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Review of Intelligent Healthcare for the Internet of Things: Challenges, Techniques and Future Directions

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Abstract

Connected devices, sensors, and other technologies can be used to enhance healthcare delivery and administration, and this is what is meant by "intelligent healthcare" for the IoT. Medical care, illness prevention, and overall health management could all be dramatically altered by this discovery. The Internet of Things (IoT), Big Data, AI, and ML have all come a long way, and their expanding use in our daily lives makes it evident that technology will play a crucial role in the future of healthcare. These technological advancements, after overcoming technical hurdles like dealing with huge volumes of data, present a variety of ethical and security problems that must be addressed for the successful integration of technology in healthcare. Ethical concerns around the use of AI and ML technologies, as well as issues of getting people used to working alongside machines. These obstacles need to be dealt with and conquered if smart healthcare is ever going to reach its full potential and enhance people's lives through the integration of technology and healthcare. The complexity of IoT-enabled smart healthcare in the present day is the subject of this research.

Keywords: IH-IoT, Internet of Things, Intelligent Healthcare, IH-IoT Techniques, IH-IoT Review, IH-IoT Future Direction.

1. Introduction

We have entered a new era of life characterized by the growing number of connected devices, ranging from smartphones to smart wearables to even smart refrigerators. The umbrella term for these devices is the Internet of Things (IoT). It has enabled us to collect data from a variety of sensors connected to any type of microcontroller and then store that data using Big Data technology. This information can then be analyzed using Big Data Analytics and AI algorithms to help physicians and nurses provide smarter and more efficient healthcare. Although there is no official definition of intelligent healthcare, it can be said that it essentially refers to the use of IoT devices to communicate and deliver healthcare more smartly and efficiently [1]. The IoT brings a whole new toolbox to the table, which includes general monitoring of patients with wearable sensors and other devices. This allows healthcare providers to track a patient's vital signs, medication adherence and other health data even in rural areas.

Intelligent healthcare also allows for early detection of potential health problems so providers can intervene before issues worsen. Remote monitoring can also improve patient satisfaction and reduce hospitalizations, saving money for both patients and healthcare providers.

Using ML and AI to analyze and interpret patient and device data is another aspect of intelligent healthcare. This can help providers make more informed decisions about treatment plans and even aid in the early detection of disease. In epidemics like COVID-19, analyzing data from devices and sensors can help track the spread of infections and take action to contain outbreaks.

Telemedicine, the use of telecommunication technologies to deliver medical care remotely, has become increasingly common in recent years. This allows patients to consult healthcare providers without having to visit a clinic or hospital. Wearable devices and sensors can also help patients manage chronic conditions such as diabetes and hypertension by providing real-time feedback and helping them improve their health.

There are many more promising applications in Intelligent healthcare, and it is foreseeable that the potential is almost endless. It can reduce healthcare costs, improve the overall efficiency and effectiveness of healthcare systems, help reduce the need for hospital visits, improve patient satisfaction and even identify inefficiencies and bottlenecks in the healthcare system and suggest areas for improvement. However, with these technological gains come challenges such as security and privacy, and even fundamental ethical considerations. The rest of this paper is structured as follows. Section 2. introduces basics about intelligent healthcare and IoT. Section 3. presents the concepts of IH-IoT. Section 4. reviews several studies based on IH-IoT. Section 5. provides challenges and future direction of IH-IoT. Finally, Section 6. concludes this paper.

2. Intelligent Healthcare and Internet of Things

2.1 Basics about Intelligent Healthcare

Healthcare is a basic need of human existence and combines the natural instinct to be as healthy as possible with combating chronic disease, managing the aging population, and enabling an overall healthier and thus more productive lifestyle [2]. Healthcare also represents a huge industry in economic terms on a global scale. The annual growth rate for smart healthcare devices is estimated to be 16.2% between 2020 and 2027 [3]. There is no society on this planet that does not have some basic form of basic healthcare system. Traditionally, monitoring, care, treatment, and constant supervision were performed manually by doctors and nurses. Decisions were based on their personal experiential knowledge [4]. With the information technology revolution, machine support came into play, and since then, medical devices such as ultrasound machines, X-ray machines, anesthesia machines, sterilizers or spectrophotometers, and many others have played an important role in supporting healthcare [5]. Recent technological advances have included the improvement of this medical equipment. They helped us analyze certain diseases and patient conditions more accurately to assist medical staff in their daily decisions. However, medical errors still claim patient lives because records are absent, diagnoses are missed or made too late, or data in general are falsified [1, 6]. Intelligent healthcare consists of additional technological advances that leverage IoT, wearable appliances, wireless communications, cloud computing, and Big Data management to obtain and store better data so that healthcare is increasingly efficient, medical errors are reduced and the overall quality of healthcare delivery will be improved [2]. Current technologies such as telemedicine, digital hospital, and eHealth will provide the foundation for advances in smart healthcare, enabling remote diagnosis and self-diagnosis, potentially reducing patient hospitalizations and increasing general efficiency [7–9].

Health networks also offer great opportunities through the potential networking and collaboration of international medical data on a global scale [2, 10]. This could provide access to vast data sets of medical records to predict the health status of patients. Intelligent healthcare is the art of capturing these data sets improving healthcare solutions in the following ways [8, 11, 12].

• **Disease Prevention and Identification:** This is enabled by the use of various health monitoring sensors in comparison with cloud computing databases to detect with higher probability certain diseases in the patient's body (e.g., dengue virus [13]) Moreover, constant monitoring of health status through pattern recognition can potentially predict certain diseases and prevent them in advance [2, 13, 14].

• **Patient Decision-Making Process:** Once a disease has been identified, not only physician experience but also data statistics can help make better decisions with neural network diagnosis and machine learning algorithms to push for a positive outcome with a higher probability, with e.g. the use of proper medication [1, 15].

• **Monitoring and Alerting of Infected Patients:** Through combination with social network analysis, global tracking systems for infectious outbreaks can be created. The use and need could be clearly seen during the Covid-19 pandemic [13, 13].

• **Medical Research Advancements:** With the help of Big Data storage and the connectivity of global health networks, more targeted data about specific diseases can be found, which can help various medical research areas better understand conditions and improve treatments overall [10].

To accomplish those goals, technological advances in these specific areas are the mainstays of intelligent healthcare, facilitating the latest rapidly growing progress.

• **Advanced Sensor Data Extraction and Management:** These include a variety of sensors and more advanced and specific sensors integrated into clothing or the environment that collect real-time health related information about the individual [4]. These may include invasive and non-invasive sensing methods on the human body [14]. Fog computing (or edge computing) enables pre-processing of data on the end device itself for automated analysis before sending it to Big Data storage systems [13, 16].

• **Big Data and Cloud Computing Storage Solutions:** Big Data refers to the large amounts of data generated by healthcare organizations and other sources. This data can include electronic medical records, performance data, genomic data and more. Cloud computing refers to the use of remote servers and software to store, process and analyze large amounts of data. In this way, healthcare organizations can access and use large amounts of computing power and storage, even remotely, enabling the infrastructure to handle this volume of data [17].

• **AI Supported Information Extraction:** AI is used to extract relevant information from vast amounts of Big data storage systems. An AI system is trained to classify patient demographic data, diagnoses and treatment plans, clinical reports and notes, medical images such as X-rays, CT scans and MRIs, analyze and extract relevant information that is subsequently used by healthcare professionals. This also includes knowledge graphs, which is the networked overview of a patient's health status and treatment history, which can be useful for diagnosis and treatment planning [14].

These technological advancements offer high chances of enhancing healthcare overall and reduce costs per patient, but intelligent healthcare also comes with increased technical issues as well, such as:

• **General Security:** General security includes several vulnerabilities that could compromise patient security and confidentiality, including hardware failures, device vulnerabilities, and lack of interoperability between different systems. In addition, using multiple IoT systems for communication and monitoring can increase the risk of information leaks or connectivity issues. Falsified data or dead batteries can also have serious consequences, including the potential for toxicity or flammability [18].

• **Trust and Privacy:** Trust and Privacy are critical factors in smart healthcare, as handling sensitive and critical medical data can be extremely important to keep private. Patient trust in the healthcare system is important to ensure they feel comfortable seeking treatment and sharing information with their healthcare providers. At the same time, the handling of sensitive medical information is subject to strict privacy regulations, and breaches of this information can have serious consequences for both patients and healthcare providers. Protections may include the use of encryption, secure communication protocols, and other measures to protect data from unauthorized access or misuse [6, 11, 18].

• **Availability:** Availability can be important in critical care situations where access to information and communication can mean the difference between life and death. Issues include network outages, sensor interoperability problems, and device communication issues. In particular, the failure of IoT devices can lead to service interruptions or a denial of service in certain circumstances. Countermeasures could be redundant networks and backup systems, robust communication protocols, and protocols for testing and maintaining devices [2, 10].

• **Authentication:** Authentication protects against unauthorized access or misuse of access rights and ensures that sensitive information and systems are protected against tampering. In the context of smart healthcare, authentication is often used to ensure that only authorized individuals or devices can access specific systems or data. This can be especially important when dealing with IoT devices that may be used to monitor or control critical systems or to collect and transmit sensitive data [2, 18].

• **Efficiency:** The use of the Internet of Things and Big Data can help streamline processes and improve patient care through greater efficiency. However, storing and analyzing vast amounts of data can present efficiency issues, such as latency in finding the information needed to complete a task. In addition, barriers between different health networks can make it difficult to share and access data, further reducing efficiency [2]. One way to improve efficiency in smart healthcare is to use machine learning algorithms and other advanced analytics techniques. In addition, Fog computing can be used to bring computation and storage closer to the data source, reducing latency and improving efficiency [13, 18].

2. Internet of Things

2.1 Basics about the Internet of Things

The concept of the Internet of Things (IoT) can be traced back to the late 1980s, when researchers at the Massachusetts Institute of Technology (MIT) first proposed the idea of interconnected devices and systems that could communicate and exchange data [19]. It wasn't until the late 1990s and early 2000s that the term "Internet of Things" was coined and the concept began to gain widespread recognition. This was largely due to technological advances such as the development of wireless networks and the proliferation of low-cost sensors that made it possible to connect a wide range of devices to the Internet [20]. In the early years of IoT, the focus was primarily on connecting devices in industrial and manufacturing environments, such as sensors on factory floors or equipment in power plants. However, as the technology evolved and more devices became available, the scope of IoT grew [21].

Today, IoT encompasses a wide range of applications and has the potential to increase productivity in areas such as healthcare, transportation, agriculture and home automation. The proliferation of smart devices such as smartphones, smart thermostats, and smart home security systems has contributed to the growth of the IoT [22], making it a part of everyday life for many people around the world. Applications nowadays can be found in every aspect of life. A small set of Applications for a general viewpoint can be seen in Figure 1.

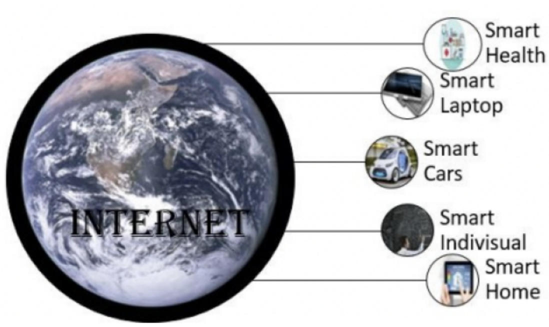

Figure 1: Internet of Things Application Overview [23]

IoT refers to a network of physical devices, vehicles, buildings and other objects that are connected to the Internet and can collect and exchange data [21]. These devices are equipped with sensors and other hardware that enable them to collect and transmit data, and they often have some level of computing power and connectivity as well [21].

One of the key drivers of the IoT is the proliferation of low-cost sensors and other hardware, as well as the development of wireless networking technologies that enable a wide range of devices to be connected to the Internet [24, 25]. In addition, advances in data analytics and cloud computing have enabled the processing and analysis of the large amounts of data generated by IoT devices, allowing for increased productivity and quality of life in both old new industries and societies [1].

When it comes to healthcare, therefore, IoT has the potential to leverage their usefulness to change the way care can be delivered and managed. IoT devices can be used to monitor and track patient health, collect and transmit data from medical devices, and support remote care and telemedicine. Other potential uses of IoT in healthcare include supply chain management, asset tracking, and facility management [21]. However, the adoption of IoT in healthcare and other industries is not without its problems. One of the main issues is security, as the use of networked devices can have vulnerabilities that can compromise the security of systems and data. It is important to implement robust security measures such as encryption and secure communication protocols to prevent unauthorized access and data misuse. Legal issues such as data protection laws and personal data protection standards must also be considered. Some basic considerations in IoT include:

• **The Potential for Cost Savings:** One of the potential benefits of IoT is the ability to reduce costs through improved efficiency and automation. For example, IoT devices can be used to monitor and control equipment, reducing the need for manual intervention and maintenance, which can reduce overall human workload. The use of IoT can help reduce waste and improve supply chain efficiency and productivity overall, resulting in cost savings across a huge range of industries [20].

• **The Impact on Jobs:** The adoption of IoT is likely to have an impact on the labor market, as automation and other efficiencies may lead to the displacement of certain types of jobs. At the same time, however, the IoT is likely to create new employment opportunities, particularly in white-collar jobs overseeing machine labor and areas such as software development, data analytics and cybersecurity [23].

• **Ethical Considerations:** The use of IoT can change human life tremendously. But it raises a number of ethical considerations that goes deep into human society, including questions about privacy, surveillance, and potential misuse of data influencing the general way we life. Another important part of that is the question of ownership. and legal considerations. It is important to carefully consider these issues, because negative consequences of IoT can outweigh the pros, if these ethical concerns are not address properly [26].

• **The Role of AI**: AI plays a key role in IoT by enabling devices to make highly intelligent decisions and take actions based on the huge amounts of data collected from sensors. This technological advancement will be a big part of the future IoT growth, but comes with their own challenges and security concerns which come hand in hand to IoT [26, 27].

• **Infrastructure Implications:** The Internet of Things requires a robust infrastructure to support the collection, transmission and processing of data. This includes both physical infrastructure, such as sensors and other devices, and digital infrastructure, such as data centres and cloud computing resources utilize the full potential of IoT [21].

2.2 Fog Computing

Fog computing, also known as "Edge Computing", is a way of distributing computing and data storage closer to the source of the data. Instead of relying on a central, remote server like in traditional cloud computing, fog computing decentralizes computation power to sensors and devices at the edge of the network [28–30]. This is depicted in Figure 2, which highlights the shift towards distributing computation power to edge devices and sensors rather than relying solely on cloud processing.

Fog computing offers a key advantage for IoT systems through real-time data processing and analysis at the network's edge. With computing resources close by, data can be quickly analyzed without the delay of transmission to a central server. This feature is particularly useful in situations that require low latency, such as IoT or real-time decision systems [28, 31].

Another advantage of Fog Computing is its ability to increase scalability and reliability by distributing computing resources across the network. This facilitates the efficient handling of large amounts of data and reduces the risk of single-point failures. This is especially crucial in IoT applications where numerous devices generate a vast amount of data, effectively addressing the challenge of managing and processing the exponential growth of IoT data [28, 32, 33].

In the field of Intelligent Healthcare these two benefits can have a significant impact. Quick decisions based on massive amounts of data from various sensors can often be the deciding factor between life and death, making these advantages particularly valuable in this industry.

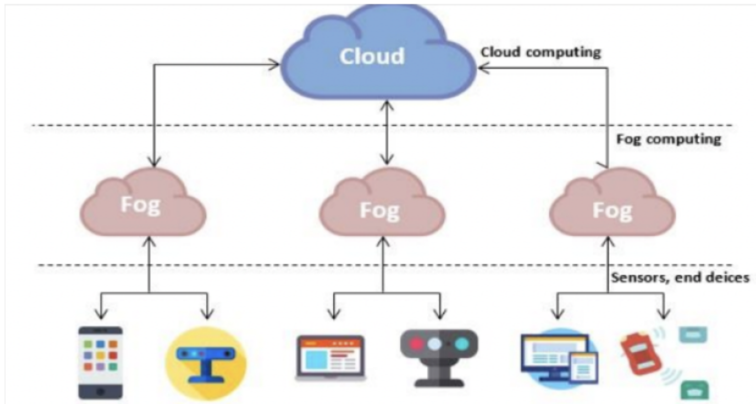

Figure 2: Fog Computing Basic Concept [16]

3. Intelligent Healthcare for the Internet of Things (IH-IOT)

3.1 Overview

Intelligent Healthcare leverages the latest IoT advancements to create scalable and resilient systems that can effectively impact various aspects of both general and specific healthcare. A high-level data flow diagram is shown in Figure 3.

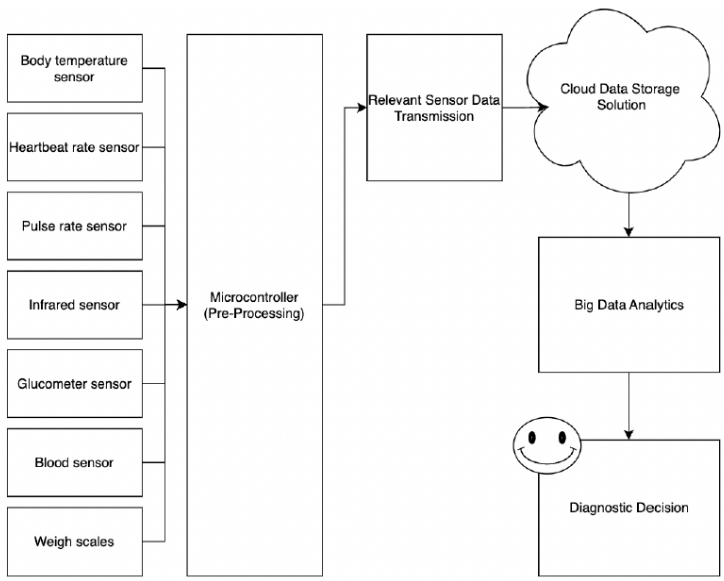

Figure 3: High-Level Intelligent Healthcare Data Flow Diagram

It firstly shows data aggregation through sensors. These sensors come in different forms including one-dimensional (1D) and two-dimensional (2D) signals, such as electrocardiograms (ECGs), electroencephalograms (EEGs), electroglottographs (EGGs), electrooculograms (EOGs), electromyograms (EMGs), body temperature, blood pressure (BP), heart rate, ultrasonography, glucose receptors, and more [2, 34]. The combination of all these signals through multimodal technology helps in improving the accuracy of diagnoses. Data from these sensors can be aggregated by a number of devices such as a basic microcontroller, wearable health bands, smart meters, smart video cameras, fitness shoes, smartwatches, and smartphones [4]. The collected data is then transmitted to a data gateway, a storage system, for processing and analysis. The addition of Fog Computing to the data aggregation process can hereby enhance the efficiency of processing [4, 35].

The development of AI and ML algorithms within the framework of deep learning (DL) and the integration of wireless local area network (wLAN) technologies, including 5G and beyond 5G interconnections, has greatly impacted the ability to extract relevant information from datasets in the big data analysis process [36]. Based on those insights automatic or manual diagnostic decisions can then be made with higher precision. Based on that model, Intelligent healthcare challenges and research areas can be broadly grouped into:

• **Sensor Data Volume:** The use of sensors in healthcare can generate large volumes of data, which can be difficult to process and analyze in a timely manner, especially when informing treatment decisions. However, the quality and accuracy of sensor data can be a challenge as well, due to factors like noise, interference, and calibration issues, in an implemented system for Healthcare Monitoring from 2020, it showed 95% accuracy between the observed and actual data of patients [37]. Privacy and security concerns can also arise with the collection and transmission of sensor data, which may involve sensitive personal information. Implementing appropriate safeguards to protect against unauthorized access such as implementing additional security components and protect against misuse of data is crucial [38]. Additionally, ensuring interoperability between different sensors and systems also with the cloud systems can be a challenge, as different protocols and standards for data transmission and communication may be used and a failure of real-time interaction may provoke a life-threatening incident [39]. Furthermore, sensors can be prone to failures and bugs or other issues that affect their performance, making it important to ensure their maintenance and reliability in critical healthcare settings [40].

• **Big Data Storage Methods:** There are several methods that can be used for storing big data in intelligent healthcare for IoT. The most present method is Cloud storage services for IoT, such as Amazon AWS IoT Core or Microsoft Azure IoT Hub [41, 42]. They can be used to store unlimited volumes of data in a distributed fashion. It also offers built in Security features such as Authentication and Authorization and supports different Data Protocols to work with [41]. To aggregate those amounts of data, usually a NoSQL database is used in combination for better efficiency [43]. Collecting diverse data from various sensors in healthcare in large quantities presents a challenge and necessitates the implementation of a robust, secure, efficient, and energy-efficient protocol for data collection. Techniques such as dimension reduction can aid in this process [43, 44].

• **Classify and Identify Correct Information:** The stored data in intelligent healthcare is predominantly heterogenous and requires large-scale and timely analysis. Continuously analyzing the information with scalability and low latency is a significant challenge. Big data analytics can utilize various techniques and tools such as data profiling, categorization, or visualization [17]. Our paper focuses on modern AI techniques, including pattern recognition and deep learning-enabled ML, to improve decision-making. This can aid in recommending treatments or predicting disease conditions with a certain degree of accuracy [17, 45]. ML algorithms come in various forms such as Convolutions Neural Networks (CNN) or Support Vector Machine (SVM) and have been extensively studied. For instance, they can be used to predict lung cancer [45]. A special type of ML algorithm is a neural network, which mimics the human brain and relies on training data to achieve accuracy. Neural networks allow for rapid classification and clustering of data, which can greatly benefit intelligent healthcare. They have shown great potential in the latest analytics for intelligent healthcare [46, 47].

3.2 Neural Networks

A neural network is a type of artificial intelligence (AI) that is inspired by the way the human brain works. It is composed of layers of interconnected "neurons", which are designed to process and analyze data. Neural networks are able to learn and adapt over time, allowing them to improve their performance as they are exposed to more data [48].

There are several types of neural networks, including feedforward networks, convolutional neural networks, and recurrent neural networks. Each type of neural network is suited to a particular type of task, such as image recognition, natural language processing, or time series analysis [48]. Neural networks are trained by presenting them with a large dataset and adjusting the connections between the neurons based on the patterns in the data. This process, known as "training", allows the neural network to learn and adapt to new data. Neural networks have a wide range of applications, including image and speech recognition, natural language processing, and predictive analytics. They are also used in a variety of industries, including healthcare, finance, and transportation [48].

A possible concept for Neural Networks in Intelligent Healthcare can be seen in Figure 4. The sensor data is stored in a database, and the neural network processes learning algorithms to produce inference rules for decision-making. The learning algorithms, in turn, use previous knowledge to optimize the training of the neural network [15]. The growth rate of AI publications related to healthcare has risen significantly over the past decade and shows no signs of slowing down. Among AI techniques, machine learning and neural networks are the most widely used for classification, diagnosis, and prediction, with Convolution Neural Networks being a popular choice.

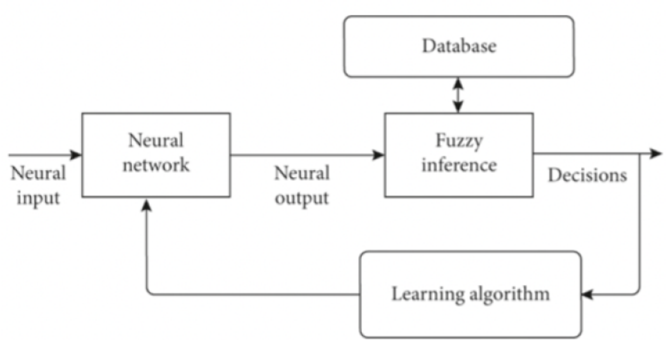

Figure 4: Neural Networks Concept [15]

3.3 Remote Diagnostics

Another promising and future-oriented technology in intelligent healthcare we wish to examine is remote diagnostics. It involves utilizing remote communication technologies to diagnose and monitor patients' health from a distance, without the need for physical presence at a healthcare facility. This offers several global benefits, including providing advanced healthcare to areas that are otherwise inaccessible due to a lack of resources and uneven distribution of medical resources [7].

Since the outbreak of the COVID-19 pandemic, it has become evident that our society is facing global health threats. Remote diagnostics in healthcare can monitor various health parameters, such as vital signs, medication adherence, and other critical health metrics. Healthcare providers can use data collected from wearable sensors and other devices to track a patient's health in real-time and take action if necessary. This can also aid in pandemics by effectively screening and isolating individuals through constant monitoring [49].

Remote diagnostics are also crucial for managing chronic conditions such as diabetes and hypertension. Daily monitoring of patients' health allows healthcare providers to identify patterns and adjust treatment plans, leading to improved patient outcomes and reduced hospital visits [50]. Wearable sensors can be used to monitor vital signs, which are stored in a cloud database maintained by the healthcare provider. Utilizing advanced algorithms, remote diagnoses can be provided. Figure 5 showcases this setup. Remote diagnostics leverages AI technology to deliver maximum benefits and enhance traditional hospital-based treatments. It reduces the workload of healthcare workers and creates a more efficient healthcare environment overall.

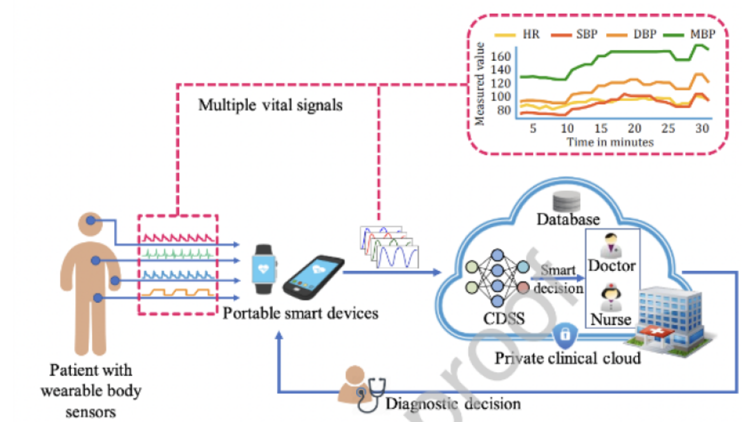

Figure 5: Remote Diagnostics in Healthcare [51]

4. Literature Studies in IH-IOT

Exploring the latest advancements in intelligent healthcare with the help of IoT is a widely studied area. In the following, we will delve into a selection of recent, noteworthy studies in this field, highlighting the key concepts previously discussed in the realm of intelligent healthcare.

• **Digital Twin:** Haya Elayan proposed the introduction of digital twins in healthcare in 2021. This involves using a digital twin that relates to a digital image of the physical object. A model for classifying ECG heart rhythms was created using ML to diagnose heart disease and detect heart problems. It has been shown that ML and AI can be used with various human body metrics to continuously monitor and detect abnormalities. In this context, it has been recognized that neural network-based algorithms are very promising in and can cope better with ECG data than traditional ML algorithms. There are questions about trust issues in field experts and ML algorithms, as well as security and privacy concerns, since the data is very sensitive and traditional security controls are usually not appropriate with the digital twin framework [6].

• **Tackle Challenges of the COVID-19 Pandemic:** The Covid-19 Pandemic has highlighted the importance of intelligent healthcare solutions in tackling new medical challenges. In a 2021 study, Mohd Javaid explores the use of IoT in healthcare during the pandemic. The study, based on a review of research papers, concludes that IoT has the potential to improve healthcare performance, resolve various challenges, and offer benefits such as better record-keeping, monitoring of critical parameters, and better treatment options. Another study focuses on the growing need for intelligent healthcare systems in regards to the COVID-19 Pandemic and in response to the limited time people have to take care of their health. The authors propose using IoT to provide a wearable device that can continuously monitor a person's health and provide insights to both the user and their physician, particularly in rural areas where healthcare is limited. The IoT wearable device uses AI-based healthcare monitoring systems to collect real-time data, analyze it for abnormalities, and deliver updated information to medical professionals and caretakers. This deployment offers real-time monitoring, secure data transmission, prompt emergency notifications, and long-term healthcare guidance, which can be especially useful when tackling pandemics or endemics [52].

• **At Home Treatment:** In Another paper the cutting-edge field of remote diagnostics is discussed and it introduces a healthcare monitoring framework for chronic patients. The framework incorporates innovative technologies such as data mining, cloud servers, big data, ontologies, and deep learning to enhance the performance of data handling and improve the accuracy of health data classification. The proposed solution automates the process of detecting valuable information, extracting relevant features, reducing data complexity, classifying patients' health conditions, and predicting drug side effects. The framework is a valuable tool for monitoring chronic patients and can handle both structured and unstructured data. The results of the study indicate that the use of PCA and IG with ontology-LSTM is more efficient for numeric and textual data classification. However, the limitations of the study include limitations in understanding textual data with SentiWordNet lexicons and not considering multimodal data. The framework can be improved by incorporating fuzzy ontology and fuzzy LSTM for better classification performance [53].

• **Cancer Disease Prediction:** One benefit of Intelligent Healthcare is improved treatment for common causes of death. In a study, the benign or malignant nature of cells was predicted using five machine learning techniques: Support Vector Machine (SVM), K-Nearest Neighbours (K-NNs), Random Forests (RFs), Artificial Neural Networks (ANNs), and Logistic Regression (LR). A ten-fold cross-validation was applied, with 90% of 699 instances used for training and 70 instances used for testing. The performance of each technique was evaluated using a confusion matrix, and the results showed that ANNs had the highest accuracy of 98.57%, followed by K-NNs and SVM with 97.1% accuracy. ANNs also had the highest specificity of 96% and precision of 97.8%, with the lowest false-positive and false-negative rates. The ROC and PR-AUC curves indicated that ANNs performed the best. The proposed system was found to be more accurate than other studies [54].

• **Solving Privacy and Security with Modern Cryptography:** One of the major concerns in Intelligent Healthcare is Security and Privacy in the face of increasing data collection. The article on "CloudSim for cancer disease prediction" describes the use of CloudSim to simulate the encrypted patient details collected through IoT, for improved security and accessibility of sensitive medical information [55]. Another paper presents a privacy-preserving medical record search scheme that allows patients to securely diagnose themselves with blinded abstracts of current and previous records. The authors emphasize the need for privacy-enhancing technologies, such as blockchain and homomorphic encryption, to protect personal information. [11] A third article discusses the challenges and potential solutions for securing IoT systems, highlighting the vulnerabilities of weak authentication and encryption, and the need for standardization and regulation to mitigate these risks. The paper also highlights the need for continuous monitoring and updating of security measures in the rapidly growing IoT landscape [56].

5. Challenges and Future Directions

Having explored the advancements of modern intelligent healthcare, it is important to address the challenges that arise and consider the future directions for overcoming these obstacles. In this chapter, we will outline the most prominent subjects for a successful integration of technology in healthcare.

First, it is clear that the future of intelligent healthcare will be characterized in part by technological advances in IoT, i.e., the availability of improved sensor data and a broader range of wearable devices and IoT-enabled technologies. These devices will have increased computing power and be less expensive, allowing them to be seamlessly integrated into everyday life and enabling more specific and comprehensive health measurements. The integration of Fog computing technology will further enhance the capabilities of these endpoints and enable improved data processing.

With the increasing integration of IoT devices into daily life and the possible insertion of wearables into the human body, people need to get accustomed to a machine-based environment. This poses a major ethical challenge in the current healthcare landscape and requires a great deal of familiarization. In addition, there are new potential health concerns that may arise and need to be addressed and overcome.

Advances in AI and ML, particularly the use of neural networks, promise to revolutionize healthcare through improved prediction and analysis. This has the potential to overcome current limitations and combat pandemics and diseases that were previously considered nearly impossible to defeat. However, such advances require large volumes of medical datasets, necessitating global medical dataset networking. This presents a challenge, as some countries may prefer protectionism to globalization. The integration of these datasets and AI technologies also raises other important ethical considerations, so their continued use must be approached with caution and a thorough examination of these ethical challenges is essential.

One of the most pressing issues underlying technological progress is the question of privacy and security. This should take precedence over any technological efficiency gains. These concerns are often not given the attention they deserve during the development process and only come to the fore after security incidents. However, they are of paramount importance because they impact how people will live in the future, how robust healthcare will be, and how they can make the difference between life and death. While cryptography offers promising solutions, it is critical that it is implemented, especially early in the development phase, and then used effectively to ensure sensitive information is protected and data is secure.

6. Conclusion

In summary, the integration of technology into healthcare presents enormous opportunities and enormous obstacles. Improvements in health measurement, prediction, and analytics could transform the healthcare sector in tremendous ways as a result of IoT and AI developments. However, the ethical implications of these developments must be very carefully considered, as they have security and privacy implications that have the potential to change the level of freedom forever. Familiarization with machine environments and the integration of global medical data sets also pose challenges. It is important to prioritize privacy and security in the development process and implement effective cryptography to ensure sensitive data is protected. The future of intelligent healthcare is very promising, but these challenges must be overcome to achieve successful integration of the technology.

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