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Improving Quality of Life with Emerging AI and IoT Based Healthcare Monitoring Systems

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ABSTRACT

Two of the technologies that are spreading at the fastest rates in the whole world are artificial intelligence (AI) and the Internet of Things (IoT). Considering the growing number of people who are relocating to urban areas, the idea of a smart city is not new. A smart city is a concept that is centered on the notion of improving the healthcare sector by enhancing its efficiency, cutting expenses, and placing the emphasis back on a better patient care system. In order to successfully use Internet of Things and artificial intelligence for remote healthcare monitoring systems, one must have a comprehensive grasp of the many frameworks that are utilized in smart cities. Traditional healthcare services are not only prone to causing patients to pass away, but they also have the potential to cause delays, squander resources, and result in financial loss. When utilized in combination with the intelligence and prediction capabilities of the Internet of Things (IoT), frequent Remote Patient Monitoring (RPM) at home, at work, or at a hospital may assist persons who especially need it in overcoming challenges that are given by conventional healthcare facilities. The Internet of Things (IoT)-based RPM may act as a precursory warning system for approaching circumstances that, if ignored or treatment is delayed, might result in major health concerns or even patient death. Wearable technologies, sensor networks, and other digital infrastructure are employed in this system. Wearable gadgets (biosensors) that integrate with the internet of things allow medical professionals to obtain real-time vital indicators from their patients. Through the development of a framework that is supported by both the Internet of Things (IoT) and Artificial Intelligence (AI), the purpose of this article is to facilitate the implementation of a Remote Patient Monitoring System that is equipped with data analytics capabilities. Following the implementation of a Remote Patient Monitoring System for the purpose of data collecting, we suggested an algorithm for the diagnosis of diseases.

Keywords: Remote Patient Monitoring (RPM), Internet of Things (IoT), Artificial Intelligence (AI), Data Analytics, Healthcare, UCI Repository.

Introduction

As the population continues to increase, the healthcare industry is confronted with a multitude of issues. Following an exhaustive analysis of the relevant literature, it was discovered that the most prevalent problems associated with healthcare include inadequate communication techniques, insufficient staffing, poor patient flow, and extended hospital stays. Indeed, there is a need to address these issues, which is exactly what the purpose of this work is to achieve. When it comes to the internet of things (IoT), [1] the most important concerns for developers are the availability of resources, the availability of security, and networking. Within the realm of healthcare, the use of the Internet of Things (IoT) [2] has brought about a fundamental change in the manner in which medical services are given and administered. A network of physical objects, such as wearable sensors and medical equipment [3,] that are linked to the internet for the purpose of data gathering, sharing, and analysis is referred to as the Internet of Things (IoT) in the healthcare industry. Because of this technology, patients can now be monitored remotely, data can be accessed in real time, and patient participation and care have been significantly enhanced. Additionally, technology has made it easier to manage resources effectively in healthcare settings, which has led to an improvement in the overall quality of healthcare services. Artificial intelligence (AI) has emerged as a crucial technology in contemporary healthcare systems, pushing breakthroughs in diagnosis [4], treatment planning, and patient care management. All of these advancements are being driven by AI. As a result of their ability to evaluate complicated medical data, find trends, and give insights, artificial intelligence algorithms may support healthcare practitioners in making educated choices [5].

The applications of artificial intelligence span from the creation of customized medicine to the use of predictive analytics in patient care. Additionally, AI plays an important role in research and the discovery of new drugs. AIoT [6] is causing a revolution in the care that is provided in the healthcare industry. Electronic health systems, telecare networks, diagnosis, preventive, rehabilitation, and patient monitoring are all supported by this technology. Wireless Body Area Networks and Radio Frequency Identification systems are two examples of key components that play an important part in the Internet of Things [7], despite the fact that they are not absolutely needed. It has been shown via research that remote health monitoring is within the realm of possibility, showing its potential to dramatically improve the delivery of healthcare in a variety of settings. The use of remote monitoring, for example, makes it possible to observe non-critical patients from home, which reduces the amount of burden placed on hospital resources such as personnel and beds respectively. Due to the fact that RPM has the ability to save lives and provide healthcare services with little expenses and delays, it has the potential to totally revolutionize the way healthcare is delivered in the real world. The research suggests that there are a great number of RPM systems now in use that are capable of resolving the problem that was described before. [9] and [10] are two examples of studies that study the possibility of providing tailored healthcare treatments via remote access. It is necessary to have an eco-system that is capable of reaching RPM. In addition to data analytics and artificial intelligence, a significant number of researchers also made use of other technologies, such as blockchain technology [11], cloud computing [12], and wearable technology [13][14]. In the field of healthcare, the combination of artificial intelligence and the internet of things has the potential to bring about a profound transformation. This integration has the potential to result in more accurate diagnoses, predictive analytics for preventative care, and individualized treatment strategies [15]. This is accomplished by merging the analytical powers of artificial intelligence with the massive data-gathering capabilities of the internet of things. By allowing real-time, data-driven decision-making and automating routine processes, it has the potential to minimize the amount of labour that healthcare personnel have to do and increase the efficiency of healthcare systems [16]. It promises for enhanced patient outcomes.

Related Work

A rising interest in the implementation of the Internet of Things in healthcare is shown by the literature. Studies like as [17] have provided insights into the ways in which Internet of Things (IoT) technology, such as wearable sensors, remote monitoring tools, and linked medical equipment, are transforming the way patients are cared for. These devices are responsible for collecting vital data, which is then used for continuous patient monitoring. This helps to reduce readmissions to the hospital and contributes to the treatment of chronic care conditions. The wearable device that was created by Wu et al. [7] is capable of monitoring a variety of physiological indicators, such as the electrocardiograph (ECG), the heart rate (HR), and the body temperature (BT). It is feasible to determine blood pressure (BP) by measuring electrocardiograms and pulse phonograph readings using the pulse arrival time (PAT) [18]. Due to the fact that all of the components are created within a rigorous framework, the interaction between people and remote monitoring systems is uncomplicated. In addition, the devices have a low power consumption, and they are able to connect wirelessly with one another in order to perform physiological signal assessments that are specifically customized to the individual.

The study on RPMS, which is essential for human life, intensified during the epidemic, according to Boikanyo et al. [19]. Mobility, networks, standards, and quality of service are all among the challenges. The emphasis switched after the year 2020. Using remote monitoring, Yakkala et al. [210] are able to identify potential health problems in groups who are at risk. In order to improve diagnosis accuracy, CNN deep learning guarantees that electrocardiograms are classified accurately.

The Internet of Things (IoT)-based healthcare monitoring system that Hamim et al. [21] present is based on an Android application and is intended for patients and older persons. In this prototype, the sensors capture data on blood temperature (BT), heart rate (HR), and galvanic skin response (GSR), which is then sent into a single system, which is the Arduino Uno platform. The information is uploaded to the cloud storage by the Raspberry Pi. Android Studio was used in the development of the Android application, which allows for the visualization of health parameters that were obtained from patients. By using the program, medical professionals are able to prescribe appropriate medicines and monitor the patient's health throughout the course of time.

The Internet of Things (IoT)-based system that was suggested by Kabir et al. [22] makes use of sensors for remote health monitoring, the detection of cardiac problems, fever, and anomalies, the provision of real-time feedback, and the connection to medical professionals for further diagnosis. The problems of asthma and COVID-19 in Bangladesh are discussed by Rafa et al. [23], with a particular emphasis on telemedicine and real-time monitoring technologies. Access to healthcare and understanding of its importance are both improved by the prototype. According to Wang et al. [24], the Internet of Things (IoT) health monitoring system tackles COVID-19 concerns by providing real-time remote tracking, reducing the burdens placed on healthcare providers, and enhancing pandemic management. The wearable Internet of Things gadget developed by Gomare et al. [25] monitors health measures, saves data in the cloud, enables remote access, and guarantees continuous monitoring with alarms. Several holes in the existing technology are brought to light by a thorough examination of the existing literature. Despite the fact that Internet of Things devices are effective at collecting data, the integration of these devices with healthcare systems often encounters interoperability issues, as pointed out in [26]. In a similar vein, artificial intelligence has shown its potential in the field of data analysis; nevertheless, concerns over the ethical use of AI, biases in AI algorithms, and the need for transparency in AI decision-making [27] have been recurring topics in recent research. In addition, studies such as [28] highlight the absence of established legislation and norms for the combined use of artificial intelligence and the internet of things in the healthcare industry, which is essential for safeguarding the safety of patients and the privacy of their data [29].

Gera et al. [30] focused their attention on a patient health monitoring system that was linked to the Internet of Things (IoT) Cloud Talk platform. This system provides all systems, including medical exams, facilities, and testing, in a single area, which simplifies the typical workflow and makes this system more efficient. Because it is composed of five fundamental components that are capable of carrying out a variety of tasks, this system is capable of being implemented in a real-world setting. These components include the ability to collect patient data from wearable Internet of Things sensors, upload the report to a cloud platform, analyze the findings, and provide medical check-ups, diagnostics, and facilities to patients [31]. In addition to these advantages, the system makes it easier to make better decisions and simplifies the process of traversing the traditional workflow of the typical healthcare system. During the process of device recognition and interaction, this paper addresses a number of problems that may occur [32]. Through the establishment of a foundation for user interoperability, it makes it possible for users of devices to connect with heterogeneous systems that have different configurations by using a language and semantics that are consistent. Within this framework, a new separation strategy is proposed; an approach to device representation is created for real, common, and virtual devices; and a device [33] transformability model is provided to guarantee that device syntax and semantics are changed in the appropriate manner. These recent advancements in the design of Internet of Things technologies have led to the development of intelligent systems that are being used to assist and enhance healthcare and biological procedures [34].

Methodology

In order to monitor and transmit patient health [35] signals for the purpose of real-time analysis and anomaly verification, the design of the Remote Patient Monitoring System (RPM) that has been proposed makes use of technology that is connected to the Internet of Things. Several different sensors are available, each of which is capable of collecting a particular set of physiological information from the patient. The Heart Rate Monitor sensor employs the unit of measurement known as beats per minute (BPM) in order to ascertain the patient's heart rate. [36] [36] In addition to monitoring the systolic and diastolic components of the blood pressure, the Blood

Pressure Sensor (BPS) is a device that measures the blood pressure. In order to collect information on the rhythm of the heart and to diagnose issues such as arrhythmias, the electrocardiogram (ECG) sensor is responsible for recording the electrical activity of the heart. This is a crucial component of the diagnostic process. An instrument known as a temperature sensor is used in order to ascertain the core temperature of the patient. These sensors, after they have been linked to the patient, will provide continuous data that will be processed in real time for the purposes of monitoring [37]. Continuous data collection is performed on the values obtained from these sensors. Zigbee is a low-power, short-range wireless communication protocol that is often used in Internet of Things networks. The data that is gathered by the sensors is then sent to the Internet of Things Gateway. Zigbee is a protocol that is frequently used in wireless communication networks. Establishing a mesh network enables the sensor nodes and the gateway to interact in a trustworthy manner. This is made possible by the mesh network having been established. The transmission of data in an efficient way is essential for monitoring settings such as hospitals and homes, and this helps to guarantee that the data is provided in an effective manner. It is [38] The Internet of Things Gateway is the primary hub that is accountable for processing and sending the data that is collected from the sensors to the cloud. In addition to these three basic duties, it is responsible for the following: In order to build a complete dataset, the gateway gathers data in real time from a variety of sensors. This is done for the goal of generating the dataset. In this way, the loss of data is prevented and the correct monitoring is carried out, as stated in reference [39]. Before the information is sent, the gateway encrypts it [40] in order to prevent unauthorized access or alteration of the data. Not only does this ensure that critical patient data is safeguarded from unauthorized access, but it also ensures that their privacy is maintained. A real-time analysis cannot be performed on all of the data since it is not feasible. Through the elimination of noise and duplicate data, the gateway serves the objective of ensuring that only meaningful and relevant data [41] is sent to the cloud on a regular basis. This procedure is shown in Figure 1.

When sending data to the cloud or to local servers, the Internet of Things Gateway utilizes a variety of communication protocols. These protocols are used to convey data. The use of cellular networks allows for the transport of data at high rates, which is especially useful in circumstances that include mobility or remote monitoring. Wireless fidelity (Wi-Fi) is a wireless networking technology that allows wireless communication inside a home, hospital, or other residential or commercial establishments. In environments that need a connection that is more dependable, such as hospitals and permanent installations, the use of cable transmission is a viable option. The technology known as Low Power Wide Area Network is used in order to realize the goal of providing low-power, long-range communications. Because of this, it is an excellent option for computers and other electronic equipment that are often situated in remote areas and need the transmission of little amounts of data across vast distances.

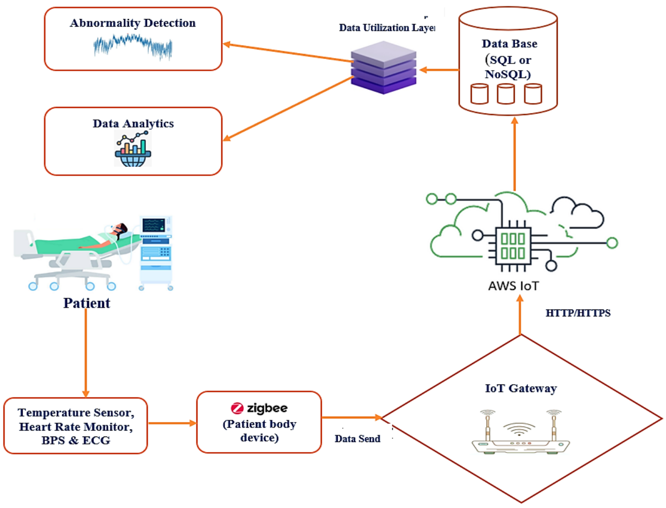

Figure 1: The Proposed Model

Following that, the patient data is sent to Amazon Web Services Internet of Things (AWS IoT), which is a cloud platform operated by Amazon that handles the storage, processing, and real-time analysis of data from Internet of Things (IoT) devices. The Amazon Web Services Internet of Things (AWS IoT) [42] supplies a number of the most essential services for this system, including the following: The information is stored in secured databases (such as Amazon DynamoDB or S3) via the Amazon Web Services Internet of Things (AWS IoT) so that it may be processed further and studied in the past in even greater detail. Protecting sensitive patient information is the responsibility of Amazon Web Services (AWS), which does this by ensuring that the data is secure both while it is in transit and while it is at rest. With the assistance of additional Internet of Things (IoT) services offered by Amazon Web Services (AWS), such as IoT Analytics or AWS Lambda, it is possible to generate real-time insights and alarms. Because of this, medical professionals are able to take immediate action in the event that anomalies present themselves. The Data exploitation Layer is in charge of managing the processing and exploitation of the data that has been obtained and provided. This layer is responsible for managing the data. There are two major functions that it fulfils. The data is analyzed using artificial intelligence and machine learning models, such as LSTM for time-series data, in order to search for anomalies. These abnormalities may include irregular heartbeats, abnormal spikes in blood pressure, or variations in body temperature. It is possible for the system to send a notification to either the patient or the healthcare practitioners in the event that it detects an irregularity.

For the purpose of developing reports, predicting future health events, and gaining an understanding of the evolution of patient patterns over time, applications of advanced analytics are used to the data. Another area that may benefit from data analytics is the administration of long-term healthcare. This helps to make the system more proactive rather than reactive, which is a significant improvement. In order to determine whether the data is stored in structured or unstructured databases, it is necessary to consider both the quantity and the nature of the data. Data that is either transferred to the cloud (AWS IoT) or stored on-premises is categorized as belonging to one of these two categories. This knowledge is useful on many different fronts, including the following: The examination of previous patient data is something that medical practitioners and other providers of healthcare could do in order to arrive at informed decisions. When it comes to training artificial intelligence models that are able to recognize abnormalities and increase the accuracy of the model's predictions, it is very necessary to have access to historical data with which to train these models.

The design demonstrates how sensors connected to the Internet of Things (IoT) are used to continuously monitor the vital signs of patients, as well as how cloud-based services such as Amazon Web Services (AWS) are utilized to assist the secure transmission and storage of this data. A number of different transmission protocols, including 5G, Wi-Fi, Ethernet, and Lightweight Wide Area Network (LPWAN), are used by the Internet of Things Gateway in order to collect, filter, and encrypt the data before it is sent to the cloud. Following that, the data is analysed for the purpose of identifying anomalies and conducting analytics via the use of AI and ML models, which are advantageous for real-time monitoring and predictive healthcare. For the purpose of training, it makes use of the data that is shown in figure 2 from [44], and for testing, it makes use of patient data that was collected via the Internet of Things. When it comes to the diagnostic procedure, MLP is used in combination with feature selection. Within the framework of the performance assessment process, accuracy metrics are used. Metrics that are obtained from the confusion matrix are used in order to assess the performance of the proposed system as well as the approaches that are regarded as being at the cutting edge of the field in terms of forecasting cardiac disease. In order for models to be trained, it is important to gather data for training purposes.

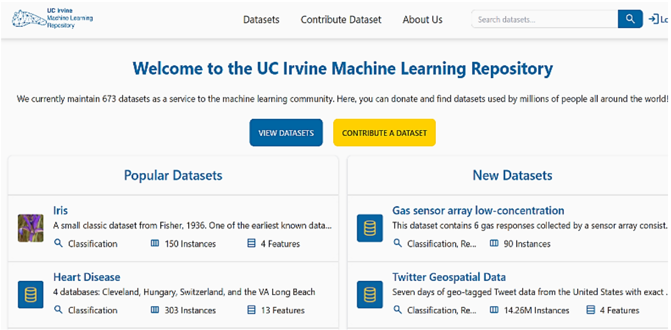

Figure 2: The UCI Repository

In total, the evaluation is comprised of four distinct instances, each of which is based on the actual value as well as the value that was projected. A real positive is an example of a circumstance in which the model accurately detected the sample as having a positive result (heart abnormalities). This is only one example of a genuine positive. Those samples that have been identified by the model as being negative and that do not display any anomalies in the cardiac system are regarded as genuine negatives [45]. A false positive is a sample that the model incorrectly labeled as positive despite the fact that it was negative (no cardiac abnormalities). This particular sample is referred to as a false positive. In the event that the model mistakenly classified a sample as negative when, in fact, it was positive (heart abnormalities), then the sample may be called a false negative.

Outcome

During the process of assessing the system, a patient is engaged in the process. It is estimated that the patient stands at a height of 170 cm. tM is equivalent to nine, tl is similar to sixty, tGT is similar to three, and tAT is similar to four. Throughout the course of the empirical inquiry, the values 2 were taken into consideration as additional parts of the equation. It was necessary to design algorithms that combined the information obtained from accelerometers and gyroscopes in order to enable the detection of falls. The inclusion of these sensors in Android mobile devices was a common feature that was included in all of them. A smart watch that was powered by the Android operating system was able to monitor both the wearer's blood pressure and their heart rate [46]. This system has the power to identify falls that may occur in any direction, including forward, backward, left, and right of the user. It can also detect falls that occur in any direction. An illustration of the precision that may be attained in health data analytics via the use of a variety of models is shown in Figure 3. When it comes to diagnosis, the model's performance is improved when it has a greater level of accuracy, which shows that it is more accurate. The model that was utilized in the case of logistic regression achieved an accuracy of 88.55%, the model that was utilized in genetic algorithm (GA) and recurrent fuzzy neural network (RFNN) achieved an accuracy of 95.94%, the model that was utilized in improved independent component analysis (ICA) achieved an accuracy of 93.55%, the model that was utilized in improved deep neural networks (DNN) achieved an accuracy of 92.86%, and the model that was utilized in artificial neural network (ANN) and analytic hierarchy process (AHP) achieved an accuracy of 90.64%. Artificial intelligence and internet of things enabled remote patient monitoring (AI-IoT-RPM) is the name of the approach that has been offered, and it achieves an accuracy rate of 98.95%. Using this approach, the best possible degree of accuracy is achieved.

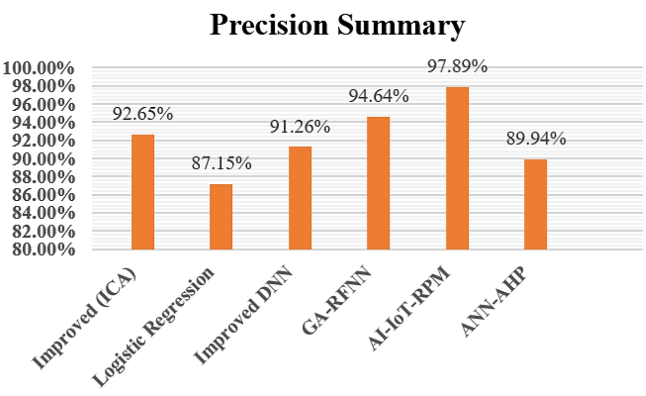

Figure 3: The Precision Comparison of Different Models

Figure 4 illustrates the imperfection rate in health data analytics that is provided by a variety of models.

This rate may be observed in many different models. A reduced error rate is correlated with higher diagnostic performance of the model, and this association exists because of the correlation. The accuracy of the model that was used in logistic regression was 12.85%, the model that was used in genetic algorithm (GA) and recurrent fuzzy neural network (RFNN) was 5.36%, the model that was used in improved independent component analysis (ICA) was 7.35 percent, the model that was used in improved deep neural networks (DNN) was 8.74 percent, and the model that was used in artificial neural network (ANN) and analytic hierarchy process (AHP) achieved 10.06% accuracy.

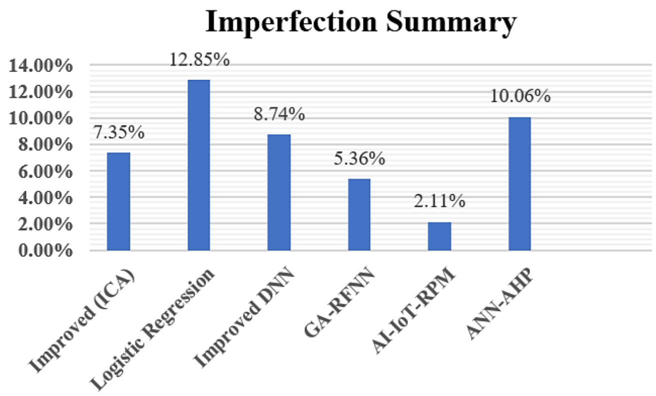

Figure 4: The Imperfection Rate Comparison of Different Models

With an error rate of 0.54, the proposed method that is referred to as AI and IoT Enabled Remote Patient Monitoring (AI-IoT-RPM) is able to achieve the lowest standard deviation that is achievable. When compared to the models that are currently being used, the findings of the trials shown that the model that was recommended had a greater degree of performance levels.

Conclusion

The Internet of Things has the potential to improve medical care in an endless number of different ways with limitless potential. These advantages include a reduction in expenditures in addition to improvements in levels of efficiency, accuracy, and performance across the organization. When it comes to automating healthcare systems in the most efficient way possible, it is now possible to do so thanks to the benefits that come with using the Internet of Things. The Internet of Things (IoT) solutions that have been used in the area of healthcare have evolved from a simple design to complex and advanced systems. In addition, the implementation of artificial intelligence and the internet of things has been of equal relevance in the field of healthcare, where they have played an increasingly important role. In conclusion, the outcomes of this research have shed light on the significant potential that Artificial Intelligence (AI) has in terms of increasing the quality of healthcare systems that are constructed on the Internet of Things (IoT). The marriage of artificial intelligence and internet of things technology has the potential to revolutionize the healthcare business. This is because it has the ability to improve diagnostic accuracy, enable real-time patient monitoring, and simplify the process of developing tailored treatment regimens. Within the scope of this investigation, we proposed the implementation of an artificial intelligence system that is facilitated by the internet of things for the purpose of determining RPM and disease. It is possible to gather data from patients via the usage of the Internet of Things (IoT), and artificial intelligence may be used to identify ailments. Our framework is cloud-assisted, in addition to being adaptable to changing circumstances. It is a solution that is both cost-effective and efficient since it makes use of sensors that are already present in smart phones and wrist watches. For the goal of sickness diagnosis, the MLP model is used by the system that has been recommended. According to the results of our investigation, the approach that was recommended displayed the highest degree of accuracy, with a rate of 98.95% accuracy. In the future, we want to improve our system by including more sensors for the purpose of getting vital signs from patients. Additionally, we will examine the use of deep learning models for the purpose of illness detection.

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