). However, it's important to ensure that these technologies are implemented in a way that maintains patient privacy and security.

1.2 Remote Patient Monitoring

Remote patient monitoring, also known as "telemonitoring," is an assortment of distinct technologies and techniques that enables and aids medical personnel, such as doctors, to monitor developments related to a patient's health, gather information about the patient from faraway locations, and employ that information for medical procedures and patient management. It is a vital aspect of the entire digital health sector. The cutting-edge technological solutions that RPM systems often rely on are a part of healthcare Artificial Intelligence of Things (AIOT) systems, which integrate a variety of sensors, devices, and communication networks to gather and exchange real-time medical data. With remote patient monitoring, medical professionals may keep a close watch on patients wherever they are—in their homes, workplaces, or even while they are travelling—enabling continuous monitoring of vital signs including

body temperature, blood pressure, heart rate, respiration rate, oxygen saturation, and other parameters. The individual healthcare professionals have direct access to this real-time data, which enables them to act quickly when a problem arises, often minimizing the need for routine office visits or treatment.

In the research community, remote patient monitoring (RPM) is a new idea that has attracted a lot of interest as the world today faces a devastating pandemic attack. The epidemic has brought to light a number of issues, including hospital overcrowding, a lack of ventilators, and the possibility of healthcare personnel acquiring the disease. To resolve this issue, an RPM system is required to remotely observe COVID-negative individuals and enable COVID-positive individuals to access the healthcare facility in the situation of emergency. If COVID-positive individuals are not in a life-threatening scenario, RPM can monitor them. The RPM system helps with real-time remote monitoring, which aids in the early detection of particular diseases and disorders (Umair et al., 2021). RPM is an AIOT solution that enables patients to be monitored from a distance and outside of the hospital setting. The beneficial characteristics of RPM include early diagnosis of patients' extremely serious medical conditions, real-time patient health status monitoring, and patient protection against serious medical illnesses, being hospitalized, and even fatalities. RPM places more of an emphasis on those with long-term illnesses, subsequent surgeries patients, elderly people, and residents of isolated regions with limited access to healthcare facilities (Janaki & Sravanthi, 2022).

This AIOT-based approach for sophisticated healthcare monitoring systems makes the following main contributions:

- An Internet of Things (IoT) assisted health tracking device is built using algorithms based on machine learning to measure the patient's activities, including sprinting, sleeping, jogging, and exercising, as well as the vitals during those activities, including the body's temperature and cardiac rate, as well as the patient's respiration pattern;
- For tracking the patient's various activities, artificial intelligence (AI) models are deployed;
- These models examine the patient's respiratory condition as they are engaged in numerous activities;
- To maintain track of the information shared by the suggested devices, a web-based app is also designed.

1.3 Advantages or Positive Aspects of Remote Patient Monitoring

The benefits of tracking patients remotely are numerous and include the following:

1. **Enhancing the overall standard of medical treatment for patients:** RPM aims to enhance patients' overall health by offering patients and medical expert access to more precise details about patients.
2. **Assurance of patients:** Patients may feel more secure knowing that potential issues will be identified promptly under regular device monitoring.
3. **Improvement in obtaining access to the medical sector:** RPM permits people to perform simple health checks on their own, permitting healthcare practitioners to treat more patients.
4. **Enhancing involvement of patients**: Through the use of RPM technologies, people can actively participate in the examination of their own medical conditions.

1.4 Bringing AI and IoT Together for Healthcare Advancements

There are many ways through which IoT and AI are assertive during a global epidemic. The Internet of Things (IoT) and artificial intelligence (AIOT) are emerging together as a network of digital devices that can handle and interact with one another. While IoT forges vast connections, AI gives these devices life. This chapter explores the widespread uses of AIOT, the difficulties we face in putting it into practice, its wide variety of applications, and its potential future advancements. Because of the decision paradigms and algorithms employed, health services have limited decision-making capabilities. With the assistance of AI, we are able to spot crucial health issues and take necessary measures ahead of time. By monitoring disease progression, predicting mortality risks through patient health history evaluation, detecting high-risk patients early on, implementing remote or home therapy, and utilizing other strategies that can drastically lower hospital occupancy, artificial intelligence can significantly lower the number of fatalities. Artificial intelligence serves as a system's brain, Internet of Things devices function as its digital central nervous system. The internet of things will be able to analyze data and make decisions when artificial intelligence is added.

The convergence of Artificial Intelligence (AI) and the Internet of Things (IoT) in the realm of healthcare holds immense promise, ushering in a new era of innovation and progress. This integration, often referred to as AIOT, has the potential to transform healthcare by offering solutions that are both groundbreaking and highly practical.

Remote patient monitoring is among the most important uses of AIOT in healthcare. Healthcare providers can now continuously monitor patients' vital signs and general health in real time by integrating IoT devices and AI-powered analytics with ease. Data on parameters including heart rate, blood pressure, glucose levels, and physical activity are collected by wearable devices, sensors, and smart medical equipment, which then send this data to centralized systems. Medical professionals

can act quickly because of the early detection of even small changes in a patient's health made possible by this real-time monitoring. AI is crucial to this advanced process. A huge volume of data can be analyzed, patterns can be found, and irregularities can be detected by its sophisticated algorithms. Thus, early indicators of health problems like erratic pulses, variations in blood sugar, or abrupt shifts in vital signs can be identified by AIOT systems. This ability is crucial for prompt interventions, which may prevent serious health issues and lower the need for ER visits or readmissions to the hospital.

AIOT additionally facilitates the development of highly customized healthcare plans. AI is able to create personalized treatment plans based on past patient data, taking into account each person's specific health profile. In the end, these plans improve patient outcomes and treatment efficacy by taking into account variables like lifestyle preferences, medical history, and past treatment responses. AIOT also significantly improves remote consultations and telemedicine. Virtual patient appointments allow medical practitioners to make decisions based on up-to-date information. This strategy guarantees that patients, wherever they may be, receive the most precise and prompt care in addition to being convenient for both patients and providers. The cost-saving potential of AIOT in healthcare is substantial. Healthcare systems can achieve substantial monetary savings through early intervention and improved management of chronic conditions, which can prevent expensive hospital readmissions and lower the frequency of ER visits. By facilitating more effective resource allocation, such as the scheduling of follow-up appointments and the distribution of hospital beds, predictive analytics also helps to reduce costs. Increasing patient engagement is one of AIOT's outstanding features. Easy access to health information by patients promotes self-awareness and following doctor's orders.

Moreover, AIOT in healthcare has broader implications for research and population health. Aggregated, anonymized patient data collected through these systems can serve as a valuable resource for large-scale health research. Researchers and public health officials can gain insights into disease trends, identify risk factors, and evaluate the effectiveness of healthcare interventions on a population level. In conclusion, the fusion of AI and IoT in the medical field, especially in the context of remote patient monitoring, provides a momentous stride forward in healthcare advancements. It equips healthcare providers with the tools to offer more precise, assertive care, while patients enjoy the benefits of advanced treatment plans and greater control over their health. Additionally, AIOT has the potential to reduce healthcare costs and facilitate more efficient resource allocation, all while maintaining robust data security and patient privacy (Baker & Xiang, 2023). This convergence of technologies is poised to redefine healthcare and improve patient outcomes significantly.

2. METHODOLOGY

2.1 Comparison of Classical Health Care System vs. Modern Health Care System

The classical healthcare system and the modern healthcare system differ significantly when it comes to the incorporation of AIOT healthcare. In the classical healthcare system, doctors and healthcare providers relied heavily on manual processes and paper-based records. Patients physically visit their doctors for consultations and tests, and there was limited coordination between different healthcare providers.

In the traditional health care system, the existing remote patient monitoring mobile applications, referred to as telemedicine applications," are based on common video, audio, and chat technology. The classical healthcare system makes use of only IoT technology, and there is no combination of smart AI technologies with it. In the classical system, we can enable patients to connect with doctors, who provide consultation through video chats, but the information is not accurate and correct. In the classical healthcare system, it is not possible to give accurate information about the intensity of diseases, although this is a part of smart healthcare technology.

In the modern healthcare system, the COVID-19 pandemic has changed the way research and development are conducted in the fields of IoT technology and AI facilities. This technology can predict illness within seconds, and the patient data that we get is accurate, so the patient's treatment can continue with ease. In this new modern healthcare system, we use data analytics and smart artificial intelligence-like technologies in combination with IoT, which helps in detecting many life-threatening diseases like cancer and heart attacks with accurate intensity and correct information and results in providing smart healthcare.

Technology is used in the modern healthcare system to enhance patient outcomes and simplify procedures. Patients can now monitor their health using a variety of wearable gadgets that track anything from heart rate to sleep patterns due to the integration of AIOT healthcare. Doctors can use the real-time data from these devices to further inform their patient care decisions. Overall, AIOT healthcare represents a significant shift in the healthcare industry, moving from a traditional, reactive system to a more proactive, data-driven approach. It is expected that the use of artificial intelligence and other technologies will continue to increase within the healthcare industry, leading to improved outcomes and a more patient-centered approach to care (Dhaka et al., 2022).

Figure 1. The conceptual diagram of AIOT technology's transformation from traditional technology

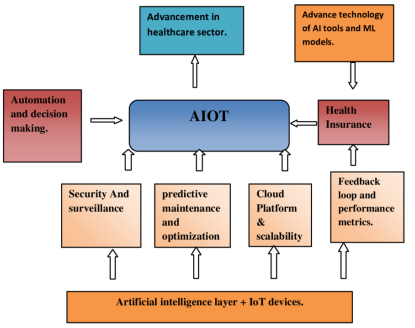


Figure 1: The conceptual diagram of AIOT technology's transformation from traditional technology.

2.2 AIOT-Based System Architecture for Monitoring Patient Activity

RPM systems are utilized to collect various types of biological information from patients, such as heartbeat rate, respiration rate, electrocardiogram (ECG), blood oxygen level, blood pressure level, etc. In this proposed system, we make use of sensor nodes to keep track of patient symptoms and signs during multiple operations. The detector nodes implement an artificial intelligence model to do an analysis of the vital parameters of an individual. The sensor nodes examine the patients and detect the physical temperature of the individual, cardiac rate, and amount of blood oxygenation during various tasks such as sleeping, sprinting, jogging, working out etc. The proposed system collects patient data using sensors that are linked to the nRF5340 manufacturing toolkit. These connected sensors include accelerometers, heart rate sensors, temperature sensors, and pulse oximeters.

Accelerometers help in detecting and monitoring patients' vital signs during different activities such as exercising, running, etc. By using a microphone, we can keep an eye on patients' respiratory functioning. ML models help in classifying patients' respiratory health. The attached sensor node's microphone is utilized to record information for use in analyzing functioning of lungs. A respiratory analysis can identify illnesses like pneumonia. The proposed method makes use of the MFCC (Mel Frequency Cepstral Coefficient) to derive characteristics from sound signals for vocal data to detect patients' speech signals and compare them with other audio information in the record set. This system uses two ML models for the identification of physical activities and mental health, which are voice data and physical activity data. These models' outputs are constantly synchronized with outputs from other sensors, such as cardiac rate sensors, oximeters, etc., to give an overall report of the patient (Malche et al., 2022),(Pise et al., 2023).

Data is gathered from nodes of sensors and sent to the nodes that act as a bridge or gateway to operate this system through Bluetooth or Zigbee (Gourisaria et al., 2022). This bridge helps in forwarding information to the Internet of Things (IoT) cloud through the telemetry transmission method for message queues (MQTT). The gathered information gets stored in the IoT cloud and is easily accessible to doctors through the web application dashboard (Prakash et al., 2022), (Prakash et al., 2023a).

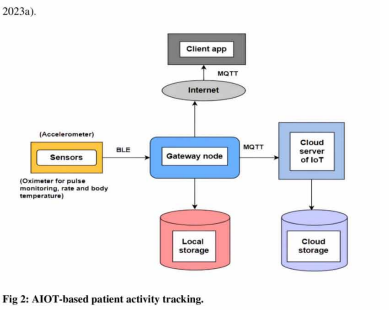
3. DEVICES AND APPLICATIONS USED IN HEALTHCARE SECTORS

3.1 Various AIOT Healthcare Devices

3.1.1 Connected Inhalers

A significant medical condition affecting many individuals worldwide is asthma. Inhaler users with asthma can increase their reservoir, giving them more control over their symptoms and therapy since they have access to cutting-edge asthma software. A sensor developed by Propeller will enable remote operation of an inhaler or spirometer. Patients with COPD and asthma who wear sensors are informed of their thoughts and other information that could be useful in making decisions about their health. The usage of medications and the presence of allergens are detected by sensors and software, which also forecasts and notifies clients of these changes. Because using the attached inhaler required more effort from the patient, some people believed it had significant advantages. The sensor also generates a report that the patient's physician can consult.

Figure 2. AIOT-based patient activity tracking



3.1.2 Robotic Surgery Devices

Surgeons can carry out sophisticated procedures that would be impossible with human hands by putting tiny, Internet-connected robots into the human body. Simultaneously, the number of surgical incisions would be drastically reduced because of robotic treatments carried out by tiny AIOT devices. This will lessen the discomfort of the procedure and speed up the patient's recovery.

3.1.3 Blood Clotting Testing Devices

Researchers has introduced a coagulation tool with Bluetooth functionality. The AIOT system can be used by patients to monitor the rate of blood clotting. The first AIOT platform created specifically for patients taking anticoagulants is from Roche. Patients who self-test are less likely to bleed or suffer a stroke because they stay within their treatment parameters. Due to the capacity to electronically convey test results to their healthcare provider, fewer patient visits were necessary.

Additionally, Roche's device encourages patients to retest and underlines testing results that fall outside of a specific range, in addition to allowing patients to make notes on their test results.

3.1.4 Connected Wearable Devices

The IoT would appear incomplete without connected wearables. Wearable and connected sensors are important equipment for medical staff and also assist in assisting patients. These enable medical professionals to keep an eye on vital signs such as pulses, body temperatures, and heart rates while still evaluating the health of their patients. The benefit of continuous contact wearable devices is that hospitals can monitor their patients even after they have departed from the clinic. Patients who report any problems they had in the hospital after being released are extremely useful in helping with follow-up appointments (Pradhan et al., 2021). The wearable sensors would alert the clinician from any location if the condition changed. A doctor can provide their patients with live instructions if they receive a real-time warning.

3.1.5 Depression Control and Monitoring Smart Watch App

A tracking system can be regularly used by patients to gauge their emotional state and MDD condition. To do this, put on a smartwatch. In this situation, there is undoubtedly an opportunity for smartwatches technology to have a greater effect than step tracking; suitable devices will be those that gauge the severity of depression. An IoT depression app could provide users and their caretakers with further details regarding their issues, similar to other IoT apps.

3.1.6 IoT connected Contact Lenses

The goal of extracapsular cataract surgery and other lens-enlarging and lens-stiffening procedures is to permanently cure acquired long-needs cataracts. An effort is being made to address the long-lens failing, also known as presbyopia, which causes far-sightedness. To ensure full recovery, it will assess the lens's refraction, stiffness, and lens repairing. Researchers created SENSIMED signals, which monitor eye pressure fluctuations for signs of glaucoma using non-invasive detectors.

3.2 AIOT Healthcare Applications

3.2.1 Heart Disease Monitoring System

When it comes to issues related to health, people may die without receiving any therapy because many heart patients are unable to contact healthcare providers on their own. However, it is possible to receive therapy via AIOT technology and remote tracking. Sensors are used to measure blood pressure and pulse rate, etc., and persuasive monitoring helps in transmitting patient symptoms in real time to a remote healthcare application. This monitoring system consists of three layers of architecture: the application layer, the transport layer, and the sensor layer. In the sensing layer, sensors are placed to gather information or data about the body. A constant stream of real-time data is transmitted at the transport layer. In the application layer, data analysis of patients' data is possible for medical experts. Thus, it helps many remote medical practitioners to use this technology to keep a track of patients' health and easily anticipate their needs.

3.2.2 Smart Hospital System

As we know, hospitals can store information up to a certain amount, but they also have certain drawbacks, such as manual input of medical information and interdepartmental interdependence. AIOT can be used to solve these issues, according to the proposed system. The proposed system has a tendency to exchange data, track and determine the exact location of any patient, and perform intelligent recognition. In this system, a number of technologies are used, without which the IoT cannot function properly. RFID (Radio Frequency Identification) can be used to automatically or non-intrusively identify an object or any other item. It is a sensor-based technology. Various parameters of objects, such as position, temperature, pressure, and movement, can be easily tracked using a sensor network and RFID. Zigbee, WIFI, and infrared are all examples of wireless communication technology (Pradhan et al., 2021),(Gourisaria et al., 2022).

3.2.3 Smart Ambulance and Traffic Clearance System

It is extremely challenging to transport patients to the hospital on time because of traffic congestion and human contact. When ambulances and other medical vehicles are slowed down by traffic jams, patients are put in danger. All of these problems can be easily handled with an intelligent ambulance system. These IoT-based intelligent ambulances transmit signals to the traffic lights at checkpoints using RFID technology and sensors. On the traffic light receiver, a light will flash to indicate that space

needs to be cleared for an ambulance. The vehicle in the back may be used to alter the direction of traffic lights in an emergency. Receivers placed in traffic lights permit them to receive signals from emergency vehicles while they are functioning in emergency mode. If the new approach is put into practice as intended, ambulances can reach hospitals more quickly(Soomro et al., 2018).

3.2.4 Medicine Reminder System

Missing a dose is usual among patients of all ages, particularly those who take numerous prescription drugs and supplements daily. A smart pillbox with cutting-edge features for patients and caregivers has been proposed. With the adjustable dose and time frame in this pill box, taking medications has never been simpler. The pillbox will assist in reminding patients to take their pills. The pill box has been suggested as a solution to the medication-related issues affecting the elderly. The medication reminder system was designed to assist seniors in taking their medications in the proper amounts and at the appropriate times.

Some patients struggle to remember to take their prescription on time due to their busy schedules. Patients can remember to take their medication by using the smart pill box. An alert is sent to a patient's family if they fail to take their medication. There are two operating modes for pillboxes: regular and management. In its normal mode, the pillbox doesn't start working until the patient needs to take a dose. When the user touches a button on the pillbox, medication will be automatically provided. A message will be transmitted to the medical professionals or the patient's family members after a predetermined period of time. In management mode, the medical professionals or caregivers are in charge of the pillbox. They can do diagnostic tests and modify the controlling software if the pillbox isn't working properly.

3.2.5 Orthopedic Treatment

AIOT can be used to raise the standard of orthopaedical care provided to patients. Sensors can provide data on bone and fracture assessments in a matter of seconds. IoT-connected sensors can deliver exact information on things like blood pressure, bone pain, and even brain functioning. Engaging in safe and efficient physical activity can help injured patients heal more quickly. Also, this technique enhances patient satisfaction, productivity, and outcomes. Orthopaedic surgery patients need to engage in a lot of physical therapy and specific exercises so that sensors can warn doctors if something is amiss. In addition, even if a patient is far away, doctors can still give advice. Patients and their family members can check on the status of their health and get the required medical advice without the need for an appointment. The IoT in orthopaedics is generally used for:

- Monitoring the health of patients and in generating reports on patients;
- Used in giving descriptions of bone fractures and bone deformities. Doctors use a variety of sensors to detect fractured bones in orthopaedical treatment;
- Used in knee replacement surgery.

3.2.6 Perception Layer

In the suggested system, this layer is separated into two layers. The following steps in the data collection procedure involve locating hospital networking networks and collecting pertinent information. This layer enables the system to track physicians and other medical officers as well as identify assets and patient medical information. physiological data of patients in both the neighborhood and the hospital. Or, to put it another way, this layer is very important to the system. The access layer, the subsequent lower sublayer, is used to transmit data to the backbone network. The main way that patients, doctors, and other staff members communicate and work together in a smart hospital is through mobile networks. The application layers are the second and final levels.

4. DISCUSSION

4.1 Challenges in Efficient Healthcare Services

4.1.1 Integration Protocol Diversity

Such a problem arises when we integrate multiple devices. Despite having connections between various of them, the difference due to a lack of communication protocols makes data aggregation much more difficult, which leads to a slowdown of internal processes and a hindrance in the implementation of healthcare services. The primary cause of this barrier is the lack of consensus among device manufacturers on communication specifications and protocols. In an attempt to offer patients with appropriate care, it is important to make sure that all manufacturers involved in the healthcare industry communicate clearly and work together effortlessly.

4.1.2 Standardization

One of the major challenges faced in healthcare services is standardization, as there is no efficient way of collecting patient data or managing medical devices. The format and quality of data collected from various AIOT devices may differ. It can be difficult but very important to standardize data for analysis and decision-

making. Standardization is the key to creating universally accepted protocols for interoperability between healthcare devices. All healthcare facilities or providers may not offer the same level of quality care. The standardization of care quality is necessary in order to ensure that it fits the demands of each patient.

4.1.3 Cybersecurity

Cyber Attacks and breaches are one of the major concerns and threats in the healthcare industry. One primary cybersecurity risk is the susceptibility of IoT devices to cyberattacks. Many of these devices, including wearable health monitors, remote sensors, and medical equipment, may not have the same level of security measures as traditional computing devices (Imoize et al., 2023). This makes them appealing targets for malicious actors looking to exploit vulnerabilities and gain unauthorized access to the network or the devices themselves. The connected devices, which interact with each other in real time to transfer healthcare data, can get hacked by a cyberattack in the middle of the process. Another risk is the potential for service disruption. If AIOT devices and systems are compromised, they may become inoperable, disrupting patient monitoring, clinical decision support, and communication between healthcare professionals. This interruption could have severe consequences in critical care situations. In the medical industry, keeping patient information confidential is standard procedure. Due to the Internet of Things (AIOT), researchers must make extra effort to safeguard their data and information from cyberattacks. They should also ensure that their systems are secure so that there are no security gaps.

4.1.4 Increasing Medicine Ultimately Costs

When we intend to contemplate IoT app development for healthcare services and the cost charges increase in bulk quantity, one of the primary issues that arise is the cost of medications. But when you spend a certain amount of money to build an AIOT application, the returns will be equally huge. To make sure that investments in AIOT technology leads to better patient outcomes and efficiency, healthcare institutions need to carefully consider the cost-benefit ratio.

4.1.5 Data Overflow and Accuracy

Due to variances in information homogeneity and communication methods, it is particularly challenging to obtain general information for crucial conclusions and analysis. The sheer volume of data generated by IoT devices can overwhelm healthcare providers. Managing, processing, and making sense of this data can be

challenging, and there's a risk of information overload. Long-term decision-making in the hospitality industry may be impacted by overload of information. Another crucial issue is ensuring data accuracy. To enable precise clinical judgments and treatment, the data obtained must be of the highest caliber. Misdiagnoses and potentially dangerous therapies might result from inaccurate or inadequate data. It is also crucial that the sensors and equipment themselves are reliable. The calibrating and quality of these equipment determines the accuracy of the data. Due to the inability to make sense of the available data, data overload in AIOT healthcare might result in erroneous diagnosis, postponed treatment, and poor patient outcomes. Healthcare experts can have trouble analyzing the data properly, missing chances for early diagnosis and treatment.

4.1.6 Limited Bandwidth and Connectivity

Poor connection issues make the process of exchanging data very slow. In healthcare services, the stakes for a dropped connection are too high, and it can result in serious patient consequences. Restricted connectivity and bandwidth, however, might lead to a number of issues. Initially, insufficient bandwidth may result in data congestion, impeding the prompt transmission of vital patient information. Information loss or delays can occur from insufficient bandwidth, which is especially problematic in emergency scenarios.

Interruptions in data transmission can also be induced by problems with connectivity. These such interruptions may influence the continuity of care and even risk patient safety by resulting in incomplete or delayed data transfers. Setting priorities for data is another issue arising from restricted connectivity and bandwidth. When the network fails, the functionality of medical IoT services is hampered. Thus, it is very important to have the best cellular network that works well for specific devices in each setting (Baker & Xiang, 2023).

4.2 Security of AIOT Healthcare Sector

The security of the patient is the first priority. A cloud-based database contains all the individual's data. Management of information, privacy protection, and data storing are the three core functions of cloud data centers. Storage of data includes data in the form of video, image storage, structured storage and unstructured data storage. The more sensitive data is kept encrypted and is separated from main data. In AIOT healthcare services, it is necessary to keep data safe, have access control over data, to have data backups and it is also necessary to manage permissions. Sensitive data on patients should be secure against illegal access. Cyberattacks and breaches are one of the major concerns and threats in the healthcare industry. The connected

devices, which interact with each other in real time to transfer healthcare data, can get hacked by a cyberattack in the middle of the process. In the medical industry, keeping patient information confidential is standard procedure. Due to the Internet of Things (AIOT), researchers must make extra effort to safeguard their data and information from cyberattacks. They should also ensure that their systems are secure so that there are no security gaps. To promote patient health, sensitive data must be encrypted, isolated, and managed access controls, permissions, data backups, data recovery, and audit trails. Data should be accessible to only authorized users and to administrators. AIOT creates a huge amount of data which is not standardized. IoT healthcare apps need to be safe and secure. Together with other difficulties, they must take into account the risks to patients' security and privacy that they pose (Pise et al., 2022),(Imoize et al., 2023).

Figure 3. Security and privacy requirements of AIOT

Fig 3: Security and privacy requirements of AIOT.

Advanced steps are adopted to preserve sensitive patient data and offer a smooth monitoring experience in the AIOT healthcare sector, with the goal of providing patient comfort and security. How to do it is as follows:

4.3 Comfort and Security of the Patient

4.3.1 Personalized Settings

Patients may personalize their monitoring preferences with RPM systems. This includes modifying monitoring frequencies to suit their comfort levels and setting alarms for medication reminders.

4.3.2 Non-Intrusive Sensors

Wearable technology and advanced sensors are made to be as non-intrusive as possible, so they don't bother or discomfort patients while they are being monitored continuously.

4.4 Safeguarding Data

4.4.1 Encryption Techniques

Only authorized persons may access critical health information by using cutting-edge encryption methods to safeguard patient data both in transit and at rest.

4.4.2 Secure Cloud Storage

To guard patient data from cyber threats and unauthorized access, dependable cloud storage solutions with multi-layered security policies should be used. Strict access control methods should be put in place to restrict data access to patients and authorized healthcare providers, preventing unauthorized people from seeing private health information.

4.5 Possible Issues and Technological Remedies

4.5.1 Issues

- Concerns over the security of their health information and the possibility of illegal access are common among patient;

- There can be doubts about the dependability and precision of RPM technology in the collection and analysis of health data.

4.5.2 Technological Solutions

- Blockchain Technology: Using blockchain technology to provide a transparent and safe health data management system that protects patient privacy and data integrity (Wazid et al., 2021);
- Advanced Data Analytics: Applying techniques for advanced data analytics, such artificial intelligence and machine learning, can improve the dependability and accuracy of health data interpretation while lowering the possibility of false positives or negatives.

5. MOTIVATION

- The aim of this remote patient monitoring system is to create healthcare that is more effective, productive, and conveniently available to a bigger population;
- With the help of AI and the Internet of Things, a patient can be monitored with accurate disease prediction, and illness can be detected within seconds;
- The aim to start this remote patient monitoring with AIOT is to provide accurate predictions for many life-threatening diseases like cancer and heart disease at early stages so that they can be cured.

5.1 Contributions of This Chapter

This chapter contributes to a lot of research on technologies like artificial intelligence, data analytics, machine learning models and how they are implemented with the internet of things to contribute to healthcare fields. The fusion of AI and IoT in the medical field, especially in the context of remote patient monitoring, provides a momentous stride forward in healthcare advancements.

5.2 Open Aspects and Research Challenges/ Future Research Opportunities

The future research opportunities are how IoT and artificial intelligence can be integrated with smart health to improve some challenges like healthcare availability, access and costs and also how to improve security and privacy of patients. The future work also includes detection of some life-threatening diseases like cancer, heart disease in which data should be accurate and we can get timely treatments.

Regarding future potential, it is anticipated that the healthcare AIOT remote patient monitoring market would expand rapidly over the coming years due to factors such an ageing population, rising healthcare expenses, and expanding demand for remote care platforms. AIOT remote patient monitoring solutions are anticipated to advance in sophistication, dependability, and usability as the technology develops.

5.1.1 Safety

Safety of patient data should be the first priority. The data should be kept safe and sensitive data must be encrypted; data backups must be stored. There should be no access of patient's data to unauthorized users. In the medical industry, keeping patient information confidential is standard procedure. Due to the Internet of Things (AIOT), researchers must make extra effort to safeguard their data and information from cyberattacks. In order to prevent security gaps, they should also make sure that their networks are safe.

5.1.2 Data Exchange

In AIOT, we must ensure that there should be no transfer or exchange of data of patients to unauthorized users. Admin and approved individuals should be the only individuals with access to all data, only they have permission to exchange data. To ensure security of data a security architecture needs to be maintained.

5.1.3 Extensive Data

This covers information gathered from numerous sources, including wearable technology, health applications, electronic health records, and imaging systems for use in the medical field. Patient data consists of a patient's medical background, contact details, vital signs, and other health-related information.

Sensor data comprises information gathered from a variety of sensors, including those found in smartwatches, fitness trackers, and other wearable gadgets. Data gathered during virtual visits and remote consultations with healthcare professionals is referred to as telehealth data. Imaging data refers to information obtained from various medical imaging instruments, including X-rays, CT scans, and MRIs. A significant problem in AIOT healthcare is managing and analyzing this enormous volume of data. Big data analytics, AI, and machine learning are among the cutting-edge technologies being utilized to glean insights from this data, increase the accuracy of diagnoses, identify health hazards, and provide patient-specific treatments (Prakash et al., 2023b),(Rao et al., 2023).

6. FUTURE SCOPE

In this chapter, we offered a comprehensive survey on possibilities of providing healthcare assistance at home to individual patient, by using the techniques of AIOT. According to the study, IoT has significantly impacted the healthcare sector. Utilizing AIOT, researchers have come up with an innovative technique to support patients and healthcare workers. For the convenience of their patients, doctors can more readily perform their services, from consultation to surgery, with greater ease because of the support of the AIOT. An Internet of Things (IoT) assisted health tracking device is built using algorithms based on machine learning which make use of artificial intelligence to measure the patient's activities, including sprinting, sleeping, jogging, and exercising, as well as the vitals during those activities, including the body's temperature and cardiac rate, as well as the patient's respiration pattern. The patient's various activities were identified and detected using artificial intelligence algorithms. Only congestion and good breathing are currently detected using artificial intelligence algorithms. This study's recommended health monitoring device did not hurt the patient or make them uncomfortable. With the help of this implementation, we can provide a comfort zone to patients who physically cannot visit doctors and they can get medical aid through a monitoring system. The remote patient monitoring system generally focuses on providing the patient correct info about their disease and prevention from disease. It aims at providing the best treatment safely and quickly even in remote areas.

By integrating specialized sensors and cutting-edge algorithms for early detection and diagnosis, enhanced disease monitoring capabilities will enable RPM systems to identify a larger spectrum of ailments, including cardiovascular disorders and cancer. Furthermore, RPM systems will be able to evaluate patient-specific health data thanks to the use of AI and machine learning algorithms. For information to flow across various healthcare systems seamlessly, data integration issues must be resolved. By putting in place interoperable standards and protocols, data integration will be made easier, guaranteeing thorough patient monitoring and well-informed decision-making. Ensuring adherence to healthcare data privacy and security regulations, such HIPAA and GDPR, will be crucial, requiring strong data governance structures and procedures for monitoring compliance.

Deep learning algorithms will improve jobs related to pattern identification and classification, making it possible to analyze health data more accurately. Processing sequential health data will be made possible by recurrent neural networks (RNNs), which will enable anomaly identification and predictive modelling. Gradient Boosting Machines (GBMs) are designed to enhance ensemble learning and feature selection processes, hence improving prediction performance. Real-time tracking and monitoring of patient health parameters will be made possible by statistical

techniques like Kalman Filtering, and decision-making based on noisy or incomplete data will be improved by Bayesian Inference, which supports probabilistic reasoning and uncertainty modelling. RPM technology will provide more precise, dependable, and individualized patient health monitoring by using these sophisticated algorithms, which will eventually enhance patient happiness and healthcare results (Zhang et al., 2021), (Bansal et al., 2018).

7. CONCLUSION

In conclusion, the combined effect of AI and IoT in the medical field, especially in the context of remote patient monitoring, provides a significant stride forward in medical sectors. It equips healthcare providers with the tools to offer more precise, assertive care, while patients enjoy the benefits of advanced treatment plans and greater control over their health. Remote patient monitoring for healthcare AIOT is a promising tool for raising the standard of care for patients with a range of medical disorders. It enables carers to remotely monitor patient health indicators, identify possible issues before they develop, and take prompt corrective action. Additionally, applying AI and machine learning algorithms can aid in the analysis of significant data trends, the generation of insightful conclusions, and the provision of individualized treatment plans. By enabling preventative actions and early interventions, AIOT remote patient monitoring can also help the shift from reactive to proactive healthcare models. Overall, healthcare AIOT remote patient monitoring has enormous potential to enhance care quality, save costs, and improve patient outcomes.

Regarding future potential, it is anticipated that the healthcare AIOT remote patient monitoring market would expand rapidly over the coming years due to factors such an ageing population, rising healthcare expenses, and expanding demand for remote care platforms. AIOT remote patient monitoring solutions are anticipated to advance in sophistication, dependability, and usability as the technology develops. Healthcare practitioners will use AI and machine learning algorithms more frequently to enhance clinical decision-making and deliver more individualized patient care. Further enhancing its capabilities and value proposition will be the integration of AIOT remote patient monitoring with other healthcare technologies including telemedicine, EHRs, and wearables. In the future, we will extend this RPM technology for other kinds of life-threatening diseases with more accuracy.

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