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INTEGRATION OF AI, ML, AND IOT IN HEALTHCARE DATA FUSION: INTEGRATING DATA FROM VARIOUS SOURCES, INCLUDING IOT DEVICES AND ELECTRONIC HEALTH RECORDS, PROVIDES A MORE COMPREHENSIVE VIEW OF PATIENT HEALTH

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ABSTRACT
An abundance of new avenues for information sharing have opened up thanks to the IoMT, or Internet of Medical Things. Empowering patients, fostering healthcare collaboration, educating and training medical professionals, utilizing data for innovation, creating personalized treatment plans, managing supply chains, promoting public health, utilizing wearable health devices, and implementing quality improvement initiatives are all possibilities. Concerns about infrastructure costs, data privacy and security, regulations, and interoperability are only a few of the obstacles to the widespread use of IoMT. The purpose of this research is to fill a gap in the literature by discussing the possible solutions to the security issues related to data fusion in IoMT and its ramifications. Prediction accuracy is directly affected by the quantity, quality, and relevance of data acquired from IoMT devices. The most effective algorithm for identifying epileptic seizures in IoMT networks is the Epilepsy seizure detector-based Naive Bayes (ESDNB) algorithm, which achieves an accuracy ranging from 99.53% to 99.99%. On the other hand, data storage needs a complete overhaul, with enhancements needed at every stage (collection, protection, and storage). Possible improvements in the detection of security threats and compromises could result from standardizing architecture and security measures.

1. INTRODUCTION

A healthcare service that utilizes a variety of technology and services to offer patients integrated and coordinated treatment is known as the Comprehensive treatment Service System. Some of the features included in this system are electronic health records, telemedicine, medication management, remote patient monitoring, and caregiver support. To further optimize resource allocation, boost patient safety, and improve clinical decision making, the system also employs big data and artificial intelligence. Numerous benefits are associated with the Comprehensive Care Service System [1]. Thanks to the system's ability to track patients' vitals in real time, medical issues can be identified sooner and treated more effectively. Care coordination and diagnosis are both enhanced by the increased communication and collaboration made possible by digital technology like electronic health records. Reduced use of the emergency department, fewer hospital readmissions, and fewer needless tests and treatments all contribute to lower healthcare costs, which the system helps to alleviate. By receiving treatment in the familiar surroundings of their own homes, patients are able to maintain more autonomy and have higher quality of life. Caregivers also receive assistance from the system, which can lessen their workload and lead to better patient results [2].

The term "healthcare system" is used to describe an organization's approach to patient care that makes use of modern technology and data management in order to give better, more all-encompassing treatment. Among its possible components are health monitoring devices, electronic medical record systems, remote monitoring services, virtual medical consultations, and so on. By utilizing these technologies, healthcare providers can gain a deeper understanding of patients' health conditions and develop treatment plans and interventions that are more tailored to their specific needs. A healthcare system can aid the elderly in better managing and monitoring their health state, which is an important aspect of care for the old [3]. Wearable electronic health trackers allow the elderly to keep tabs on vitals including heart rate, blood pressure, and more. In healthcare facilities, this data can be wirelessly transferred to EMR systems, where doctors and other medical staff can see them in real time and give patients the care they need. Furthermore, aged care services must also include remote monitoring. Video chats, text messages, and emails are just a few ways that seniors can stay in touch with their healthcare providers using remote monitoring services. This can aid the elderly in comprehending their conditions and treatment regimens, as well as in obtaining prompt assistance when required [4].

To sum up, healthcare services can improve and become more convenient for the elderly through a healthcare system. Improving the health and quality of life of seniors is possible with the help of these technology and tools, which allow them to better control and monitor their health status and allow healthcare professionals to offer timely treatment and assistance.

Personalized health care models that can prevent, manage, or monitor diseases, improve patients' health status, reduce home care expenses, promote health and chronic disease control, and set up a comprehensive and safe innovative application service system are the main goals of this study. Additionally, we aim to develop a precision medicine-based health and safety care system. An elderly person's health status can be quickly assessed with a multipurpose physiological monitoring equipment [5]. The old person's wearable device can also serve as an electronic fence, keep them from wandering off, set up emergency features, and offer protection from harm. It integrates applications with smart devices to offer complete health and safety care services for the aged, primarily based on action safety and health and safety principles.

Despite the widespread use of IT in the last several years, many nursing homes still aren't making the most of it. Problems such as inadequate IT infrastructure, inadequate personnel training, and a lack of standardization remain. Another factor that can reduce the usefulness of new technology is the fact that many elderly people may be reluctant to use it. Consequently, long-term care facilities continue to depend significantly on conventional care practices, which can be expensive and time-consuming. More work is required to resolve these issues and encourage broad adoption of IT in long-term care if its benefits are to be fully realized [6].

One cutting-edge and adaptable application service system for managing and monitoring one's health is the wearable Internet of Things (IoT) care system. Through the use of Internet of Things (IoT) technology, the system enables a multitude of functions and applications by facilitating the connection and communication of numerous sensors and devices [7].

- **Wearable Device**

Personal physiological indications like heart rate, blood pressure, and body temperature can be tracked by the wearable IoT care system. In addition to keeping track of food preferences and prescription details, the system may track users' level of physical activity. To better comprehend the patient's health status, caregivers can wirelessly transfer all of this data to a central monitoring station. Wearable internet of things (IoT) care systems also allow for real-time communication and location features, which are useful for both patients and their caregivers. The system is designed to accommodate various needs and scenarios by supporting several communication channels, including voice, text, and video. Simultaneously, the system can use positioning technology like GPS to better attend to and manage individual needs. A novel, secure, and adaptable application service system, the wearable IoT care system is on the rise. It offers real-time communication and location functions to enable caregivers better manage and care for individuals, while also helping caregivers monitor and manage own health. Data and personal information are safe within the system because it is dependable and secure.

A wide variety of wearable gadgets for fitness and health monitoring have recently been developed, made possible by recent advances in downsizing of sensors and low-power electronics. In order to aid in the diagnosis, prognosis, and tracking of fitness, wearable biosensors that can continuously monitor biochemical indicators in the human body are the subject of intense research and commercial endeavors across the globe, especially in North America [8].

2. LITERATURE REVIEW

Wearable electrochemical biosensors were reviewed by Min et al. [17]. The present state and future prospects of wearable electrochemical sensors for glucose and dehydration monitoring in fitness applications were covered in the review. Wearable electrochemical sensors have great promise for remote and individualized healthcare, however the authors gloss over new developments and the way care service management systems will evolve.

The most recent advancements in skin-interfaced wearable sensors were reviewed by Gao et al. [18]. They classified and evaluated physical and biochemical sensors, and they talked about how to choose materials and develop procedures for sensors that can come into touch with human skin. Power concerns, wireless connectivity, and data analysis were also covered extensively in the article. In their analysis of wearable technology, the writers uncovered both potential problems and solutions. Unfortunately, there was not a comprehensive plan for creating a system to manage care services in the article.

Figure 1Managing intelligent long-term care services through an integrated platform.

Using the wearable devices that the elderly use, the wearable IoT care system is tasked with monitoring their daily status. This includes basic physiological data such as blood pressure, pulse, temperature, and emotional response monitoring. Additionally, the wearable devices assess heart function and monitor atherosclerosis and other chronic diseases.

Smart services can't make use of IoMT until they can detect and gather information about their physical surroundings and the objects in them. When attempting to increase the depth of the data fusion output and to increase the range of information obtained, it is sometimes necessary to employ many sensors, as a single sensing modality is typically inadequate [11]. Due to the variety of the various sources and the volume of sensory data, it would be inefficient to distribute all of the data in terms of network bandwidth and device power. Data fusion is a vital tool for mining massive amounts of sensed or collected data for actionable insights that can improve data quality and decision-making. The field of data fusion investigates effective ways to merge disparate data sets acquired at different points in time and from diverse places into a single, coherent whole that can inform decision-making by people and computers alike. Information extraction, data size and dimension reduction, and data quantity optimization are only a few of the many specialized uses for data fusion [11]. It aids in the elimination of data abnormalities and prevents the detection of data collusion from several sensors. Because neither the collecting terminal nor the processing center can be trusted, the heterogeneous data produced by the data fusion process contains extensive sensitive patient information, putting it at danger [12].

Both proactive and passive attacks might lead to the exposure of confidential information. Cybercriminals target IoMT devices more frequently than any other industry because of the carelessness with which they are deployed into networks. Somewhere around half of all IoMT devices are vulnerable to cyberattacks. In order to better detect assaults while simultaneously preserving users' privacy on various levels, Al-Hawawreh& Hossain [13] suggested a novel privacy-aware architecture.

Rapid innovation is required for IoMT goods to keep up with the market's inherent vendor competitiveness. Security, privacy, and authentication issues arise because of the proliferation of non-standard devices that use different communication protocols and use different data transmission standards [14-25]. Attackers frequently use the vulnerabilities in the IoMT infrastructure as a springboard for other types of assaults. The security of the Internet of Things (IoT) is of paramount importance, hence most prior review studies have concentrated on this topic, looking for ways to make IoT products safer. Nevertheless, there has been very little investigation into the potential effects of data fusion in the IoMT field.[26-30]

3. METHODOLOGY

3.1 IoMT architecture

The Internet of Medical Things (IoMT) offers a safe and effective environment for the gathering, processing, and analysis of medical data in order to generate valuable insights and methods for making decisions. In Fig. 2 we can see the four main layers that make up the IoMT architecture: the sensor, the edge (gateway/fog), the cloud, and the interface (visualization/action). A patient's vitals can be tracked in real-time with the help of wearable sensors. Patients' vitals are monitored in real-time by the sensor layer, which uses wearable sensors linked to a system—like a Raspberry Pi—to gather data remotely. Fuzzification and edge decision-making are done by the gateway layer to create real-time alerts on a patient's high-risk medical conditions. When it comes to healthcare data monitoring, the cloud layer is in charge of both computing and storing the acquired data so that authorized staff may access it securely. An approval-based mechanism is used to implement data access security at the action layer. In addition, the action layer is the first point of contact between humans and the natural world. Local servers and gateway devices make up the gateway layer, which acts as an intermediary between the cloud and the action layer. One solution to the problem with conventional health monitoring is the rise of Internet of Medical Things (IoMT) based individual health monitoring systems. These systems enable wearable sensors to track vital signs and establish online connections with loved ones and doctors.

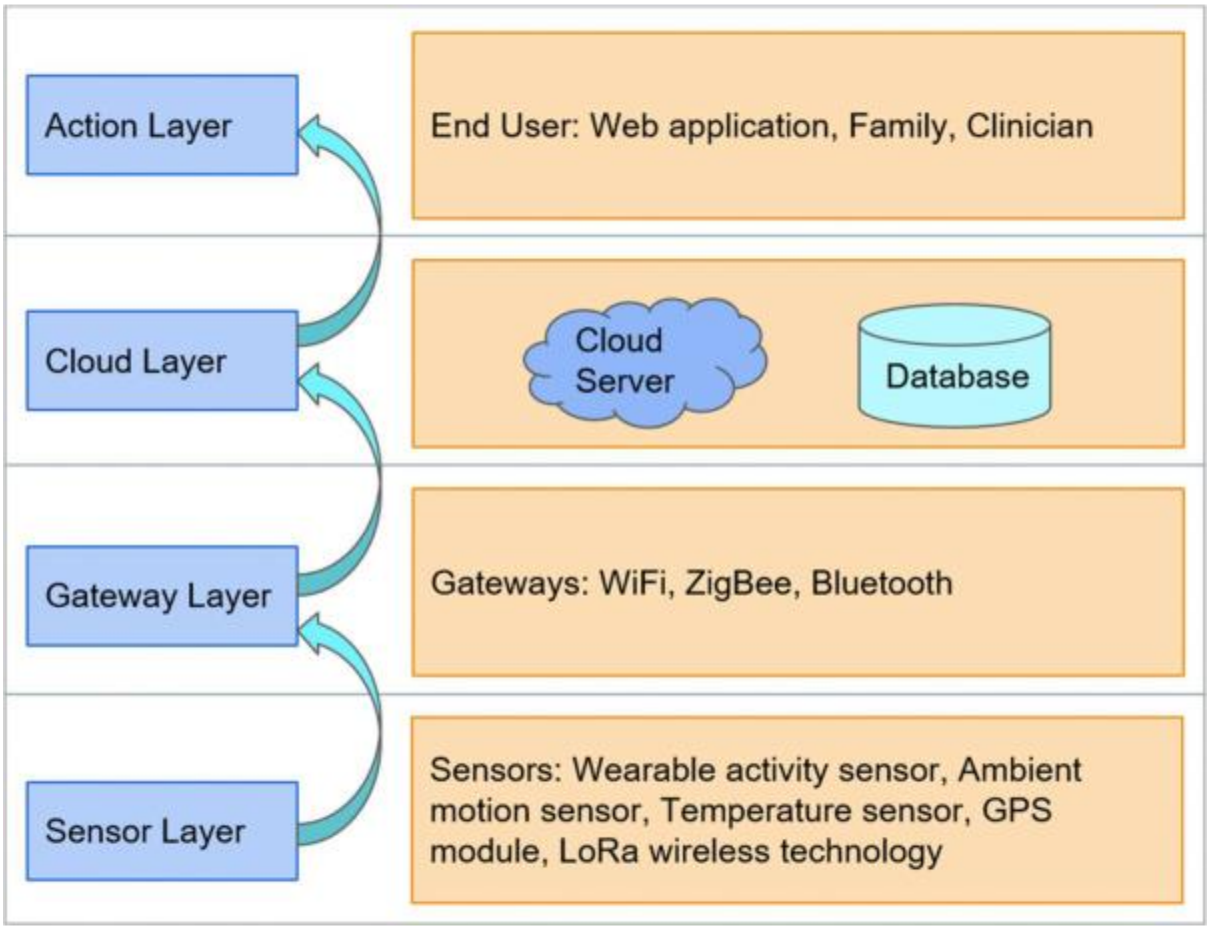

Fig. 2. IoMT architecture.

3.2. Sensor layer

In order to process patient data, the IoMT system's sensor layer gathers information from a number of sensors and sends it to the gateway or cloud. Hardware components such as sensors, controllers, and actuators make up this layer, which enables precise detection of health-related factors. There are two sublayers within the sensor layer: data entry and data processing. Data comprehension is the primary function of the data process sublayer, which uses a number of medical perception and signal gathering devices to achieve this goal. You can acquire signals using graphical coding, general packet radio service (GPRS), or radio frequency identification (RFID). The data entrance sublayer then uses short-range data transmission protocols, such as Bluetooth, Wi-Fi, 4 G, and 5 G, to send the acquired data to the next state.

3.3. Gateway layer

Several steps, jobs pertaining to the interface, and methods for data transfer are provided by this layer, which is sometimes called the fog layer or the edge layer and follows the sensor layer. In addition to the transmission and service sublayers, this layer also includes local servers and gateway devices. The sensor layer communicates with the transmission sublayer in real time. Networks, data warehouses, and formats for data description can all be integrated using the service layer. Instead of processing data in the cloud, edge computing moves it to the gateway layer. To summarize the many advantages of edge computing, which are listed:

- With the data processed and ready to go, devices can transfer them to the cloud, reducing the load on the cloud layer.
- The proximity of the gateway server to the IoT devices greatly reduces latency.
- Proper security and privacy measures are put in place.

3.4. Cloud layer

In order to analyze the data and create decision-making apps based on the assessments, the cloud layer has the processing and data storage capabilities needed. The data produced by the medical devices will be stored by the cloud resources of this layer, which will enable additional analytical processing as needed. Medical statistics, epidemiology, data warehousing, and machine learning are all performed by this layer. It completes the feedback and visualization process with a graphical user interface. Service providers and caregivers can access medical histories, patterns of sickness, epidemics, and remote healthcare monitoring through this cloud architecture . Cloud services including Google Cloud, IBM Cloud, Microsoft Azure, Amazon Web Services, and IBM Cloud offer a variety of services to Internet of Medical Things (IoMT) systems, including discussions, data processing, storage, and analysis.

3.5. Action layer

Apps, environmental sensors, remote diagnosis, and a number of non-wearable healthcare equipment are just a few of the applications that the action/application/visualization layer of IoMT uses to manage medical data. Managing medical information and making decisions are the responsibilities of the medical decision-making and medical information sublayers, respectively, that make up the action layer. The medical information layer encompasses a wide range of resources for the upkeep of patient data, such as tracking systems, telemedicine, medical electronic records, remote diagnostic systems, etc. Medical diagnosis and treatment-related resources are also part of this layer. This medical data decision-making action layer is all about exploring different types of information, such patients, diseases, medications, diagnostics, and treatments.

Figure 3 The wearable IoT care system.

The care data management system keeps track of the elderly's physiological data in order to create an electronic contact book for them, and the integrated intelligent long-term care service management system uses AI technology to evaluate and track their mental and physical health. Health promotion and chronic disease management can be accomplished by the system with the help of expert doctors. In order to keep tabs on the emotional and physical well-being of the elderly, a comprehensive intelligent system for managing long-term care services is in place. In the event of a possible health danger, the system may detect it automatically and offer advice accordingly. The system can save the physiological and care data of the elderly, allowing medical staff and family members to easily see and manage their care effectively. Together with medical experts, patients can control chronic diseases and improve their overall health with the help of an intelligent long-term care service management system. By analyzing the patient's condition and care data, doctors can create individualized plans for managing their health and offer remote diagnosis and therapy. Additionally, the technology allows for real-time communication, which facilitates the older person and their family members' ability to reach out to medical personnel in order to address issues swiftly.

As shown in Figure 3, the following methods are adopted.

1. In addition to utilizing facial recognition technology, the system also makes use of RFID cards for check-in.
2. Data input device worn by the user: The results of the measurements are entered into the computer system through a wearable device. After that, the data is double-checked, mixed with personal details, and utilized for the check-in process.
3. Personalization based on user tastes: Each wearable device is designed to cater to the unique tastes of its owner. To accommodate individual tastes and prevent the elderly from feeling constrained or watched, alternatives like pendants, belts, bracelets, or badges are offered.
4. Radio frequency identification (RFID) system for location and tracking: This technology is used to accurately locate and track elderly people both indoors and outside. The device verifies their precise whereabouts by means of area recognition and tracking algorithms. When an individual stays motionless for more than 10 minutes, the system notifies caregivers to do any required checks or care based on their location.
5. Sending the acquired data, which may include the whereabouts of old people, to the backend server allows for computation of the data. To improve the standard of care for the elderly, we use AI, big data analysis, and deep learning methods to make use of this data as a baseline.

The provision of comprehensive care services is the primary goal of these techniques. It is our hope that the elderly will feel secure, cared for, and respected when interacting with digital technologies.

4. RESULTS

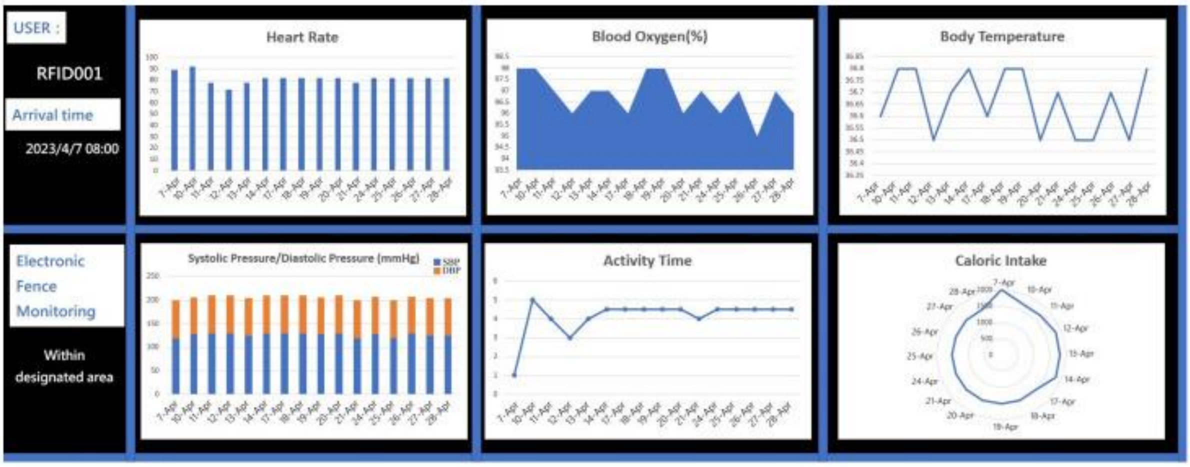

Figure 4 Data dashboard.

A data dashboard is used to record and evaluate data from all IoT devices, as demonstrated in Figure 4. A bird's-eye perspective of all the data collected, the dashboard makes it easy to analyze and draw conclusions.

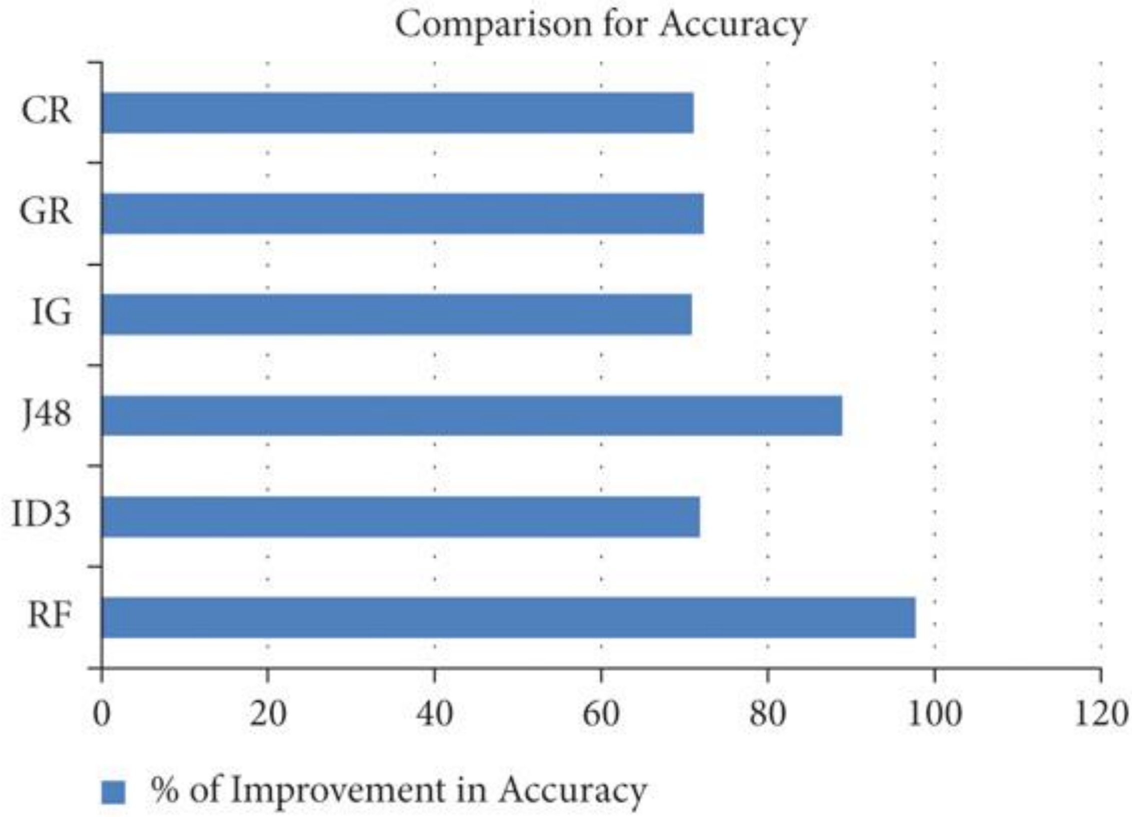

Figure 5 Comparison for accuracy.

There are six decision tree classification models that were compared in terms of the percentage of accuracy. These models are J48, ID3, RF, CR, IG, and GR.

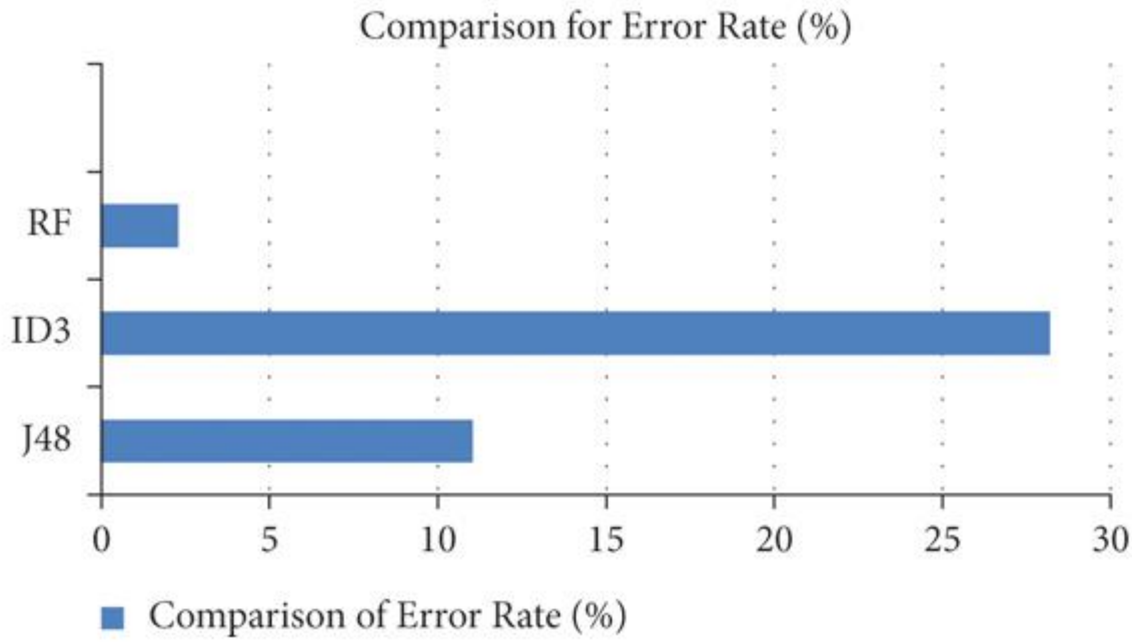

Figure 6 Comparison of error rates.

Using three different machine learning decision tree classification algorithms—J48, ID3, and RF—the error rates are compared in Figure 6.

CONCLUSION

This study introduces readers to the IoMT, or Internet of Medical Things, and focuses on the several enabling strategies employed by SHS. In this article, we covered a variety of approaches utilized in smart healthcare systems, including RFID, blockchain, AI, etc. Several authors are using different Internet of Medical Things (IoMT) architectures for smart healthcare systems that are based on artificial intelligence (AI), and this paper describes and compares them all. Only with precise and reliable data can a smart healthcare system function. In order to ensure that the medical data collected is accurate, we have compiled a comparison of various smart healthcare data collection approaches. Every day, more and more platforms for exchanging information across many industries find uses for IoT and IoMT. With the advent of IoMT, more and more data is becoming accessible from a wide variety of sources, such as clinical systems, wearables, EHRs, and medical devices. A more complete view of a patient's health status can be achieved by data fusion, which entails combining these disparate data sources.

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