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Survey on Sensors and Smart Devices for IoT Enabled Intelligent Healthcare System

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Abstract
The Internet of Things (IoT) in the healthcare system is rapidly changing from the conventional hospital and concentrated specialist behavior to a distributed, patient-centric approach. With the advancement of new techniques, a patient needs sophisticated healthcare requirements. IoT-enabled intelligent health monitoring system with sensors and devices is a patient analysis technique to monitor the patient 24 h a day. IoT is swapping the architecture and has improved the application of different complex systems. Healthcare devices are one of the most remarkable applications of the IoT. Many patient monitoring techniques are available in the IoT platform. This review presents an IoT-enabled intelligent health monitoring system by analyzing the papers reported between 2016 and 2023. This survey also discusses the concept of big data in IoT networks and the IoT computing technology known as edge computing. This review concentrated on sensors and smart devices used in intelligent IoT based health monitoring systems with merits and demerits. This survey gives a brief study based on sensors and smart devices used in IoT smart healthcare systems.

Keywords Healthcare · Patient monitoring · Sensors · IoT · RFID · Edge intelligence · Protocol · Big data

1 Introduction

The increasing population, people with persistent health issues, and old people curing medical issues are important. Precautions are distinguished not to maintain a disease-free lifestyle through exercise, diet and sleep but to reduce ongoing problems through aggravation. A large number of patients and a lack of medical services cause the innovations like smart devices, health monitoring sensors etc. These devices improve patients' health by accepting and fulfilling their demands and needs. The COVID-19 situation highlights the importance of healthcare [1] and smart remote in medical management systems. Also, each individual can check their health condition by monitoring smart wearable sensors like

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mobile, digital watches etc. IoT technologies like fetching data from different things, such as sensors without wires, Wi-Fi, cloud computing, Radio Frequency Identification (RFID) and Bluetooth, the devices like sugar level monitors, Electrocardiogram (ECG) monitors, wheelchair management systems, temperature monitors, blood pressure monitor are worked by using these technologies [2].

The use of modern health systems techniques and observable constructions should serve to find possible medical problems quickly and, at the same time, arrange for important measures such as analysis and prevention of medical check-ups. Based on the research, the medical industries are utilizing smart devices with sensors to diagnose the disease at 143.6 billion in the US and a cumulative annual growth of 16% in the seven years [3]. Then deal with health conditions effectively and behave logically. Smart healthcare has various interveners, such as doctors, nurses, patients and organizations [4]. It shows a composite idea including disease manage and finding, valuation and care, medical management of a patient, and hospitality. Electronic devices like sensing devices using IoT, speed in the Internet, cloud computing, communication with wireless devices, networking, artificial intelligence (AI) and machine learning are the foundation of an intelligent health monitoring system [5]. The symptoms and changes can be detected using the sensors [6]. Technic conducted a more detailed search of various patient health devices such as ECG, Electromyography (EMG), Electroencephalography (EEG), Mechanomyogram (MMG), Electroocoulogram (EOG), Magnetoencephalography (MEG), respiration rate (RESP), Photoplethysmography (PPG), blood pressure devices, etc. Most hospitals use smart beds with sensors to monitor the patient and take corresponding precautions.

The survey reordered the sensors devices and their working procedures, which the IoT intelligent healthcare alert model verifies. The research organized in Sect. 2 shows the intelligent healthcare network in the IoT system. Sections 3 and 4 introduce the sensor devices used in health care. Section 5 describes the IoT technology for healthcare. Section 6 shows the three-layer architecture of IoT technology. The 7th section demonstrates the protocols used in IoT technology. Section 8 shows the sensors and devices used in different approaches. Section 9 shows edge computing to improve efficiency and performance and reduce latency by processing the data within the network. Section 10 describes the concept called big data to generate valuable insights because of the large variety, arriving in enlarging volumes and with high velocity. Sections 11 and 12 demonstrate machine learning and physiological concept. Section 12 demonstrates the IoT system's implementation of the sensors and devices. Section 13 shows the heath care monitoring using the smartphone device. The security, challenges, limitations and future scope are provided in Sects. 14 and 15. Finally, the review is concluded in Sect. 16.

2 Intelligent Healthcare Network for Smart Devices

IoT plays a huge role in the modern medical system. Due to the updates of VLSI technology, the sensor device is developed in micro size that promotes the evolution of wearable solutions for smart devices. The unbreakable data connection helps the technologies to become smart and intelligent. Health care monitoring devices based on the IoT will scan a patient 24 h daily. IoT devices give corresponding signals in every critical situation by analyzing statistical data. As IoT based devices are permanently attached to the Internet, the patient can be remotely monitored anytime, anywhere. These devices can supply both identification and instant response services to the patient. There is a notable change in IoT based health monitoring systems to normal health care monitoring systems. The IoT's initial vision must expand the word Internet to the present, keeping physical objects related to the RFID method every day. Fortunately, the sudden changes in technology and sensors are used to find health-related problems and collect the patient's data. IoT has become extra popular due to the update of commercially acceptable devices and mobile apps.

Some recent articles about hospitals using IoT devices are explained below. Tamilselvi et al. [7] presented a disease detection model used to check a person's minority diseases, such as the number of heartbeats, the amount of oxygen in the blood, body temperature, and an eye's placement on the IoT network. The suggested method explained the performance calculations without proper explanation for every patient. Acharya et al. [8] suggested a method for the IoT healthcare industry with a kit for monitoring the patient. The implemented technology detects the health condition of regular functions of human organs. The main physical things that are utilized here are sensors and microcontrollers. The information was gathered using the sensors, then transmitted to the microcontroller for processing and then sent to the Internet. The main demerit of this device is the data vitalization without implementation. Banerjee et al. [9] presented a heart rate monitoring device under non-invasive technology. The proposed method used in health care also gives the result of forming a detector device. The system has proven efficient for people with other methods.

Trivedi et al. [10] proposed a sensor device based on the microcontroller to measure health variables. Gathered the device information, which is transmitted to the microcontroller board. The added ADC (Analog to digital converter) transfers the collected analogue data as a binary value. Internet is used to send the physical data into the implemented method. Internet providers utilized a system with a small space. Kumar et al. [11] presented an efficient IoT device for sensing safety measures. The architecture procedure is divided into three parts in which the first is control, the second is the device part, and the final is the transport part. The sensor device used is named DS18B20 to quantify the patient's body temperature and use the sensor to calculate the heartbeat. The information stored in the microcontroller sends to the cloud through an internet module. Finally, the architecture part gathered the server information. Moreover, using microcontrollers, lots of sensing devices are not performed efficiently.

Table 1 demonstrates the sensors and devices used in health monitoring systems using IoT. The IoT healthcare system [12] utilizes many interconnected devices for forming a network in the IoT process, like monitoring, robotic surgeries, and health diagnosis [13] . The continuous study of IoT promotes healthcare systems by processing and identifying networks and applications [14]. Inertial sensors [15], Global Positioning System (GPS) [16], ECG, and EEG sensors are considered smart devices. It stores different information related to the patient's health, such as heaviness, current position, number of heartbeats in one minute, the pressure exerted by blood vessels, glucose level, and user-context information. Some of the studies respond that [17] they use digital mobile phones to attain the feelings in the patient's body through character information in specific applications of digital mobile phones. Figure 1 displays the intelligent healthcare system.

3 Medical Sensors

Many sensors are available to collect patients' health information through the IoT network. Specifically, heart sensors are considered significant sensor which analyzes the patient's heartbeat. A body temperature sensor is used to record the patient's body temperature. A

Table 1 Different IoT devices

References	Device name	Purpose	Sensors used	Advantages	Disadvantages
Tamil selvi et al. [7]	Health monitoring device	check minority symptoms of a patient like heart rate, percentage of oxygen saturation, body temperature, and eye movement in IoT	Heartbeat, SpO2, Temperature, and Eye blink sensors	Maintaining costs is less	No proper performance calculations are explained for any patient
Acharya et al. [8]	healthcare monitoring kit	Detecting the health condition of humans like a heartbeat, body temperature, ECG and respiration	Body temperature sensor, ECG, pulse monitor,	Easy to handle	Data vitalization without interfaces is implemented
Banerjee et al. [9]	Pulse rate detection system	Measure the pulse waves in the patient body	Heart rate sensor	Reliable for the people with respect to other methods	The Plethysmography procedure gives less accurate measurements
Trivedi et al. [10]	Microcontroller based health parameter surveillance	Monitor the patient's health, such as the temperature of the body, rate of heart etc	Heart rate, SPO2, body temperature sensor	Analogue to digital converter makes the performance of the device faster	Less accurate, low efficiency and complex structure
Kumar et al. [11]	Adaptive IoT safety monitoring device	Quantification of the body temperature of the patient and a pulse sensor to calculate the pulse rate	DS18B20	Three-layer architecture improves the performance of the system	Sensors cannot be treated properly

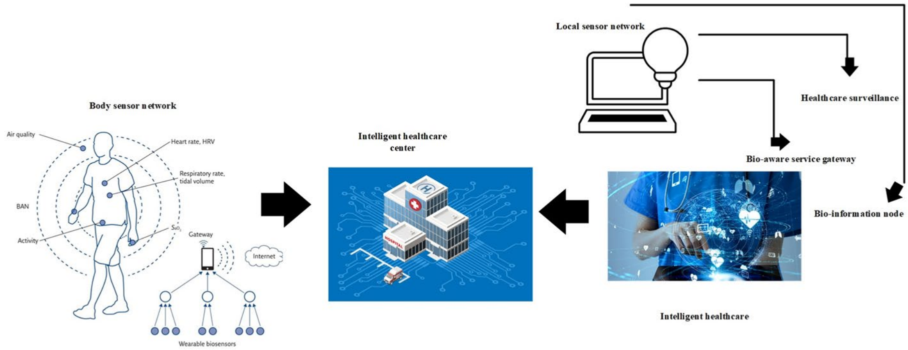


Fig. 1 Intelligent healthcare system

pressure sensor is used to determine the pressure value, and a glucometer is used to check the glucose level. A respiration sensor, pulse sensor and gas sensor gather information from the patient's body to monitor the patient's health.

Table 2 shows the list of sensors and their usage, like pressure, heartbeat, body temperature, etc. These sensors were placed to collect the corresponding data value from a patient's body. The accuracy of this collected data determines a patient's illness.

4 Healthcare Devices

The sensors are placed in the devices to work as a system. The devices used for the IoT healthcare system are explained below.

Table 3 shows the different types of devices used to monitor the patient's condition. Each device has one or more sensors to collect information from the patient's body. The table describes the devices such as wheelchair management, medication management, asthma monitoring, diabetes management, etc. It also shows the smart devices used to monitor the baby.

5 Iot Technology for Healthcare Devices

The IoT technology is used in healthcare to sense health information from the patient's body [18]. The usage of IoT technology reduces the delay time and irritation of the patient and the physicians. Figure 2 displays the intelligence of IoT with smart devices and sensor systems. As Fig. 2 shows, the sensing devices were implanted in a patient to gather the patient's health information.

After sensing the health information from the body, the data is moved to the cloud with the help of a gateway. The data transmitted to the cloud platform is moved to the server to analyze all information related to healthcare. IoT technologies in healthcare units enable real-time recognition and accurate value. Digitization has made a large change in medical technologies. After processing the information, the output message is sent to the end users. Healthcare sensors and devices assist doctors and patients in monitoring different physical problems at a minimum price. Hand-friendly healthcare devices are also customized while

Table 2 Use of medical sensors

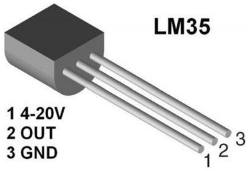
Sensors	images	Use
Heartbeat sensor		It is used to calculate the change in blood volume and measures pulse waves by changing the volume of the blood vessel when they pump blood
Temperature sensor (LM35)		The LM35 sequence is a correctly minimized hardware to calculate the body temperature
Pressure Sensor		The pressure sensor is used to measure the blood pressure of the patient’s body. This is characterized by swapping the body pressure to the electrical signals. There is a tube to change the position of the needle present in the sensor

Table 2 (continued)

Sensors	images	Use
Glucose sensor		A device is used to measure glucose in the patient's blood. To check the amount of glucose in the blood, the patient uses it to check their glucose level
Respiration Sensor		High-quality sensors are used for respiration; the device measures minute flow rates around the respiratory flow's zero point and determines the flow rate of several hundred l/min. Used in anaesthetic devices
Pulse Sensor		Students, artists, athletes, makers, and developers of games and mobile devices can use a well-designed sensor to collect the data values
Gas Sensor		The sensor can detect the presence of gases, toxins, humidity and vapours in the body of the patient
Body Position Sensor		Body position sensors find the primary sleeping positions left, right and upright. Body position can be checked continuously, regardless of patient movement during the sleep test

Table 2 (continued)

Sensors	images	Use
Weight Sensor		A weight sensor is also known as a load cell. These are available in large sizes and capacities
RFID Sensor		RFID is a sensor that identifies the track tags in the patient's body. By using these tags, the sensor collects the body's data
ECG Sensor		A sensor is used to collect the data related to the number of heartbeats per minute through which electrodes are connected to an ECG machine. No current is passed into the body
Force sensor		Used in the kidney dialysis machine
Air flow sensor		Used in anaesthesia delivery systems, laparoscopy, and heart pumps

Table 3 Healthcare monitor devices

Device	Images	Uses
Implantable pacemaker		The real time embedded sensor maintains the cardiac rhythm
Oximeter		A device is used to calculate the amount of pulse rate in the patient's body
EEG		A device used to record the electrical characteristics of the brain
EMG		The device used to produce the skeletal muscles characteristics
Respiration rate monitor		It gives the rate at which how many times the chest rises in one second

Table 3 (continued)

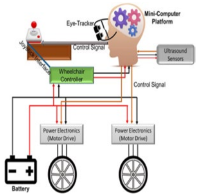
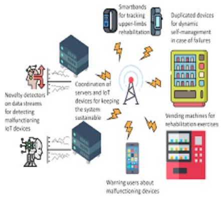
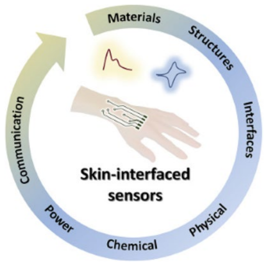
Device	Images	Uses
Wheelchair management		Wheelchairs are typically used for physically challenged people. Bluetooth connects the locomotion of the device. The patient is observed by the sensors attached to the device
Rehabilitation of system		Patient rehabilitation is not a system handled by the poor, but it also makes a difference in a modern better lifestyle. IoT is to escape the problems due to the population. The Body Sensor Network (BSN) is explained to make a method to quickly rearrange healthcare resources with respect to patients' needs
Device for detecting diseases of the skin and monitoring the diet		The studies have explained better solutions for IoT based smart healthcare devices. The Skin cancer detection tool is suggested based on a retrained Convolutional Neural Network (CNN) method. Food differentiation and recognition for dietary assessment. Using a cloud platform, they perform the pre-processing on mobile technology and a CNN model

Table 3 (continued)

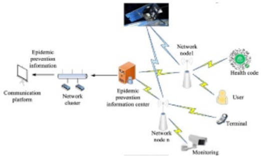
Device	Images	Uses
epidemic prevention system		IoT smart healthcare devices have provided helpful solutions for disease monitoring. In real time processing, position monitoring and locomotion details are the different information integrations. By utilizing biosensors, location and ambient sensors, the system can monitor the patient during difficulty
Diabetes treatment		Most studies are based on repeated health problems like increasing blood and body sugar levels. The proposed method recognizes diseases and cures. A lot of hand-friendly devices are made to monitor blood sugar levels. Most devices, like smartphones, can perform as edge devices forming output by not using the cloud
Device for analyzing mood and depression		The device provides data based on the patient's emotions and is used to analyze the different impulses in the brain. It also helps to find the mental disorder of the patient
Blood pressure monitoring		The main method in any diagnostic process is quantifying blood pressure (BP). The most common method of determining blood pressure for at least one patient for recording. In addition, modifying the IoT and other sensor methods has changed how BP was monitored in the past

Table 3 (continued)

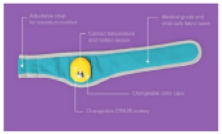
Device	Images	Uses
Device to detect Asthma		The persistent illness can cause airflow and complicate breathing. In Asthma, the air walls are reduced due to the swelling of the airflow. Due some problems related to health can occur, like wheezing, coughing, chest pain, and hard in a breath. There is no defined time for Asthma, and a device or nebulizer is the only curing mechanism at that time
Management in the medication system		Presently medication management is the central problem. Non-attachment in healthcare time may grow unfavourable issues in patients. Medication management occurs in old people as the volute of hospital techniques like cognitive decline and dementia due to age
Baby monitor		The device used to monitor the baby is strapped to the baby's body so the baby's temperature and movement can be monitored continuously. The information collected is monitored by using smartphone applications
X-Ray film processor		Processing the machine in 60 films per hour. It has a processor with three different replenishment bottles. It automatically detects a film by needing a water connection with a shut-off valve. 220 VAC and 50 Hz are the required power

Table 3 (continued)

Device	Images	Uses
Gastroscope		The device was used to find the difficulties in stomach related issues with halogen light sources having at least 4 to 100 mm depth
Colonoscope		A device used to monitor the abnormalities in the large intestine. The device is designed by using a camera to analyze the issues like bleeding
Defibrillator		A device for analyzing the patient's heartbeat also finds the shock exerted in the heart. This device can also monitor the speed of the heartbeat
Fetal monitor	 s	It is a healthcare device used to monitor the fetus's heartbeat and changes in the uterus at the time of labor

Table 3 (continued)

Device	Images	Uses
Allb baby check		The wireless device connected to smartphone apps is used to monitor the temperature and breathing of the baby. The analyzed data can be found by using the app. Also, the device will provide an alert message at the time of exceeding the threshold value
Smart clothing		A device used to monitor the baby at the time of sleeping. The sensors are integrated into the network; they gather the patient's body data and process them using Wi-Fi and Bluetooth. The parents can update the changes in activity through mobile applications
Smart sock		The device checks the heartbeat every minute and the baby's oxygen level in real time. There will be an alert message to the patient's mobile phone at the time of any changes in the current data of the patient

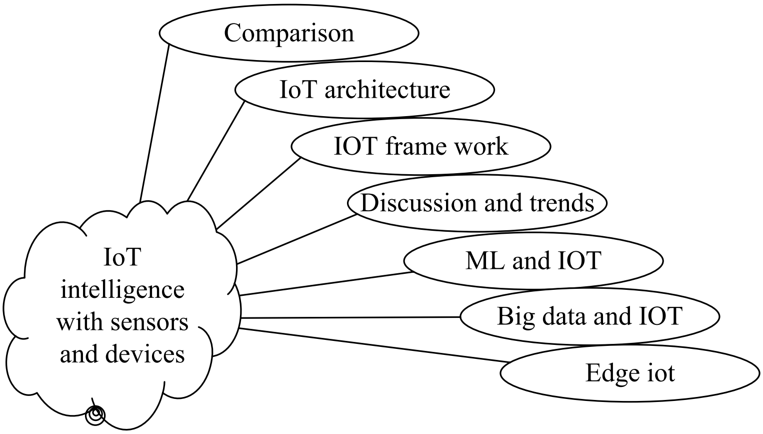


Fig. 2 IoT intelligence

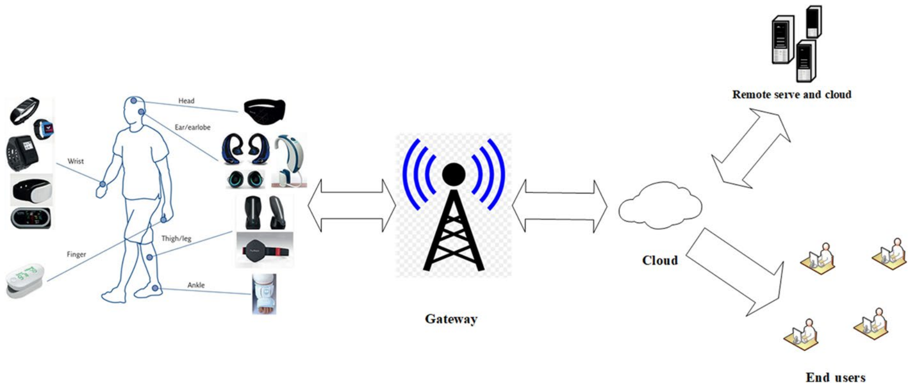


Fig. 3 IoT technology for healthcare devices

adding different sensing devices with portable things patients utilize like clothes, electronic devices with them, etc. The sensor gathers data from the people monitored under these devices. After that, the data is transmitted to the cloud. Most health monitoring devices are connected to smartphones. Integrating some portable healthcare devices with smartphone applications promotes the power of healthcare devices.

Figure 3 shows the IoT technology for healthcare devices [19]. These devices have three important parts: sensing, networking, and data processing. The technologies are explained below,

5.1 Sensing

Recognition methods concentrate on realizing characteristics and assembling patient medical data collected using sensing devices. The important grown of miniature, low-cost portable inertial sensors are used as the sensing device and healthcare sensors [20], and portable sensing devices have the procedure of finding attributes from each individual. The sensing layer is interfacing between the digital and real worlds. Sensor contributes an important role in creating solutions for IoT healthcare devices. There are USB sensors, Bluetooth sensors, and embedded sensors were utilized to collect the data. Sensors can be directly added to healthcare devices to get more sensing capabilities. Also, the wireless sensors permit data to be sent to the central terminal for regular terminal processing. Also, the sensors give services like ovulation and menstrual cycle forecasting on the basics of the body temperature data using a digital basal thermometer.

5.2 Networking Stage

The IoT network deals with the healthcare system, including a vast design and technologies [21]. Network-to-network connections are made the Internet possible for the transmission and reception of data. The network layer is the portion of Internet communications where the connection link is formed by transmitting packets of data back and forth between the different networks. The protocol used in this network layer is called internet protocol (IP). The process of internetwork connections takes place at a network layer. This contains router settings, sending and receiving data from a different network. IP and ICMP (internet control message protocol) are the main protocols used in the network layer. Network layers transmit and receive data from source to destination using these protocols, with both source and destination costs.

5.3 Data Processing Stage

The processing of information collected by the sensors is done in this stage. Data processing is used to select the data for analysis and forward the data into a format [22]. Data processing has six stages: a collection of data, preparation of data, data input, processing of data and storage of the collected data. Collecting information from the patient body is the first step in the data processing. Once data is collected, the gathered data enters the data preparation stage, which is always known as pre-processing. The data is cleaned up and arranged for the next step in this stage. The purpose of pre-processing information is to eliminate the bad information data set and create high quality information to get an efficient output. The next step is data input, the cleaned data further enters its destination, that is, the data is translated into an understandable language. Then the fourth step is known as processing; in this stage, the data is processed for interpretation. The data interpretation is used for non-data scientists in graphs, images, etc. Finally, the last step is data storage, used to store the data for future work.

5.4 Cloud Computing

The Internet contributes many opportunities to several technologies. The information transmitted from the Internet is authorized by the system to move to the network of the cloud. Cloud computing merges access with IoT-based healthcare methodology, allowing permission to deal with the shared assets [23], providing Internet services and promoting users to do common tasks. Health monitoring system with sensors and devices is a wide application of IoT technology and cloud platform [24]. The improvement of IoT and cloud computing upgrades patient welfare. The health monitoring system with sensors and devices based on technologies collected on the Internet is called cloud computing, which gives an efficient, flexible, and scalable dataset. The cloud stores the sensor data value from the body of a patient. If there is any curtail moment of health condition, a notification is transmitted to the corresponding persons. In recent years, cloud computing has become popular in new technology. It has more scalability, mobility and good security status by giving on-the machines. The cloud computing system has become the backbone of IoT technology. Cloud computing was another merit to sharing the data about the patient's health in a large arranged path.

6 Three-Layer Architecture of the IoT Devices

The three-layer architecture of the healthcare system based on the IoT consists of edge devices, fog nodes and cloud data senders. In the IoT, the value is related to the data behaviour formed by Internet devices. Like this, the cloud-centric framework stores the data in the cloud. Intelligent cloud computing gives privacy due to the supply of large flexibility and scalability. It gives techniques like software, infrastructure and storage.

6.1 Level 1 for Edge Nodes

The initial work stage is done through hand free modules like watches and mobile phones. The edge node is interested in sensing and measuring data collected through the sensors in the patient's body. The interconnected machine can identify a large amount of data utilized to make the key conclusion. The edge node also keeps the historical information [25]. The edge devices contain smart watches, smartphones, computers etc. The data set is collected through edge devices. Data collection and local processing are done using servers or PCs. Fog nodes are fog computing techniques enabling the distribution of fog services and are developed using minimum physical devices with detecting and processing abilities. The fog node monitors the data and manages the IoT system. High mobility and widespread distributions are the characteristics of this fog node. Then it analyzes the value of the information to be sent to the fog nodes after filtration, and the analyzed data is transmitted to the Internet.

6.2 Levels 2 and 3 for Fog and Cloud Processing

Cloud processing is the third level of the IoT based smart health system. Sensors collect the information and store the health information in a data set. The dataset is collected and kept in cloud processing. Figure 4 shows the IoT healthcare system's three-level architecture and is included simultaneously in the same framework. In static solutions, the data from the sensor can be collected directly through the fog node with the help of cloud processing. In this way, edge devices contact Cloud network providers directly under certain complex dynamic conditions where fog levels are not imposed.

7 Protocols Used in IoT Healthcare Device

There is great pupation in the IoT platform, and the implementation of IoT in healthcare is growing at this same time. In the last decade, the growth of various applications based on the IoT has been observed using some protocols. There are so many network communication

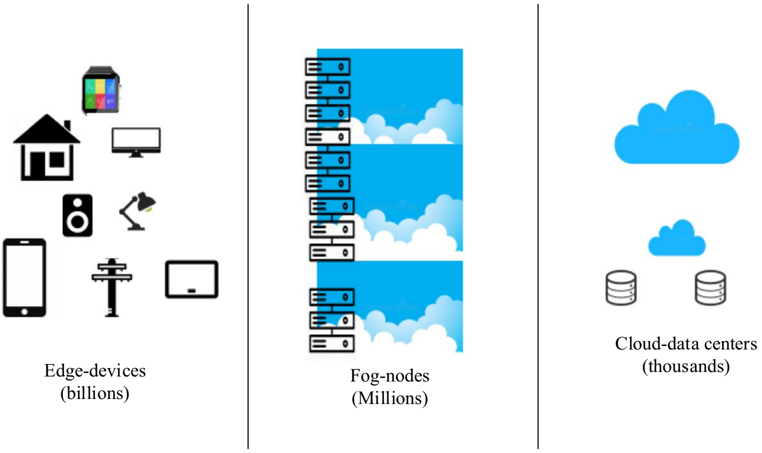


Fig. 4 Three-layer framework for IoT health monitoring system

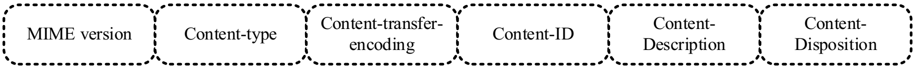


Fig. 5 Header formation of MIME protocol

protocols for IoT, like Hyper Text Transfer Protocol (HTTP) or novel protocols only in the technique of IoT, such as CoAP (Constrained Application Protocol) or MQTT (Message Query Telemetry Transport).

HTTP: The protocol used to supply synergetic, hypermedia technology. The common and dispossessed HTTP protocol is utilized in different assignments far away by using hypertext. The importance of the protocol is also writing discussion of showing the database, promoting the device to be constructed not depend on the information transmitted by the protocol, which is highly recommended in the database processing. A client transmits a message to the server as a request procedure, URI, and version of that protocol, followed by a Multipurpose Internet Mail Extensions (MIME) as appeal includes a transformer, details about the person and the information of that body to be possible to the server. It replies with a current update line consisting of the message protocol version and a success or fault code, including MIME-like data. The header formation of the MIME protocol is displayed in Fig. 5.

- *MIME-version* It mentions the version of the MIME protocol being used.
- *Content-type* It defines the type and subtype of data in the body of the message.
- *Content-transfer-encoding* It defines how the object inside the body has been encoded to ASCII format to create it acceptable for mail transfer.
- *Content-ID* This field identifies the contents. Its format is the same as the format of the standard Message-Id header.
- *Content-description* This field tells what the message is. It is the form of ASCII recipient will know whether it is worth decoding and reading the message.
- *Content-disposition* It provides information about how to present a message or a body part.

CoAP: CoAP protocol is used for an unnatural situation with HTTP's web transfer protocol. The CoAP method is integrated with a fixed technique to construct this protocol and is suitable for other implementations. The important goal of CoAP was to reduce the messages above and compel packet segmentation.

MQTT: A protocol has a weightless suitable system, surrounded technique, and storage abilities to transmit information through a small bandwidth. MQTT explains the three-level of QoS for the transmission of messages. With null information distributed for one, with QoS 1, messages are distributed at least once for acceptance; with QoS 2, information is distributed precisely at one. MQTT is done on small models. Different people can connect with brokers to subscribe to some points and then collect the transmitted information on balanced topics. Next is to establish notification to the subject.

RFID: RFID increases the "applications of the technology given by the smart healthcare system". It minimizes loads of the parental home observing and following the patient's health. An RFID can be attached to tags on the patient body. These tags incorporate antennas that can collect power efficiency regarding radio frequency queries from the RFID transceiver. Software is a good platform and crosses successful evolution for the sensor in Nanotechnology and bio-industries. In the medical field, the Healthcare system is usually used to monitor the condition of patients. Unusually, living e-healthcare technology has been skilled within a discussion among eminent spaces, for instance, network protocol and databases in hospice space [26]. A growing healthcare system's utilization of mobility, wireless communication, and emergence in techniques has authorized well appliances and gadgets with mean access energy to utilize wireless sensor nodes. With the new technique and wireless communication approach, the sudden rise in electronic devices has become the most well-known and basic tool of daily life. Updates in the IoT are mostly used to interconnect devices like sensors, appliances, vehicles, and other things. These may provide an RFID tag, sensors, switches, mobile phones, and many others. By using IoT, all the devices are attached to communicate and approach the details efficiently. The important approval of IoT is to increase the profit of the Internet with the remote-control flair, data changing, eternal relatedness and many more.

8 Sensors and Devices Used in the IoT Healthcare System

Qi et al. [27] presented real-time data from the physical monitoring system with the sensor and devices. The digital system works based on low power modules for measuring the pressure, the number of heart beats and temperature etc. A GPS module is also integrated into the network with these devices. The framework of the system is designed with the help of wireless base stations. There is a minimum error in the nursing centres and healthcare centres. Also mentioned an RF technology for analyzing the healthcare system efficiently.

Alam et al. [28] presented a smart health monitoring system with several integrated applications. The system is worked based on crew physiologic observation devices, which are used to measure the cardiac activity of the patient and the saturation of oxygen in the blood, the temperature of the patient, movements etc. Also, there are more biosensors incorporated into the device. The data that is collected from the body of the patient is processed in real time healthcare monitoring.

Shaikh et al. [29] suggested a method to monitor blood pressure, the body's temperature, oxygen saturation in the blood and heart rate. Also, they integrate an accelerometer to clarify the vital signs, measured using the sensors. Also placed peso electric sensors in the patient's body to monitor the patient's respiration rate. The information collected by using these sensors is stored using multimedia cards. Bluetooth and the corresponding PC transmit and receive the required data. It has a demerit that the wearability of the sensor is complex due to the wired connections.

Ahmadi et al. [30] presented a smart healthcare monitoring system with sensors integrated into smart clothes by arranging small conductive wires through the yarns. The system provides comfort to a patient who is under health monitoring. The system has a centralized power supply, so there is no need for any wireless module, and the size of the system is reduced. There is only one device for controlling the entire health care system as a bus. Sensors like ECG and blood pressure sensors are included in these systems. The accuracy of the system is increased.

Rajini et al. [31] demonstrate wearable garments with healthcare sensors under normal clothing. The biomedical and electrical signals are recorded by using health monitoring sensors. The system works with older people and chronic disease patients. The sensors are designed to integrate into cloth in a fabric structure. The system has ECG monitoring sensors that check the saturation of oxygen in the blood and blood pressure of the patient body. This technique helps to clip the artefacts in the generated signals.

Habibzadeh et al. [32] proposed textile sensors for collecting patient data, such as respiration rate, ECG, blood pressure etc. These are used in the data processing and analysis, for which Bluetooth and PC are used. The system focuses on the elderly patient being monitored at home. There is a good performance in the quality of the signal produced. Also, the system demonstrates low cost, wearable, stretchable and knitted garments. The sensors are included in the form of yarns and dry electrodes.

Usak et al. [33] suggested a healthcare wireless device mini model for BAN. Each node in the device can gather physiological data from the patient under monitoring. The sensors used are self-used by using the sensing platform known as Zig Bee with the microcontrollers in the IoT platform. Sensors like ECG, EMG and pressure sensors are integrated into the platform known as Telos. But this system has minimum standardization properties in the platform.

Dhanvijay and Patil [34] presented health monitoring devices, including the sensors, designed to the need of consumers or patients. Here also introduces a smart architecture for the analysis of devices with the help of some integrated protocols. Some issues are present in the bandwidth, so the system requires more security and sensor modules to communicate the signals presented in the IoT system. BAN is coordinated for the Personal data processing unit.

Qadri et al. [35] demonstrate health sensing devices with smart sensors and a central control unit. The system requires very little power design and integrates a polling method to gather health information from the patient. The sensors such as ECG, EMG and EEG are sent to the cloud in a wireless manner. This system's architecture can reduce the entire system's data flow. Also, IMEC proposed an oximeter which gives information with respect to the powered body heat. The system is efficient, and the result of the mechanism cannot be compared with the polysomno graph.

Smart healthcare (SHC) system is developed by combining recent technological advancements like AI, IoT, edge and cloud computing systems. This helps to manage the healthcare industry by using wearable sensors to access data with speed responses. A person's movement is recognized with the help of various sensors which are equipped in wearable devices. In this article, Arikumar et al. [36] developed a federated learning-based person movement identification (FL-PMI) in which the unlabeled data is auto labelled with the help of the deep reinforcement learning (DRL) model. Suganyadevi et al. [37] developed a fully automated diet tracking solution containing Wi-Fi-equipped sensors for food nutrition assessment. Also, the food ingredient nutrition data is gathered by using the smartphone. The weight of the food product is estimated using the weighing sensor. Due to the growing demand, Human activity recognition (HAR) is considered an important research area, and the application of HAR includes a healthcare framework to monitor the activities of daily living. In this article [38], HAR-based wearable sensors are considered a significant technology with three important parts: position of wearable sensors, data pre-processing and identification techniques. The comparison of these technologies is given in Table 4.

9 Edge Based IoT Healthcare Monitoring System

Edge-based IoT healthcare technique includes system checking and uses various sensor devices in the application to monitor the patient, such as diagnostic, sensitive and preventive. Studies say that technologies such as fog computing and local servers have combined that check and validate sensor data and provide a quick output. They gather information from the sensor and devices to answer the service requirements immediately. The technical group has been searching for a solution for years. Early methods mainly suggested PC based techniques to check the patient remotely. The IoT-based system is also a time-consuming process because the collection of information and data processing is done in two parts: the data is collected by the sensor, and the sensing output is directly sent to the cloud space, where this clouding processes the data and gives the output.

An IoT healthcare system with an edge computing platform is currently proposing a technique related to machine learning and fog computing. Different sensors and IoT devices are used to gather information from the patient. This collected data is used for analysis and processing. The intelligent edge architecture in terms of machine learning technologies is included. The data is taken from the intelligent IoT sensors and edge devices that pre-process the data. Here AI technology for pre-processing and data analysis is integrated into this system. The edge-based system processes the data within the network rather than sending the data collected by the sensor to the cloud. It helps the system to be less time consuming. A large amount of research exists for post-operative situations in which technologies suggest a method based on the edge technique to check the health difficulties after treatment. The following steps are used for observing an orthotic's fitness for a cut-off organ. The system worked based on the edge node concerning smartphones. Machine learning techniques are used to select the collected information from the patient.

Abdellatif et al. [39] presented a healthcare device with EEG classification and analysis using autoencoders on the edge node. EEG headset and smart sensors are used to collect the patient's data. The healthcare system uses the IoT platform to predict the disease and continuously monitor the patient using body sensors. These systems are helpful in the decision making algorithm of the smart healthcare system.

Uddin et al. [40] suggested using portable sensing devices like ECG, accelerometer and gyroscope for patient activity recognition. The GPU-based fog sensor is used in the device, and the patient's activity is detected by using the RNN model. The system creates an integrated system of real time health monitors and sensors. These sensors are connected to the same bandwidth to solve the problem of channel delay. Also, a technique named scheduling is implemented that rectifies the problem of interference.

Greco et al. [41] presented real time detection of anomalies in health data using a gyroscope and an accelerometer. The method was adopted from stream computing and the

Table 4 Different healthcare sensors and devices used in the IoT platform

Reference	Description	Advantage/disadvantage
Qi et al. [27]	The IoT platforms are used in sensing, networking and processing the data collected by using the sensors	Sensing interoperability, efficient processing of data and uncontrolled environment
Alam et al. [28]	End-to-end sensing process in the healthcare system. The system was designed based on four different disease	The exploitation of healthcare standards and the technologies
Shaikh et al. [29]	Proposed practical level technologies in electronic healthcare systems. Also used RFID based NDN	The cost is very lower but has less latency and tolerance
Ahmadi et al. [30]	A smart healthcare system with sensors and devices with the help of some protocols. The system involves network elements, and most	The overall performance of the system is good, but this has less efficient and
Rajini et al. [31]	The extended applications with smart healthcare sensors and IoT smart healthcare system devices	The system can be used for different applications, but the processing speed of the system is low compared to others
Habibzadeh et al. [32]	Healthcare devices and sensors for sensing, processing and analyzing information are presented	IoT challenges are the most important issue in the healthcare system
Usak et al. [33]	A system with four different topics of the healthcare and pharmaceutical industry	This system has minimum standardization properties in the platform
Dhanvijay, and Patil [34]	WBAN based healthcare devices in IoT technology are used	BAN is coordinated to the Personal data processing unit
Ahmad Qadri et al. [35]	A traditionally based healthcare system with explained in the fracture of current technologies	This system's architecture can reduce the entire system's data flow
Arikumar et al. [36]	Used to label the unlabelled data using FL-PMI	High efficiency, lower response time and increased scalability
Suganyadevi et al. [37]	Evaluate the food product weight and transfer the data through a wireless medium	Limited populace access, frameworks interruption, flexibility breaks and high staff turnover
Serpush et al. [38]	Monitor the activities of daily living and notifies it with relevant authorities	Privacy is achieved, but information processing is too costly

HTM algorithm. The framework of the system produces an automatic real time health monitoring system with nursing facilities. There are some protocols integrated to get the efficient output of the system. However, protocols in the smartphone healthcare applications such as CoAP with respect to the wireless network are used. The gathered information is transmitted to a control centre to remote access.

Kaur et al. [42] proposed a device for monitoring the heart rate and temperature of the body by using a pulse rate sensor and a body temperature sensor. The technology used a blue mix to remotely collect data in the cloud. The system also concentrated on monitoring anthology, which is automatic processing. WI-Fi and RFID are used in the technology based on identifying different characteristics of the disease. The designing part of the system includes a service-based framework. All patients under medical supervision receive an equivalent diagnosis with rehabilitation. The advantage of the system is that it can treat multiple patients at the same time.

Satija et al. [43] presented ECG monitoring using edge computing with ECG sensors. The gathering of ECG at the time of activities and health issues recognition have been done using DFT. The system also monitors the saturation of oxygen in the patient's blood. Sensing methods are inherently wireless. The information collected from the patient's body is transmitted to the central monitoring station. Continuous health care monitoring is provided for the patient to receive the information. Also, the system is integrated with an alarm to produce an alert at the time of any problems.

Mathur et al. [44] suggested a gait recognition for lower limp and rehabilitation utilizing hand orthotics. The sensors used for the detection are movement and temperature sensors with the BSN framework to get more efficient performance. There are two communication systems. To ensure the confidentiality of the data sent, there is authentication in the smart devices. With the help of the Raspberry Pi platform, the system presented a feasible healthcare system.

Muhammad et al. [45] presented voice pathology detection using Edge technology by collecting the sensors' data on the system. The system produces a healthcare facility for the infant. Sood et al. [46] proposed a Chikungunya virus detection and alert system using environmentally and hand-friendly smart sensors. Fog node is used for real time data analysis of health systems.

Bhardwaj et al. [47] developed a smart healthcare monitoring system using IoT technology to monitor a person's oxygen level, temperature, heart rate and blood pressure. It is very helpful to the hospitals situated in villages or rural areas to continuously monitor the patients' health conditions. Pelekoudas-Oikonomou et al. [48] developed a blockchain based Internet of Medical Things (IoMT) to monitor the healthcare system. Data security and privacy are achieved with the help of blockchain technology. A detailed comparison of these studies is given in Table 5. The system mainly concentrated on the ad-hoc analysis system to reduce the cost of the sensor network.

10 Big Data and Blockchain of the IoT System

Big data analytics has been proposed in the IoT framework; however, the requirement for QoS has not been well addressed. Figure 6 demonstrates the blockchain and the blockchain of the IoT system [49] that increase the processing ability of big data.

There are different types of medical researchers using medical big data. The big data application in IoT networks involves electronic health records (EHRs), prevents medication

Table 5 Edge based IoT devices

Reference	Process	Sensors used	Devices used(fog/edge)	Technology	Advantage/ Disadvantage
Abdellatif et al. [39]	Classification and detection of ECG	ECG sensor	Not mentioned	Employed stacked auto encoders	All data processing tasks are done at a web server
Uddin et al. [40]	Activity detection	ECG, accelerometer, gyroscope	GPS based fog server	RNN model	Few numbers of the subject are included
Greco et al. [41]	To find the real time anomaly data	Gyroscope, accelerometer	Raspberry pi	Distributed edge framework and HTM algorithm	The device did not exploit contextual information
Kaur et al. [42]	Heart rate and temperature of the body checking	Pulse rate sensor, body temperature sensor	Raspberry pi	Blue mix technique	All information processing tasks performed at the cloud
Satija et al. [43]	ECG monitoring system	ECG sensor	Arduino and microcontroller	DFT	Only use single channel ECG data
Mathur et al. [44]	Gait detection, limp rehabilitation	Hand movement and temperature sensor	Raspberry pi, Arduino, smart phone	MATLAB	Illumination and motion variance
Muhammad et al. [45]	Voice pathology detection	Voice, temperature, ECG, humidity	Smartphone	ELM technique	Only use one type of data for detecting
Sood et al. [46]	Chikungunya virus disease	Environmental sensors and wearable smart sensors	No edge support	Analysis was done on the fog node while processing done on the cloud	Less specificity in the case of the detector and highly efficient
Vaneeta Bhardwaj et al. [47]	To monitor blood sugar, blood pressure, oxygen level and heart rate	Blood pressure sensor, temperature sensor and pulse oximeter	Raspberry Pi	Python	The system can deploy in non-COVID-19 patients, and the cost of the system is relatively low
Filippos Pelekoudas-Oikonomou et al. [48]	To secure the system based on blockchain technology	IoMT sensors and actuators	Raspberry Pi devices	Hyperledger Fabric platform	It has a lightweight implementation that is suitable for IoMT networks

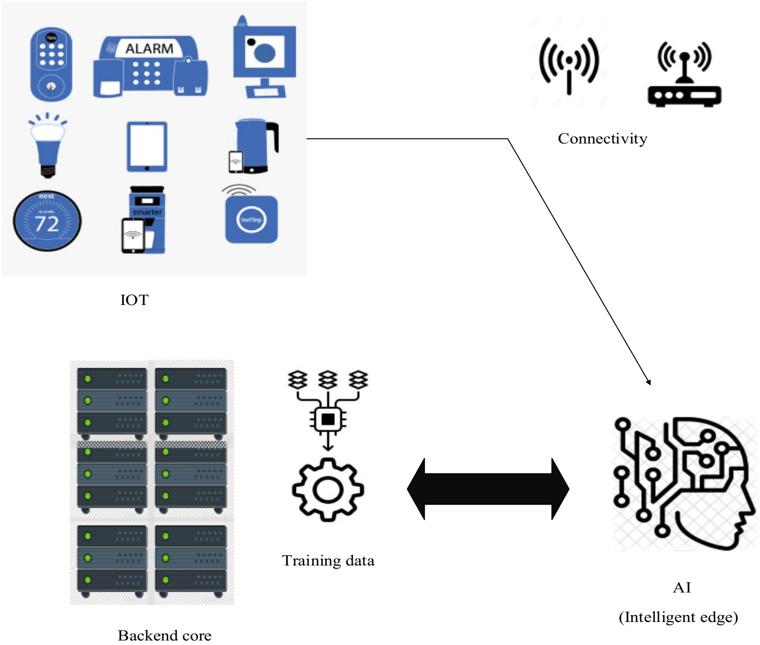


Fig. 6 Big data and blockchain of IoT system

error, reduces fraud waste and abuse, identifies high-risk patients, improves patient monitoring, and reduces read mission costs [50]. Big data in IoT is the large amount of data which is generated using traditional techniques. It was simply said that the data contains large velocity, volume, and variety. The EHR records the sensing value on the patient's body for monitoring the patient's health condition. Figure 7 displays the big data applications in IoT healthcare systems.

Some prevention medications are done to reduce fraud, waste and abuse [51]. If the health condition is critical, the system will identify the patient at risk through the IoT health monitoring system. Providing the patient with a more comprehensive monitoring system impacts the patient's health outcome [52]. By using big data, the read mission cost minimization can be done by gathering the information for storing, managing and analyzing the data. The IoT in healthcare is growing because of the technical implementation with an increasing number of people. The increasing healthcare architecture of IoT requires intelligence techniques to compare with the previous technique [53]. In this survey, edge computing technology minimized the time to get results and reduced energy usage by the past healthcare systems based on the IoT.

Collecting mechanized intuition to intelligent IoT-based monitoring devices [54] reduces costs in these hospitals for the patient and gives better care and treatment. An invented intelligent system suggested integrating technologies like machine learning and AI in the health monitoring system [55]. By integrating different types of edge devices for edge computing. The collection and updation of these technologies have enabled the large dataset of the Internet of Everything (IoE) that will be served from cloud centers worldwide. Because of that, edge intelligence is the main for processing big data. Applying these technologies in modern healthcare systems has transformed the analytical checking of the

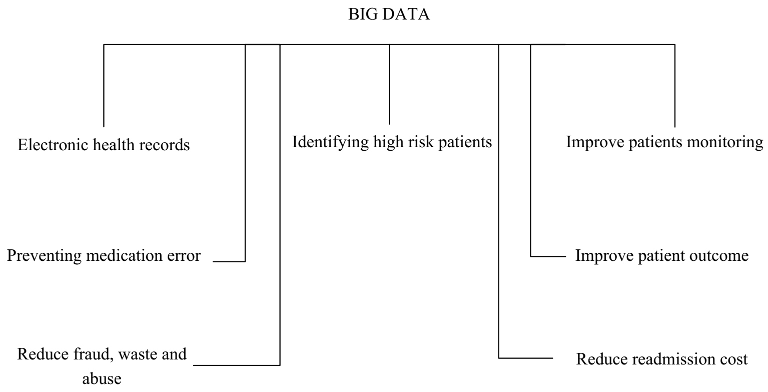


Fig. 7 Big Data applications in IoT healthcare

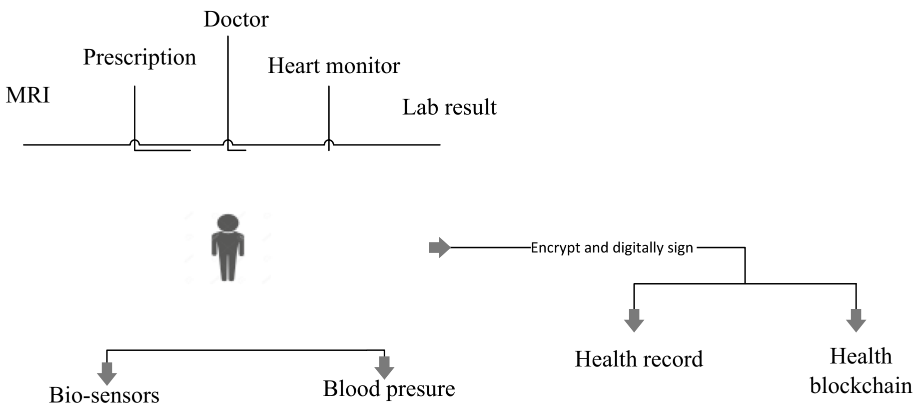


Fig. 8 Blockchain use case in IoT healthcare scenario

dataset. The dataset of wearable sensors [56] constantly follows workouts, heal care, glucose monitoring, and heart rate at home. These IoT systems will save time for consulting the doctor and minimize travel.

Figure 8 shows the blockchain use case in the IoT healthcare scenario. It has also reduced mistakes because of the human factors collecting additional confidence in all [57] health datasets. Hence, these technologies can help the smart healthcare system grow suddenly. Whenever data is stored in the dataset, a pointer called the patient unique identifier is generated and included in the blockchain [58].

10.1 Role of Big data in IoT System

Due to the immense growth of IoT, it is essential to store and analyze huge amounts of data. When IoT devices are fixed, big data analytics needs to be implemented as they produce a huge amount of data. This relationship allows big data to grow and become more sophisticated and useful. In the meantime, IoT is expanded with the help of big data technology and is utilized in different applications. Venkatachalam et al. [59] developed a monitoring system for patients using IoT devices in their body to monitor their blood pressure level, oxygen level, blood sugar level and ECG data. Initially, the Particle Swarm Optimization (PSO) algorithm is used to select the features, and then, Deep Belief Neural (DBN) network is used to identify the disease in 5G networks. Babar et al. [60] developed a data management system using big data analytics for a smart teledentistry system. The computation of medical data and resourceful cluster administration is done with the help of the Optimized RDD-enabled (resilient distribution) Yet Another Resource Negotiator (YARN) model. Mishra et al. [61] addressed the use of big data and IoMT in the healthcare system. This helps to enhance the accuracy of data interpretations and minimize the time to output the data. The use cases of big data and IoT in healthcare and telemedicine systems are given below:

Execution of EHRs The doctors get more information about patients and permit easier access to medical records due to the usage of HER. The chances of accurate diagnosis are achieved by these records, which means the EHR has the capability to share patient information among different medical institutions. Big data mechanisms can deliver EHRs across hospitals and clinics and increase patient experience.

Evidence-based medicine The ability to capture and store large amounts of patient data helps clinicians to have a broader base of cases and associated symptoms. Clinicians can compare their symptoms to the database and look for correlations whenever they treat a new patient. As a result, patients can be treated faster and more effectively, saving the hospital money and time.

Remote patient monitoring Healthcare for people from remote areas, as well as patients with disabilities, is offered by IoT big data applications. Instead of taking a trip to the hospital, they can use IoT devices that monitor their vital signs and transfer this data to their physician. The doctor can adjust the treatment plan whenever measurements exceed normal levels.

Inventory tracking Hospitals are mostly large organizations with many staff members, patients, and visitors. IoT sensors allow managers to monitor people and inventory movement across the premises and ensure enough medication.

11 Machine Learning and IoT in Smart Sensors and Devices

Many studies globally have used machine learning and IoT for many more implementations [62]. IoT and machine learning in the medical unit have seen a large interest in research studies. The H-IoT framework gives the treatment for remote and real-time data analysis of data using machine learning [63]. Machine learning is utilized to help the system to monitor patients at the time of critical health issues. Machine learning has a well-known health monitoring of heart-related patient issues using sensors and devices. ECG output is examined constantly in the heart patient, and then the machine learning algorithm performs the feature extraction after noise filtering. Different applications are made by using IoT techniques. Fall is identified and analyzed using machine learning techniques and cloud computing architecture in AAL [64]. Also, machine learning has an application for patient monitoring devices such as a model for sleep, EEG, EOG and EMG.

Machine learning can be a vast integrative method concentrated on gathering data, analysis in information, statistics and algebra, etc. Machine learning is an AI's basic methodology that selects data through data training [65]. The patient's diagnosis is in machine language, this language of the clinical note is converted into the human language using natural

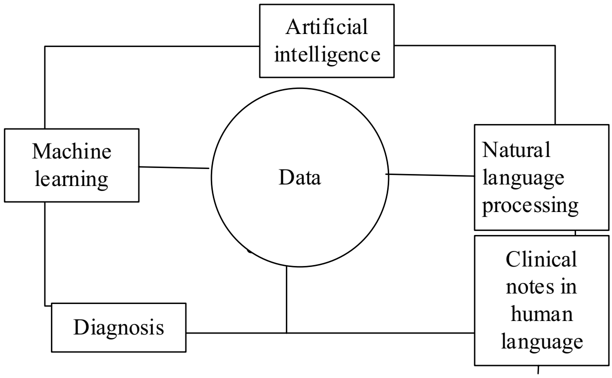


Fig. 9 Machine learning in IoT

language processing. Machine learning is also considered one of our updated techniques for conversion in the execution of methods that can study from the information of ML. Big data and cheap computational accessibility stimulate improvement in machine learning. Considering the increasing number of older people globally, there is an enlarging need to give methods to promote the elderly in their lives. It may be said that the Internet of Things will provide some customized, preventive, and cooperative types of consultants with a new method of differential healthcare [66]. This invention gives live IoT output for elderly people to check and store health information and promote an emergency alert system [67].

Figure 9 shows machine learning and IoT in the smart healthcare system. This includes centralized data collected with the number of sensors [68] placed in the patient's body. After checking the values with normal values using machine learning, a warning message was issued if the data changed [69].

11.1 Role of Machine Learning in IoT

Generally, performance aspects are related to performance improvement as the fundamental working challenges are directly related to the functional behavior of IoT systems. Describes the role of machine learning methods in such performance-related aspects.

11.1.1 Congestion Control

The performance of IoT applications is negatively affected by this congestion which causes packet losses, wastes the node energy, degrades the IoT application's fidelity and increases delays. The congestion control in IoT is enabled to enhance the network throughput and minimize the data transmission delay. Upreti et al. [70] developed a congestion control routing protocol based on the machine learning algorithm that helps to transfer emergency data packets using IoT sensor nodes with high efficiency and throughput.

11.1.2 Fault Detection

Faults occur due to the change in the IoT system's characteristics or parameters, destroying their basic operation or value. Likewise, the physical damages, including environmental interference, communication interference and low battery, can create faults in sensor nodes.

Due to the fault, the incorrect sensing of a state or event in the given space is mentioned as an error. Faults can be classified into a gain fault, stuck-at-fault, offset fault, and out-of-bounds fault. Uppal et al. [71] developed a different machine learning model to predict the faults in real-time sensor data monitoring in the hospital environment. The result analysis shows that the machine learning modes applied over IoT-based sensors are proficient in monitoring the automation process of the hospital process.

11.1.3 Resource Management

Robust resource management techniques are needed to minimize energy consumption and response time to satisfy the enormous resource demands of the various IoT applications. Li et al. [72] developed a deep learning model to monitor the physical activity of students through IoT technology. The deep learning model is mainly developed to perform the resource management issue in which it permits the students to arrange and increase their physical activity in a good manner.

11.1.4 Security

IoT systems are resource limited, and it is important to secure the system against security attacks which is considered an immense challenge. Different kinds of techniques are developed to safeguard the system, but it is still affected by such security issues. So, there is a demand to develop machine learning models to preserve the systems from security attacks. Gadekallu et al. [73] developed a machine learning and blockchain based technique to detect attacks on IoT enabled healthcare applications. The developed model utilizes the private cloud to overcome the attacks.

12 Physiological Health Data Analysis

Smart healthcare systems are based on the IoT, which focuses on the information that the patient receives at the time of monitoring. A wireless sensor network (WSN) is used to verify locomotion and heart data checking. The edge layer creates a number of patients or healthcare specialists to gain smartphone health notifications. Also measured small instant changes of sensor values [74], which helps to identify the small change in the patient and monitor efficiently. The monitoring of home patients is done by using ECG sensor data. The studies emit the Blue mix methodology based on the cloud to gather, keep and store data collected. A technique in IBM Watson used for a feasible health specialist analysis and check systematic conclusions utilizing health data [75]. The researchers suggested an integrated method for fever diagnosis that detects the patient's real time temperature. An ECG telemetry method is suggested for the IoT, where health evaluation is done through digital phones by examining various physical activities and decorating their functionality [76]. The physiological data is getting through the field sensors and can be used in differential model pursuit recognition. Medicine also measures people's characteristics to analyze the patient's current situation. The technology grew with the output of the calculations, innovation and findings into techniques. Moreover, a large part of the dataset is converted from analog to digital [77].

Table 6 Healthcare applications in smartphone

Applications used for healthcare	Description
Calorie counter	The smartphone app is used to analyze the food presented in the body. Also, calculate the amount of fat, cholesterol and the body's total weight
Heart rate monitor	The application is used to find the heart rate in the consumer's body, gather the data for analysis and record it
Blood pressure monitor	An application for gathering blood pressure that is presented in the patient's body. The collected data is analyzed and recorded
Temperature monitor	The app gives the current temperature of the body by analyzing the temperature of the body. Also, the system provides an alert when the body temperature has increased the threshold
Pedometer	The application gives data on how many steps are walked by that person with the rate of burned calories
Water your body	An application that is used to remind people to drink water at every period of time
On track diabetes	The application analyzes the amount of glucose in our blood and provides corresponding precautions
Skin vision	The application is used to find the presents of skin disease in the person. Early detection of skin disease is possible
Eye care plus	Application for checking the vision of the eye by analyzing and testing
Asthma trackers and log	The application is used to find asthma patients in real time
Cardio mobile	The application is used for analyzing the cardiac activity of people who are under health monitor. The sensors gather the information
Fall detector	The application is utilized for analyzing the monitoring patient activity. The application will give a notification alert at the time of any issues
pill reminder	The application is used to remind the patient at the time of consuming the pills

13 Healthcare Using Smartphones

Mobile devices are provided with applications to monitor health issues and give precautions to the patient [78]. Some applications exist in the case of health monitoring, such as records, time and date, doctors and corresponding communications and patient details, etc. By using the applications invented in smartphones, the patient's health monitoring can be increased with less time and cost [79]. The healthcare applications of smartphones and its description are listed below in Table 6.

14 Application

The IoT healthcare monitoring device is used for different IoT-based applications [80]. In simple words, designs are a lot of contriver-concentric, but devices are user-concentric. Instant growth in IoT technology devices is a guide for improving large portable, and hand free sensing devices, portable devices, and healthcare systems. The devices are utilized to gather patients' data, check people's physical condition, and create alerts at a critical condition stage [81]. Some of the more updated, directly accessible systems are studied. Then, different IoT-related implementations are cited by adding all the states. The application of sensors and devices used by IoT analyzes the ECG, BP, body temperature, glucose level monitoring, Oxygen saturation, Asthma checking, mood monitoring, modification management, wheelchair management, rehabilitation and other notable applications are included in the IoT healthcare [82].

Blood pressure monitoring system: Most important parameter in the physiological analysis of the healthcare data in the human body. Several blood pressure monitoring systems are available in the market as simple and safe [83]. These systems are integrated with the IoT platforms to gather blood pressure information from the patient. Also, these devices provide good communication with doctors [84].

Rehabilitation mechanism The system can gather the functions, increase the efficiency of the monitoring devices, and improve the patient's quality of life under a healthcare monitor. The problem is that the increasing population causes the minimization of healthcare devices. For efficient treatment of the patient, rehabilitation based on the community is provided [85]. Also, an IoT based automated smart healthcare system is done for the ontology [86].

Monitoring oxygen saturation The device is used to analyze the oxygen saturation in the blood. Technology is getting more advanced in the healthcare industry. Using the wireless sensor network reduces the system's conception of power and loss [87]. An oximeter is used in different applications to check the oxygen saturation of the blood in the patient. Monitor the oxygen saturation and check the patient's heart rate [88]. These are done by using the smart sensors placed in the patient's body to collect health information to minimize the patient's activity [89].

Wheelchair management A wheelchair is a healthcare device used to provide locomotion for a patient who is disabled [90]. Wireless sensors are integrated into the wheelchair to continuously monitor the patient. The device concentrates the human body activities in the wheelchair. If the person falls from the wheelchair, there will be a pressure cushion. Also, some wheelchair is designed with accelerator sensors to detect the patient's falling from the wheelchair. These systems also reduce the monitoring time, so the doctor can monitor and analyze the patient's healthcare information from the health centre.

15 Challenges, Limitations and Future Scope

In previous years, the IoT health monitoring system observed exceptional methodological improvement and techniques to find appropriate ways to cure health problems. Techniques have been updated and are important in hospital services. With the technical improvement of smart sensors and devices, the technologies such as cloud computing and technologies in communication efficiently formed the health monitoring industries. Moreover, the IoT device technique has some demerits and issues that pulse future studies and research. The part of challenges and issues are attached below.

15.1 Security and Privacy Issues

The health care sensors and devices collect private health information, and these systems are attached to the Internet every time to access anywhere. Because of that, the hacker attracts these private data sets. The private health data is utilized after patient permission. The official contravention reports from 2009 to mid-April 2013 show 51% of privacy risks. Data security in the documents challenges is corporeal protection for health devices, giving protected routing for communication of data, supplying data transparency and giving the greatest protection with the lowest resource utilization. A patient's information is collected from different health monitoring devices by using IoT technologies. To collect the data from the patient, several sellers should provide sensing devices for the rules. So the information collected by this device is not visible to another device. Because of that, interoperability issues are taking place. Due to the lack of interoperability, information from different IoT devices in each individual system can remain secure, reducing its potential value and increasing system integration costs. In the device designing section of the IoT systems in health monitoring, small sensors have fewer calculation power processors, less storing capacity, and bounded battery power. Big data is also required to preserve cloud storage for the next generation for better treatment. It is impossible to form knowledge and insights using these data. The information formed and transmitted by healthcare sensors and devices are faced many security problems like hacking, data mining etc. The data looks original but should not be correct at the time the data was transmitted. Hackers may utilize this information to hurt a person on the basis of the data set formed by using the sensor. So this corrupted data can lead to death. The trust present in the healthcare system is the central challenge of smart healthcare systems on the basis of IoT.

15.2 Environmental Impact

The device with an IoT module needs addition in different sensing devices with systems full of semiconductor materials. The formation and design need a large amount of metal and other toxic chemicals in the earth. This may generate unfavourable side effects in nature. So, a real healthy person should be generated to optimize and control sensing device production. The devices are mobile and connected to the Internet to provide patient health data. As in the case of sensors, IoT medical devices are introduced into the market. The number of healthcare devices will be attached to the framework that will manufacture many sensors and devices. The stored devices increase exponentially, and due to this gradual increase of these used and non-used devices and sensors is a problem in healthcare. Most IoT devices work in the battery, so replacing the battery at the time of putting a sensor on it also works with high power conception.

15.3 Advantages of Sensors and Devices in IoT Healthcare

Many advantages are presented in the healthcare devices used by several smart sensors. Any disease can be monitored and analyzed using these devices in less time. The patients are given continuous monitoring from the healthcare centres. Increase the level of disease management in real time, easily detect disease with minimum error, and reduce the number of doctor visits and the patient cost. The monitoring system can continuously analyze the real-time data with proper measurements of data. The measured values of healthcare devices give maximum efficient data from the patient. Healthcare devices can reduce the time for a consultant. It can also provide efficient treatment outcomes.

15.4 Disadvantages of Sensors and Devices in IoT Healthcare

IoT platforms produce some complexity in the data processing and analysis stage. It has no proper security and privacy, i.e., the information of the doctor and patients are encrypted.

There is no security in the software because anyone can hack it at any time to misuse the data. The cost of the sensors and devices is greater at the time of the initial installation of the devices.

To conclude this section, blockchain provides a secure, transparent, and resilient health data-sharing platform in a trustable environment. It resolves the privacy problem of users by enabling access control mechanisms through smart contracts. It also prioritizes critical data. Some major challenges observed in existing implementation include replaceability of private key, scalability, data redundancy, data volume, resource and power consumption, latency, usage complexity, and expensive mining cost. Future research and implementations should address these challenges to build reliable, efficient, and robust blockchain based H-IoT systems.

16 Conclusion

IoT plays an important role in sensor-based healthcare systems. IoT sensors and devices provide more intelligent work than the human brain work. IoTs have a number of devices for communication, identification, and network functions. IoT enabled healthcare systems with devices and sensors have become an innovative development in the health monitoring system. This survey discussed the sensors and devices used in IoT based smart healthcare systems. It also reviewed technologies for IoT healthcare system sensors that deal with edge computing in IoT to minimize errors and maximize operational efficiency. The integration of big data into IoT healthcare systems will generate valuable insights by organizing the information from the sensors placed in the patient's body into the dataset and optimizing the process. There are still some challenges that can be done in the IoT healthcare system. This research field gives inspiration and a brief discussion about the technologies in sensors and devices used in IoT based smart healthcare monitoring systems. As future researchers, they are studying various backgrounds promoting new technology in healthcare by addressing basic issues with respect to the social effects and ethical issues. From this study, it is also suggested that the upcoming research must focus on considering QoS requirements and practical difficulties while integrating several technologies. Also, the future health monitoring system should report the privacy and security concerns of the users. Likewise, the propelling of healthcare technology must be enhanced by considering more technological characteristics that will improve the feasibility evaluation and narrow the gap between ideas and executions.

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