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Smart Healthcare System Using IoT and Machine Learning: A Review

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Abstract

The fast-paced world of today has made technology an essential component of our daily existence. Innovations in technology, from smartphones to smart homes, have revolutionized several industries, including healthcare. The idea of smart healthcare systems is examined in this article, along with their advantages and effects on the healthcare sector. Many factors pertaining to many aspects of the smart healthcare system, such as wearable technology, machine learning methods, real-time monitoring, and the Internet of Things, have been found and compared. Next, a nine-step architecture for an Internet of Things (IoT) based smart healthcare system is provided. Finally, future directions for smart healthcare systems have been explored, with block-chain, VR, and AI being regarded as essential components.

Keywords: Smart Healthcare System; Using IoT; Machine Learning

1. Introduction

In today's fast-paced world, technology has become an integral part of our lives. From smartphonesto smart homes, the advancements in technology have transformed various sectors, including healthcare. The emergence of smart healthcare systems has revolutionized the way patient care isdelivered. This article explores the concept of smart healthcare systems, their benefits, and their impact on the healthcare industry.

Smart healthcare systems leverage technology to improve patient care, streamline processes, and enhance the overall efficiency of healthcare organizations. These systems combine various technologies such as IoT, big data, and AI to create a connected and intelligent ecosystem within healthcare facilities. By integrating devices, data, and applications, smart healthcare systems enable real-time monitoring, data analysis, and proactive decision-making (Muccini & Vaidhyanathan, 2021, Hamza 2024).

2.2.1.1 1.1 Benefits of Smart Healthcare Systems

- **Improved Patient Monitoring**

Smart healthcare systems enable continuous monitoring of patients, both inside and outsideof healthcare facilities. Wearable devices, such as smartwatches or fitness trackers, can track vital signs, sleep patterns, and activity levels, providing valuable data for healthcareprofessionals. Real-time monitoring allows for early detection of abnormalities, enabling prompt interventions and personalized treatment plans.

- **Enhanced Efficiency and Accuracy**

Automation and digitalization of healthcare processes through smart systems reduce the administrative burden on healthcare providers, allowing them to focus more on patient care. Electronic health records (EHRs) ensure accurate and up-to-date patient information,eliminating the need for manual record-keeping. Smart scheduling systems optimize appointment management, minimizing wait times and improving overall operational efficiency.

- **Remote Patient Care**

Smart healthcare systems facilitate remote patient care, particularly beneficial for individuals with limited mobility or living in remote areas. Telemedicine platforms enable virtual consultations, remote monitoring, and secure communication between healthcare providers and patients. This not only improves access to healthcare services but also reduces the need for unnecessary hospital visits (Aqeel et al., 2023).

- **Early Disease Detection**

With the integration of AI and big data analytics, smart healthcare systems can analyze vast amounts of patient data to identify patterns and detect early signs of diseases. Machine learning algorithms can process medical images, such as X-rays or MRIs, with high accuracy, aiding in the early diagnosis of conditions like cancer, brain tumor or cardiovascular diseases (Humayun et al., 2024; Abbas et al., 2024). Early detection significantly improves treatment outcomes and patient prognosis.

2.2.1.2 1.2 Implementation of Smart Healthcare Systems

- **Internet of Things (IoT) Integration**

The IoT plays a vital role in smart healthcare systems by connecting various devices and sensors. IoT-enabled medical devices, such as smart wearable devices or remote monitoring devices, collect real-time data and transmit it to healthcare professionals. This connectivity enables seamless data sharing, remote monitoring, and timely interventions.

- **Big Data and Analytics**

The integration of big data analytics allows healthcare organizations to make sense of large volumes of patient data. Advanced analytics techniques can identify trends, predict outcomes and provide actionable insights for healthcare providers. The analysis of patient data can lead to personalized treatments, population health management, and improved operational efficiency (Cornet et al., 2020).

- **Artificial Intelligence (AI) in Healthcare**

AI technologies, including machine learning and natural language processing, have immense potential in smart healthcare systems. Machine learning algorithms can analyze patient data to develop predictive models, assist in diagnosis, and optimize treatment plans. Natural language processing enables efficient processing of medical records, improving the accuracy and speed of information retrieval.

2.2.1.3 1.3 Challenges and Concerns

While smart healthcare systems offer numerous advantages, their implementation is not without challenges and concerns.

- **Data Security and Privacy**

The integration of various devices and systems in smart healthcare environments raises concerns regarding data security and patient privacy. Healthcare organizations must ensurerobust security measures, encrypted communication, and strict access controls to protect sensitive patient information from unauthorized access or data breaches (Hamid et al., 2023).

- **Cost and Infrastructure**

Implementing smart healthcare systems requires significant investments in infrastructure, connectivity, and technology adoption. Healthcare organizations must carefully assess thecosts involved and develop sustainable financial models to support the implementation andmaintenance of these systems.

- **User Acceptance and Training**

Introducing new technologies and workflows may face resistance from healthcare professionals and patients. Proper training and education programs should be implementedto ensure smooth adoption and effective utilization of smart healthcare systems. Engagingstakeholders, addressing concerns, and showcasing the benefits of these systems are crucialfor successful implementation (Iqbal et al., 2024).

2. Literature Review

As the population is growing day by day and the cost of physical hospitals is also increasing, it isnot affordable for everyone to access these medical services. Moreover, the number of hospitals, resources of the hospitals, nurses, and beds are not sufficient to fulfill the needs of the growing number of patients.

Older citizens suffer from many serious diseases such as Alzheimer's, heart disease, diabetes, hypertension, etc. These diseases need to be addressed urgently. Smart Healthcare can provide immediate services in this situation (Aqeel et al., 2023).

Figure No 1: Framework of Smart Healthcare Monitoring System.

2.1 Smart Healthcare

In 2009, IBM proposed a framework of "Smart Planet", which was an intelligent infrastructure. In this framework, sensors were used for collecting data, then the collected data was transmitted over the internet, and supercomputers were used to process the data. Smart Healthcare system was a system that was developed using IoT devices, sensors, and mobile devices to gather real-time information of the patient and then deliver it to the medical professionals (Iqbal et al., 2023).

Smart healthcare can be categorized into two main components:

2.2.1.4 Daily Healthcare Practices

Daily healthcare is a recent domain of research that needs a trustworthy, accurate, and consistent acquisition of knowledge to be up to date regarding real-time daily health information of patients.Smart healthcare systems have played a vital role in the daily healthcare domain by providing IoTand sensor-based devices in every field of life such as a house, school, office, gym, etc. Those sensors provide real-time health information of the patient and transmit the acquired information to the concerned medical professional.

2.2.1.5 Clinical Healthcare Practices

Although the clinical structure of healthcare is very improved now, there are still preventable medical errors (PMEs) that caused more than 2 lacs deaths in the U.S. in 2013. This death rate washigher than the death rate of 1999 i.e. 98,000 reported in the IOM report. Smart healthcare can improve these preventable medical errors (PMEs) by providing digital information systems for example (CDSSs i.e. Clinical Decision Support Systems) and (EHRs i.e. Electronic Health Records). Such smart healthcare systems provide up to 66% smart and intelligent medicalsuggestions to the medical staff. Therefore, most of the physical clinics are now adopting EHR- based CDSS for more efficient medical practices.

Based on the above-mentioned categories, it has become easier to prevent the diseases in the clinical environment, diagnose the diseases in the clinical as well as daily life healthcare practices,and treatment of the disease in the clinical and daily life health practices.

2.1.1 Requirements of the Smart Healthcare System

Smart Healthcare system comprises two categories of requirements i.e., functional requirements and non-functional requirements.

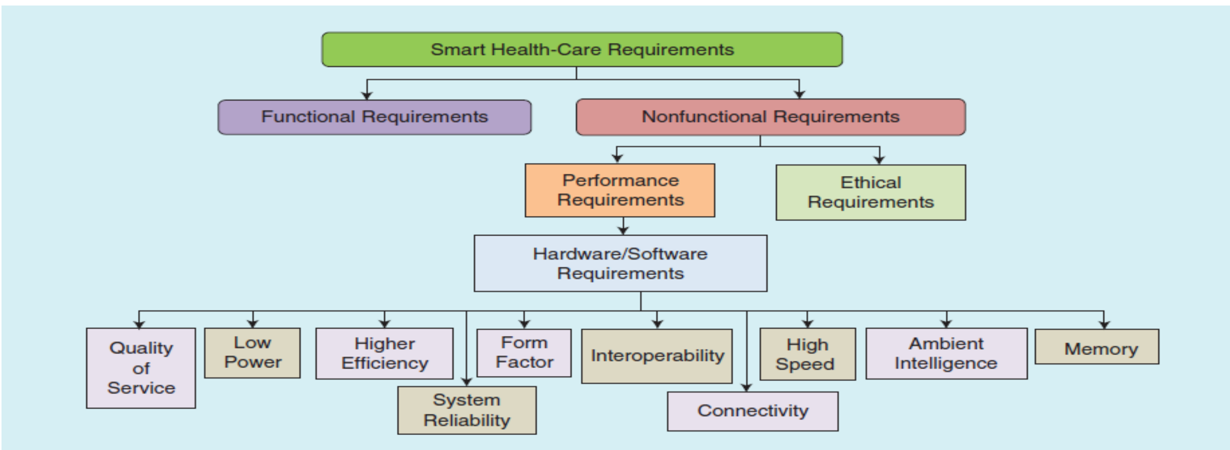
Functional requirements are specific for every component of the system. For instance, if we use athermometer for recording the temperature, it could result in different readings in different situations.

In contrast, non-functional requirements are not specific. These are the properties of a system to enhance its working and quality and can be different according to the need and the instruments used, such as:

- Low power consumption,
- Efficiency,

- Interoperability,
- Scalability,
- Quality of service,
- Reliability,
- Connectivity etc.

Figure No 2: Functional and Non-Functional Requirements of Smart Healthcare System



It is very vital to design a smart healthcare system to efficiently carry out clinical and daily life health care practices. For an efficient smart healthcare system, some key attributes should be keptin mind:

- **Efficiency:**

A smart healthcare system should be efficient in terms of energy and storage for effective performance.

- **Security:**

An efficient smart healthcare system should be highly secured. As the healthcare system gets the private information of the patients, it must be secure and private.

- **Accuracy:**

The decisions of a smart healthcare system must be accurate so that the medical alliance can be performed immediately without any negligence.

- **Cost-Effectiveness:**

A smart healthcare system must be cost-effective. In this era, physical medical treatmentsare not affordable for everyone. Therefore, a smart healthcare system must be cost- effective so that everyone can take advantage of it.

- **Highly Responsive:**

The computational and storage resource of a smart healthcare system can reduce its response time which can cause serious problems for the patients. Therefore, a smart healthcare system must be highly responsive.

- **Scalability:**

The smart healthcare system should be scalable to adapt the updates of the technology to enhance the functionality of the system.

- **Maintainability:**

A smart healthcare system should be maintained periodically. Both, the software of the system and hardware of the system should be maintained for effective results.

- **Reliability and Fault Tolerance:**

In a smart healthcare system, data is collected through multiple sources and transmitted over the internet. There is a chance of a fault in collecting and transmitting the information.Therefore, a smart healthcare system must be fault-tolerant and reliable for effective results(Riasat et al., 2023).

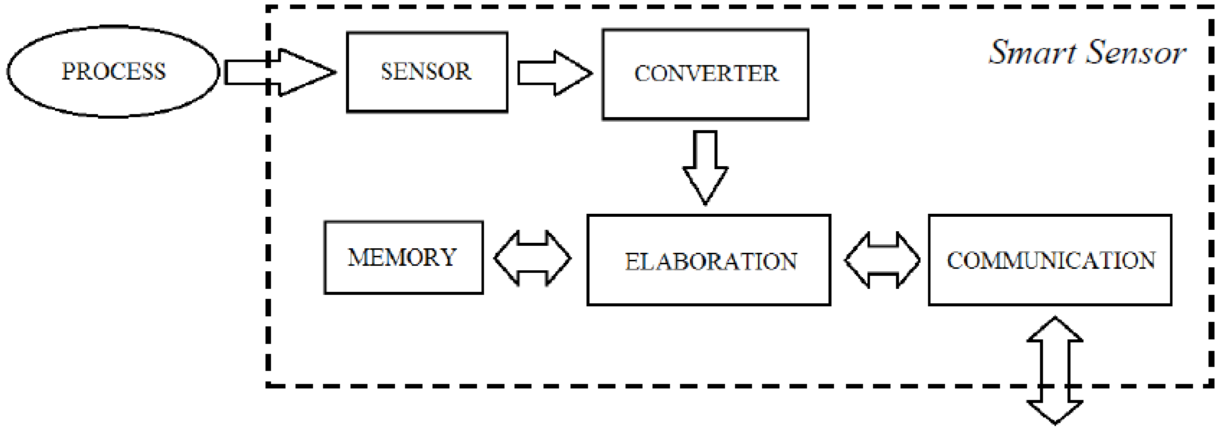
2.2.1.6 Smart healthcare System and IoT

IoT is considered as a device or a device network connected to the internet which gets informationfrom various sources and then delivers the data to the required persons. It can also be said to be networks of sensors and devices which access real-time information and process it accordingly. Therefore, IoT is playing a vital role in healthcare. When a patient leaves his doctor, IoT devices keep him connected to his doctor and the doctor can monitor his patient's health remotely (Hamid et al., 2022).

IoT devices collect data through sensors. Sensors are the devices that contain some kind of instruments to record the parameters such as heart rate, sugar level, blood pressure and then convertand elaborate the accessed information in analog or digital form. Figure 2 shows the working of asmart sensor.

After the sensors, collect the information from the patient, some algorithms are applied to the datasuch as a machine-learning algorithm to analyze the collected data. Based on the analysis, the IoTdevice decides to either take any action or transmit the information to the concerned medical person of the patient over the cloud. By receiving IoT information, a relevant medical person decides to take the necessary action (Vanteru et al., 2023).

Figure No 3: Working of a Smart Sensor (Alpala et al., 2022).



An effective healthcare system needs numerous devices, applications, and services for the best results. To combine these services and applications IoT technology for the healthcare system canbe divided into three broad groups i.e., communication technology, location technology, and identification technology.

2.2.2 Technologies of IoT in Smart Healthcare System

2.2.2.1 Identification Technology

This technology assigns a unique identifier (UID) to every node so that they can be accesseduniquely and information can be exchanged between them easily. Unique identifier (UID) can be further divided into (UUID) universally unique identifier and globally defined uniqueidentifier (GUID).

2.2.2.2 Communication Technology

This technology is used for the communication between the devices of an IoT healthcare network. This technology can be divided into two subcategories namely short-range communication technologies consisting of limited distance communication and mid-range communication technologies consisting of wider distance communication. Bluetooth, Wi- Fi, ZigBee, and RFID are some communication technologies being used.

2.2.2.3 Location Technology

Real-time location monitoring in a smart healthcare system is an essential element. For this purpose, location technology is used to monitor the real-time location and body of the patients to provide quick services. Global positioning systems (GPS) and local positioningsystems (LPS) are used for this purpose.

2.2.3 Services of IoT in Smart Healthcare System

With the advent of IoT technology in the healthcare system, numerous healthcare services havebeen developed which include a set of solutions for medical problems. IoT services are not unique but their applications make them unique. Some widely used IoT services in the healthcare system are as follows:

- Ambient Assistant Living
- Mobile IoT
- Wearable Devices
- Community-based Health Services
- Cognitive Computing
- Adverse Drug Reaction
- Blockchain
- Child Health Information

2.2.4 Applications of IoT in Smart Healthcare System

Numerous IoT-based healthcare applications have been developed for the service of mankind.The population is growing tremendously and physical medical treatments are getting more expensive. These applications can help people to monitor their health in real-time and respondimmediately. Following are some IoT based healthcare applications that are being widely used:

- ECG Monitoring
- Glucose Level Monitoring
- Temperature Monitor
- Blood Pressure Monitoring
- Oxygen saturation Monitoring
- Asthma Monitoring
- Mood Monitoring
- Medication Management
- Wheelchair Management
- Rehabilitation Management

2.2.5 Smart Healthcare System using IoT and Machine Learning Techniques

Machine learning techniques enable to upgrade of management aspects of the health care system which include patient health management, patient record management, medical insurance, and other staff information management. This preferably focuses on the patient's care rather than wasting time on gathering patient information by searching and filling (Harris & Cooper, 2019). Another benefit of this technique is the increased accuracy in diagnostics. For instance, machine learning was proven very helpful for the healthcare department in the pandemic outbreak of COVID-19 by 92% accuracy in the mortality rate prediction. Moreover, this technique can be helpful to develop the patient's treatment plan in case of medication. However, the machine learning approach can significantly work for other medical issues too (Hamid, Iqbal, Zain, et al., 2022). Numerous researchers previously have worked in multiple healthcare fields which is discussed below:

Jeong et al. (2016) presented a framework for IoT Healthcare and defined the logical structure of the proposed model. The researchers claimed that a smart healthcare system can be implemented successfully if five attributes are implemented that are efficiency, reliability, continuity, confidentiality, and stability. Data was collected through sensors, processed through a mobile device and neural network, and then transmitted to the cloud for implantingalgorithms to take decisions by the professionals.

Zeina Rayan and others examined multiple recent machine learning techniques for smart healthcare systems. Numerous health care systems are developed to help in the diseases such as glaucoma, Alzheimer, bacterial diseases, detection of cataracts, ICU admission, etc. most ofthe machine learning techniques used in such healthcare systems were the ANN (artificial neural network), the SVM (support vector machine), the CNN (Convolutional Neural Network), etc. These approaches resulted in a high level of performance evaluation (Hamid et al., 2022).

Shreshth Tuli et al. described the challenges for providing effective healthcare. The research work presented a conceptual framework for an efficient and secure healthcare system and explained how that model can accomplish the increasing demands of the healthcare department. Furthermore, existing practices of the healthcare department using IoT, AI,Machine Learning techniques, and Fog computing technologies were discussed in the study (Hamid et al., 2022).

Taher et al. (2020) described the use of artificial intelligence, blockchain technology, machine learning technologies, an IoT device for the betterment of smart healthcare systems. They further explained that the near future will be the era of robotics and smart life that will improve the lives of humans by using sensor-based devices as these technologies proved accurate and precise. Moreover, the healthcare system consisting of artificial intelligence technologies, sensors technologies, and machine learning technologies will be beneficial for patients as well as doctors in the future.

Researchers offered a complete assessment of the use of the machine learning (ML) techniquesin the healthcare system for the collected big data analysis. The benefits and drawbacks of present methodologies, as well as numerous research difficulties, were also discussed. The study gave health workers and state agencies insight into how to stay up to date on the latest innovations in machine learning-based big data analytics for smart healthcare (Barsky et al., 2019).

Li et al. (2022) analyzed the implication of blockchain technology and machine learning technology in the field of smart healthcare by using the web of science and bibliometric visualization. The researchers highlighted the countries which were using these technologies in the healthcare system mostly. The identified countries were using the technologies in disease diagnosis, telemedicine, data privacy, etc.

Researchers discussed the use of wearable IoT devices and smartphones in monitoringthe health of patients. In their research, three diseases were discussed i.e., diabetes, heart disease, and COVID-19. They also discussed the benefits of software integrated frameworks for smart health. The pros and cons of smart health and smart health technologies were also discussed (Hamid et al., 2022).

2.2.5.1 Real-Time Monitoring Systems for Smart Healthcare

Enshaeifar et al. (2020) presented a framework named "Technology Integrated Health Management (TIHM)" to monitor patients with dementia in their homes. The system gathereddata using IoT devices and then the correlation of gathered data was analyzed by the machinelearning algorithms. The solutions made by this approach were used to monitor and facilitate the patients. Both long-term and short-term changes were noticed and high-level patterns of the patients were recorded to monitor any change in their existing condition. An approach of hierarchal information infusion was developed to recognize anger, anxiety, and violence. 80% of the results were considered accurate.

Zahin et al. (2022) proposed a semi-supervised framework for the classification of data that wasachieved a series of times. The proposed framework was a combination of VAE and CNN (i.e., Variational Auto Encoder and Convolutional Neural Network). VAN was used to get the properties of human actions whereas CNN was used for making the decisions. The system was then trained to observe the actions of humans for smart healthcare. The obtained classification accuracy was 5.28 and 5.25 percent respectively. Furthermore, the proposed model had more convergence rate than the benchmarked supervised model.

Subasi et al. (2020) presented a real-time smart HAR (Human Activity Recognition) system for smart healthcare. The proposed system was explained through a use case. The body sensors observed the human body and passed the data over a server in timely intervals. Moreover, if the system observed any abnormal activity the treatment could be started timely. The system was proved 99.43% accurate according to the maximum accuracy result of SVM.

Pandey and Prabha (2023) in their research work focused on real-time health monitoring byusing IoT and machine learning techniques. The information was collected through a Web form before being fed into machine learning algorithms. So, when all techniques wereexamined, the KNN method provided 78 percent accuracy, the SVM model provided 86 percent accuracy, the random forest algorithm provided 83 percent accuracy, the decision treealgorithm provides 74 percent accuracy, and the nave's Bayes provides 83 percent accuracy. As a result, when all methods were analyzed, the support vector machine (SVM) has the maximum accuracy. The suggested software and hardware helped the patients in the early detection of cardiac disease.

Islam et al. (2017) proposed a system that monitored the patient's room in real-timeand the condition of the patient. In this framework, five sensors were included i.e., the body temperature sensor, the room temperature sensor, the heart rate sensor, the CO sensor, and the CO_2 sensor. The data was collected from the hospital room of the patients and delivered to the hospital staff through a portal to monitor the condition of the patients. The chances of error inthe proposed system were less than 5 percent in some specified conditions. Every case of a particular patient had a different rate of error. The system was considered efficient and 95.72%accurate at a maximum rate.

Souri et al., (2022) proposed a framework for monitoring the physiological health of students as well as the behavioral health of the students. The data was gathered through IoT devices and machine learning techniques were used to analyze the collected data. SVM (Support Vector Machine), multilayer perceptron neural network algorithms, the random forest, and the decision tree were also used for achieving the highest accuracy. The accuracy of the proposed framework was recorded at 99.1%.

Kaushik (2021) in his study proposed a real-time health monitoring system using AI technologies and IoT devices. In addition to these technologies, multiple sensors were used to keep monitoring the patients and immediate response was given when any change occurred inthe position of the patients. The system was helpful to monitor the patient from distance and could be used indoors as well as outdoor. The machine learning algorithms, the autoencoder, the neural networks were used in this study to get the highest results. The system was considered accurate and precise.

Savaridass (2021) proposed a smart healthcare system. The temperature of the body, blood pressure, the rate of the pulse, the glucose level, and the level of oxygen were the fundamental observable traits to be assessed. The LM35 sensor was used to detect temperature (temperature sensor). A pressure sensor (digital sphygmomanometer) had been used to evaluate pressure. A pulse sensor examined heartbeat rate (LM358 OPAMP).The concentration of oxygen of hemoglobins was examined by oxygen saturation. The blood sugar levels were measured with a glucometer. As a controller, the Node-MCU was employed.This Wi-Fi plugin enabled the users to transfer the physiological properties that have been gathered to the internet servers. If there any disparity in the actual values was determined, thephysician and the patient's family received a warning notification through either an e-mail or a text message. The system proved accurate and efficient by using less time, power, and cost.

Khan et al. (2024) proposed an IoT-based framework for the real- time monitoring of patients. The researchers considered the pulse rate, the body temperature, and the saturation of oxygen as the most vital elements. The proposed system was based on anLCD to show the results of these parameters and the results were then synced with a mobile application. A system was developed based on Arduino and was tested on five humans. The results of the system were as accurate as compared to the results of commercial devices available in the market.

Khan et al. (2024) discussed the new medical services for the elderly citizen to provide healthcare services. The data was collected by using machine learning techniques. Theresults of the experiments were obtained in terms of accuracy 0.918, sensitivity 0.912, specificity 0.923, miss rate 0.082, and precision 0.913 percent.

Amin et al. (2020) proposed a framework of a cognitive smart healthcare system for monitoring the patients in real-time. IoT devices were used in the proposed model and for thebest decision making, deep learning technologies and sensors were used. The data was collected through sensors and then transmitted to the deep learning module through IoT devices. After processing the results, the signals of EEG were classified into either pathologicalsignals or normal signals. Based on the classification, the professionals took the necessary actions. The proposed system proves more accurate than state-of-the-art systems. It obtainedthe maximum accuracy 87.32%, sensitivity 78.57%, and specificity 94.67%.

Table No 1: Parameters

Authors	Accuracy	Low Time Consumption	Convergance	Low Power Consumption	Low Cost	Sensitivity	Efficiency	Precision	Miss-Rate	Specificity
6	✓									
7	✓		✓							
8	✓									
9	✓									
10	✓						✓			
11	✓									
12	✓							✓		
13	✓	✓		✓	✓		✓			
14							✓			
15	✓					✓		✓	✓	✓
16	✓					✓				✓

2.2.5.2 Wearable Devices for Smart Healthcare

Wan et al. (2019) and others presented a novel framework "Wearable IoT Cloud-Based Health Monitoring System" (WISE) which monitored the users in real-time. The framework was based on a sensor network attached to the body. The sensors included the temperature sensor,the heartbeat sensor, the blood pressure sensor, etc. In addition, other wearable devices neededmobile devices to transmit data over the cloud whereas WISE directly transmitted the data overthe cloud which made it quicker than others, and it had a lightweight LCD for the quick view.

Nandyal et al. (2017) presented a framework that monitored the old age patients regularly and they didn't need to visit the hospital often. The wearable sensors included in thisframework were ECG, detection of position, pulse rate, and body temperature. All those sensors were then connected to the raspberry pi. The raspberry pi worked as a server when connected to the internet and transmitted the information to the specified URLs. The system was high in performance and accuracy.

Xingdong et al. (2023) proposed a smart healthcare system using IoT wearable devices and deeplearning algorithms. The case study included Sanda Athletes. By using the proposed system,athletes were monitored and advised by their physicians in real-time even if they were notmeeting face-to-face. For the accuracy calculation, multiple performance measuring metrics were applied to the collected data. The proposed system was useful enough for brain tumors, cancer, and cardio diseases. The system was accurate, precise, and high in performance. Ankush Manocha et al. proposed a healthcare model which was a combination of IoT and Fogtechnology. On the Fog layer, K-mean technology was used to determine irregular actions. TheCloud layer used k-mean clustering and artificial neural networks for the prediction. Theproposed system included 15 individuals aged between 32 years to 45 years for thirty days.The efficiency of the model was obtained by 94.51 percent accuracy, 91.58 percent precision, 91.32% percent specificity, 93.75 percent sensitivity, and 92.78 percent f-measure.

Table No 2: Parameters

Authors	**Accuracy**	**Low Time Consumption**	**Performance**	**F-Measures**	**Sensitivity**	**Precision**	**Specificity**
1		✓					
2	✓		✓				
3	✓		✓			✓	
4	✓			✓	✓	✓	✓

2.2.5.3 Security Framework for Smart Healthcare

Newaz et al. (2022) developed a novel security framework "HealthGuard" for a smart healthcare system. The model monitored and detected the malicious activities in the system by observing the actions of connected devices. The detection techniques to detect the changes in the system were decision trees, artificial neural networks, random forest, and k- nearest neighbor. The accuracy of the model was recorded at 91%.

Haque et al. (2021) presented a novel framework SHChecker to analyze the threat in the smart healthcare system. The system used machine learning techniques and formal analyzing techniques to identify the threats. A set of threats was made and tested on a real dataset to prove the effectiveness of the presented framework. Furthermore, the proposed system analyzed both supervised and unsupervised models for black-box smart healthcare systems.

Table No 3: Parameters

Authors		
	Accuracy	**Effectiveness**
[31]	✓	
[32]		✓

2.2.5.4 Smart Healthcare Systems for Heart Patients

Tuli et al. (2018) presented a novel framework "HealthFog" for heart patients using deep learning in a smart healthcare system. The framework combined edge computing and deep learning for the most accurate prediction results. The efficiency of the proposed work was measured in terms of accuracy, latency, power consumption, and execution time through the FogBus framework.

Ali et al. (2022) presented an approach using deep learning and feature fusion techniques for asmart healthcare system for predicting heart disease. First of all, the feature fusion method integrated the derived features from sensor information with electronic health records to provide useful patient information. Secondly, the information collecting method excluded useless and repeated features while focusing on the most essential, reduced computing load, and improved performance of the system. Furthermore, the conditional probability technique calculated a selected feature value for every category, which boosted system efficiency even more. Ultimately, for predicting heart disease, the deep learning model had been developed. The suggested system was compared against existing approaches consisting of feature integration, extraction of features, and weighting algorithms using coronary heart data. The efficiency of the suggested scheme was 98.5 percent, which was better than that of current methods.

Yu et al. (2022) presented a framework based on the “National Institutes of Health Stroke Scale (NIHSS)” for the detection and analysis of heart stroke in old age people over 65 years.In this research machine learning algorithm of the decision tree, C4.5 was used. These algorithms helped in classifying the stroke and analyzing the intensity of the stroke. Thirteen features of the stroke out of eighteen features were used for quicker and more accurate results.The estimated accuracy of the proposed system was 91.11%.

Table No 4: Parameters

Authors	Accuracy	Low Time Consumption	Latency	Low Power Consumption	Efficiency
[33]	✓	✓	✓	✓	
[34]					✓
[35]	✓	✓			

2.2.5.5 Smart Healthcare System for Obese People, Blood Pressure and COVID-19

Machorro-Cano et al. (2018) presented “PISIoT”, a machine learning and IoT-based platform tomonitor, control, and cure obesity in people. The machine learning algorithm API and J48 wereused in this framework to identify patterns and classify the patients. Furthermore, “ApacheMahout” and “RuleML” were used for decision-making. A case study was presented tovalidate the proposed framework. The framework was high in accuracy and lower in response time.

Alazzam et al. (2022) proposed an automatic device approach to detect "Blood Pressure (BP)" and "PhotoPlethysmoGraphy (PPG)" signals. The proposed framework removed the outlying signals created by motion distortions automatically, from the blood pressure signal.

Furthermore, eleven variables from the oscillometric waveform framework were used to investigate the link between the systolic (SBP) and the diastolic blood pressure (DBP). A recommended computational method for calculating blood pressure was proven as a finding ofthe studies. To estimate the diastolic and the systolic stress values given by PPG signalfeatures, the suggested architecture employed advanced regression. The model was consideredaccurate and precise.

Alanazi et al. (2021) proposed a model for the detection of COVID-19 in patients. They developed a “Susceptible, Infected and Recovered (SIR)” model following machine learning.SIR model was used to predict whether will the COVID-19 spread out more or will be controlled in the future. The three scenarios to examine were "the no-action scenario", "the lockdown scenario", and "the new medicines scenario". The proposed system has resulted in effected analysis of the level of the disease. RMLSE was used to achieve accuracy.

Table No 8: Parameters

Authors	Parameters	
	Accuracy	Low Response Time
[36]	✓	✓
[37]	✓	
[38]	✓	

3. Proposed Methodology

The development of IoT-based smart healthcare systems has the potential to revolutionize the healthcare industry by enabling efficient patient monitoring, remote care, and real-time data analysis. This proposed methodology outlines the key steps involved in designing and implementing an IoT-based smart healthcare system to ensure seamless connectivity, data security, and optimal patient care.

3.1 Step 1: System Architecture Design

The first step in developing an IoT-based smart healthcare system is to design the system architecture. This involves identifying the key components and their interactions within the system. The architecture should include IoT devices, sensors, data communication protocols, cloud infrastructure, and analytics platforms. Careful consideration should be given to scalability, interoperability, and the ability to accommodate future expansions.

3.1.1.1 Step 2: Device Selection and Integration

Next, select the appropriate IoT devices and sensors based on the specific healthcare requirements. These devices could include wearable devices, remote monitoring devices, and medical sensors. Itis crucial to choose devices that are compatible with the system architecture and can capture the necessary data accurately. Integration of these devices into the system should be carefully plannedto ensure seamless data flow and communication.

3.1.1.2 Step 3: Data Collection and Transmission

Efficient data collection and transmission are vital for the success of an IoT-based smart healthcaresystem. Develop a data collection strategy that captures relevant patient information, such as vitalsigns, medication adherence, and activity levels. Determine the frequency of data collection and establish protocols for data transmission. Consider security measures, such as encryption and secure data transfer protocols, to protect patient privacy and prevent unauthorized access.

3.1.1.3 Step 4: Cloud Infrastructure and Data Storage

Establish a robust cloud infrastructure to store and process the collected data securely. Cloud platforms offer scalability, data redundancy, and real-time accessibility. Select a cloud service provider that complies with healthcare data security standards, such as HIPAA (Health InsurancePortability and Accountability Act). Implement a data storage strategy that ensures data integrity,backups, and disaster recovery measures.

3.1.1.4 Step 5: Real-time Data Analytics

Leverage data analytics techniques to derive meaningful insights from the collected data. Implement real-time analytics capabilities to enable proactive decision-making and early detection of anomalies. Apply machine learning algorithms to detect patterns, predict health outcomes, and personalize patient care. The analytics platform should provide visualizations, alerts, and notifications to healthcare professionals for timely interventions.

3.1.1.5 Step 6: User Interface and Mobile Applications

Develop user-friendly interfaces and mobile applications for healthcare professionals, patients, andcaregivers. These interfaces should provide access to real-time patient data, analytics insights, and communication features. Design intuitive dashboards, customizable alerts, and interactive visualizations to enable seamless monitoring and efficient care coordination. Ensure compatibilitywith multiple devices and operating systems to enhance usability.

3.1.1.6 Step 7: Security and Privacy Measures

Implement robust security measures to safeguard patient data and maintain privacy. Incorporate authentication protocols, access controls, and encryption techniques to prevent unauthorized access . Develop policies and procedures for data sharing, consent management, and data anonymization when required. Regularly update security systems to address emerging threats andvulnerabilities.

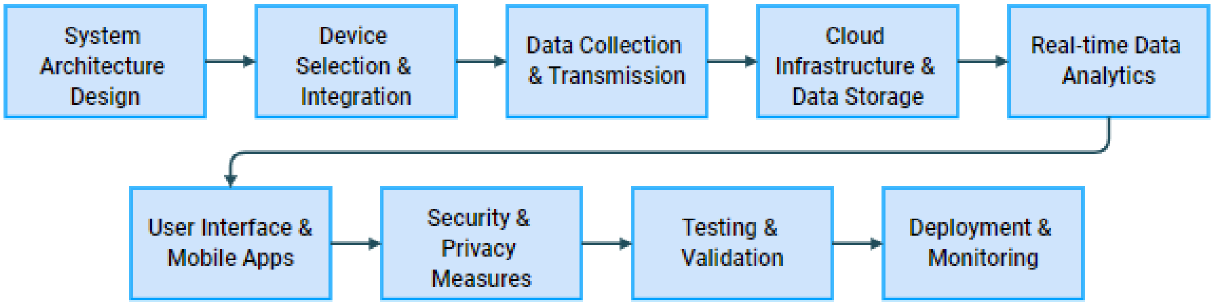
3.1.1.7 Step 8: Testing and Validation

Thoroughly test and validate the IoT-based smart healthcare system before deployment. Conductfunctional testing, performance testing, and security testing to ensure system reliability and accuracy. Engage healthcare professionals and patients in the testing process to gather feedback and make necessary improvements. Validate the system's adherence to regulatory standards and compliance requirements.

3.1.1.8 Step 9: Deployment and Continuous Monitoring

Deploy the IoT-based smart healthcare system in a controlled environment, such as a pilot study or specific healthcare facility. Monitor system performance, data accuracy, and user feedback during the initial deployment phase. Continuously monitor and evaluate the system's effectiveness,scalability, and user satisfaction. Regular updates and system maintenance should be carried out to address any identified issues or to incorporate new features and advancements.

Figure No 4: Flow Chart



4. Conclusion

Smart healthcare systems have the potential to revolutionize patient care by leveraging technology and connectivity. These systems improve patient monitoring, enhance efficiency, enable remote care, and facilitate early disease detection. However, their successful implementation requires addressing challenges such as data security, cost, and user acceptance. With further advancements in AI, IoT, and big data analytics, the future of smart healthcare systems holds exciting possibilities for transforming the healthcare industry.

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