AUTONOMOUS HEALTH MONITORING AND ASSISTANCE SYSTEMS USING IOT

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ABSTRACT
The Internet of Things (IoT) is an essential component of all applications that are focused on the future, including but not limited to smart cities, smart homes, educational institutions, healthcare facilities, transportation networks, and military operations. Apps for the internet of things are extremely crucial to the process of providing medical care because they make it feasible to conduct remote patient monitoring that is both secure and in real time. In the long run, this makes a contribution to an improvement in the overall quality of people's lives. This review article takes a look at the most recent developments that have been made in healthcare monitoring systems by taking a look at how the internet of things (IoT) functions. This research studies the advantages of healthcare systems that are based on the Internet of Things and examines their significance. Additionally, this research investigates the advantages of employing IoT in the medical industry. By doing a literature review on the subject, we are able to present a comprehensive analysis of the most recent research conducted on healthcare monitoring systems that are based on the Internet of Things. The evaluation of the relevant literature incorporates comparative analyses of a number of monitoring, data protection, privacy, and safety measures, as well as the efficacy and efficiency of a variety of different systems. In addition to this, the study offers a classification system for healthcare monitoring sensors and conducts an investigation into monitoring solutions for the Internet of Things that are predicated on wireless and wearable sensors. In addition, we delve even deeper into the challenges that are faced by the healthcare business in terms of maintaining the confidentiality of patient information and ensuring that patients receive adequate levels of service. At the very conclusion of the research project, proposals and recommendations for Internet of Things healthcare applications are offered, along with future directions linked to a range of current advancements in technical innovation.

1. INTRODUCTION

The world as we know it has been radically altered as a result of the enormous changes brought about by technological advancements in a variety of fields. Communication, business operations, education, healthcare, and many other areas have all benefited from its implementation. The rise of digital technology has been instrumental in lowering geographical barriers, broadening our perspectives, and making it easier for businesses to conduct their operations. These days, and particularly in the wake of the COVID-19 outbreak, contemporary intelligent applications have achieved an astonishing amount of popularity and are being employed for a broad variety of purposes, including the provision of medical treatment [1]. In addition, the Internet is a significant technological achievement since it serves as the backbone that unites digital technologies and makes them available all over the world. This makes the Internet a significant technological triumph. This makes the Internet a great achievement in the field of technology. There has been a rise in the importance of social media platforms as authoritative knowledge resources, particularly for the younger generation. Technologies that are portable give users rapid access to a vast amount of material across various social media sites. The Internet of Things (IoT), which is quickly becoming a ground-breaking topic in computer science, is having a substantial influence on a wide variety of aspects that make up our surrounding world [2]. This is due to the fact that IoT connects physical objects to the internet.

The way in which people all over the world work and live has been completely transformed as a result of the introduction of novel ideas and technologies. As a consequence of these technological advancements, we now have things such as smart buildings, smart cars, smart farming, smart cities that are built around smart resource management, and smart smartphones, to name just a few examples. In order to exercise control over a variety of facets of day-to-day life, numerous smart devices play an essential part in both smart cities and smart households. It is anticipated that in the near future, intelligent technologies will soon be able to monitor human actions in real time and collect data using sensors embedded within the body. These data can be sent to professionals in the medical field, which enables them to perform monitoring of human health in real time [3]. The Internet of Medical Things (IoMT) is an initiative that primarily focuses on the inclusion of IoT-based medical equipment. The name of the initiative comes from the abbreviation of its full name, which is the

Internet of Medical Things. The combination of artificial intelligence and wearable technologies has resulted in the opening of new doors of opportunity in the field of internet of things and mobile technology. As a consequence of this, businesses in the healthcare sector now have access to options that were previously inconceivable, which might encourage inventive development. Given the significance of accurate and timely diagnosis and treatment in the field of healthcare, additional efforts are required to bridge the existing gaps and develop intelligent systems for health monitoring [4]. These efforts must take place in order to meet the demands placed on the industry. This is because of the relevance of these two factors.

Because of the increased use of information technology (IT), developed nations are going through a period of transition in the field of medicine. Conventional medical systems frequently have service delays as a result of overpopulation, high energy consumption, and burdensome routine tasks. In addition, conventional medical systems are notorious for their lack of innovation. Wearable sensor devices are being integrated with the smart gadgets that are used by medical practitioners. This phenomenon falls under the umbrella of the Internet of Medical Things (IoMT). This makes it possible to keep track of patients' medical records in real time and makes it simpler to administer tailored treatment. IoMT makes it feasible to monitor patients' health in a manner that is not only efficient but also inexpensive [5]. Due to the ever-increasing rates of chronic diseases, medical systems in third-world nations face a big challenge and are under tremendous strain as a result. This difficulty comes in the form of limited staff and resources. When it comes to the business of medicine, getting to an emergency situation as quickly as possible is of the utmost significance. Figure 1 is an illustration of how IoMT operates within the context of the physical world [6].

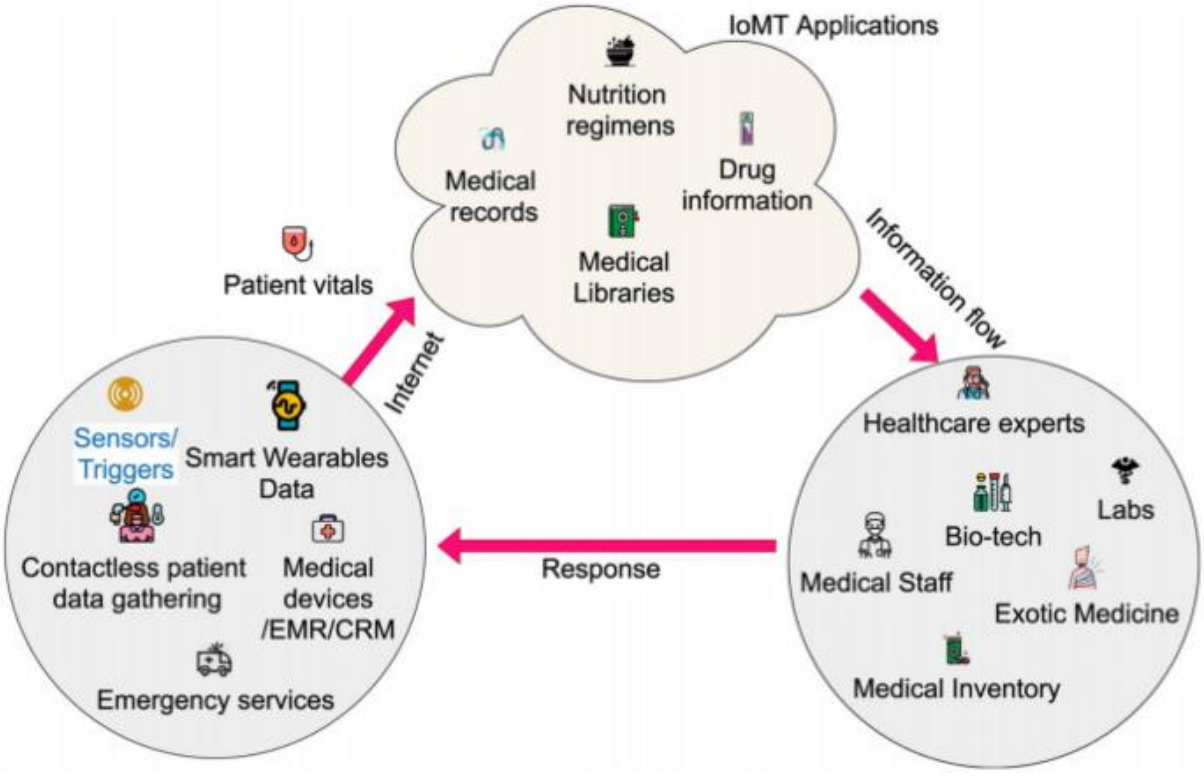


Figure 1Mechanism of IoMT.

2. LITERATURE REVIEW

More than nine percent of China's population was aged 65 or older in 2015, and current demographic trends and future estimates show that number will more than double within the next twenty years (2017–2037) to reach twenty percent. Each year, there are around 646 thousand fatal falls that take place around the world [7], as stated by the World Health Organization (WHO). The bulk of injuries received as a result of these accidents are sustained by adults who are older than 65 years old. As a result of this, it has risen to the position of the second biggest cause of death resulting from an unintentional injury, falling only behind injuries sustained in automobile accidents. Falls are a huge public health hazard for the aged population all over the world. There is no need to state the obvious, but the injuries that older people sustain as a result of falls have a multitude of repercussions, not only for their families but also for the healthcare systems and the society as a whole.

Numerous technological advancements have been made in recent times in order to improve the process of tracking patient data. The amazing strides that have been made in this area have been driven, in large part, by the

advent of sensors, which make it possible to capture and monitor data in real time. These advancements have been made possible as a direct result of these innovations. These days, smart devices come factory-installed with a wide variety of sensors, which enables them to serve as exceptionally effective instruments for the collection of data. For example, a ring-based sensor technology is utilized in the screening process for patients [8]. The patient's cardiac activity can be monitored in real time with the use of this technology, which consists of a ring that the patient wears and which contains a sensor. Patients are evaluated using this method of screening. A similar approach is taken in [9], which makes use of an ear-based sensor technology in order to do continuous monitoring of patients who have heart issues. These sensors make the monitoring procedure easier thanks to their small size and the fact that they may be worn comfortably by people of varying ages.

During medical crises involving the heart, prompt action is absolutely necessary for patients because delays in early identification and inefficient treatment can both result in lethal outcomes. The authors of [10] present a method for early detection that makes use of Internet of Things technologies in conjunction with cloud resources. The management and storage of medical data present considerable obstacles in the field of healthcare; however, significant advancements are possible through the integration of internet of things technology with cloud infrastructure, which provides a high capacity for data storage. A study that was fairly comparable to this one united multiple-layer access with physical access, integrated coding with dynamic channels, and produced an energy-efficient protocol that could be employed in healthcare applications and equipment.This protocol was developed for use in healthcare applications and devices. The optimization of energy use and the extension of the nodes' network lifetime are the two key goals.

Because the COVID-19 pandemic posed such a significant threat to the health of frontline healthcare professionals, additional precautions had to be taken in order to protect themselves while still providing care to patients. This was because the pandemic was caused by the COVID-19 virus. Applications for remote health monitoring were an essential component in the process by which medical professionals were able to accurately diagnose their patients. The installation of these applications is carried out by utilizing devices that are based on the IoT [11]. Applications that process images are used in a variety of public areas to carry out surveillance of the public in real time. The recovery of data based on IoMT by trained medical personnel allows for further analysis to be performed.

IoMT technology has seen the presentation of a variety of methodologies and systems that make use of IoT connectors, as was shown. The glucose level analysis part of the health monitoring system that was suggested by [12] makes use of techniques from machine learning (ML) in conjunction with near-infrared spectroscopy. [12]. It is becoming increasingly popular to use IoMT edge devices for the aim of monitoring human health, which offers findings that are both speedy and exact. In comparison to the methods that are still utilized in the field of research, the error ratio of the glucose level detector that was suggested has been significantly reduced thanks to the improvements made. The article [13] outlines a classification scheme for disorders such tuberculosis, COVID-19, respiratory diseases, and pneumonia. [13] also discusses the classification of diseases. This method demonstrates exceptional effectiveness in diagnosing a variety of ailments and improves the precision with which medical practitioners are able to diagnose diseases. The authors of approach [14] design a remote-controlled ambulance service as part of their methodology. The implementation of artificial intelligence (AI) methods enables the development of discoveries in real time, which is very helpful in medical applications that demand accurate and prompt responses. In a similar vein, [15] devised a system for monitoring cardiac patients that involves the utilization of a smart health band. The data collected from the patient's heart rate via the band is evaluated to determine the patient's overall health state.

3. IOT-BASED HEALTHCARE SYSTEMS AND THEIR APPLICATIONS

The following are some of the ways in which people's lives are made easier by healthcare systems based on the Internet of Things and the applications that run on them:

1. Remote healthcare: The patient no longer needs to travel to the location where they will receive care since wireless solutions made possible by the Internet of Things are able to bring healthcare directly to the patient. The Internet of Things (IoT)-based sensors are used to collect data in a safe manner, and after that, the data are sent to a cloud serviceafter being analyzed by a simple algorithm, the data are then communicated to medical specialists so that they can make recommendations that are pertinent to the situation.
2. Real-time monitoring: The collection of extensive psychological data makes use of sensors that are powered by the Internet of Things and are not invasive in any way. Gateways and cloud-based analysis are utilized in order to effectively manage the storage of data.
3. Preventive care: The utilization of sensor data in Internet of Things (IoT) healthcare systems enables the early detection of potential dangers and notifies loved ones about any developing situations. The monitoring of health trends and the early diagnosis of abnormalities are both accomplished through the application of machine learning [12]. One technology that is used to accomplish machine learning is the Internet of Things approach.

3.1. The Significance of IoT-Based Healthcare-Monitoring Systems

Researchers working in the medical area and professionals working in the industry are devoting a significant amount of their time and energy to the creation of monitoring systems for the medical industry. There have been a number of productive research endeavors completed in this field, and many more are in the process of being carried out [13]. The constantly expanding population of elderly persons as well as patients suffering from chronic illnesses is directly responsible for the large increase in the number of care gaps that are being provided by healthcare professionals. The fact that medical treatment is only provided in hospitals is the system's most fundamental shortcoming; As a consequence of this, it is not appropriate for persons of advanced age or those with disabilities, and it cannot reliably fulfill the criteria that these groups have [14]. The Internet of Things (IoT), coupled with the support of sensor values and telecommunications, offers a solution to the problem of real-time monitoring of the health condition of senior people that is both effective and realistic. This solution was developed to address the issue of monitoring the health of elderly people. When intelligent technology is linked with the Internet of Things, as has been demonstrated, it is feasible to deliver a wide variety of services that are not only improved but also taken to a higher level. This is something that was not before achievable. Researchers have developed a wide variety of emergency response systems by utilizing a number of technologies that enable intelligent and remote wireless communication. These systems can be used in a variety of settings. During the process of designing these systems, the sensors were the primary focal point of the design process. These technologies have been put to use in a wide variety of medical applications, the most prominent of which is the objective of monitoring the health of elderly individuals. This approach of collecting critical vital signs enables the collection of information on a wide number of issues, ranging from the overall health of an individual to the presence of disorders that could be potentially detrimental [15].

3.2. Benefits of Using IoT in Healthcare

The Internet of Things is going to have a significant impact on the delivery of medical care in the future, and this will occur in a variety of different situations. In order to provide answers for healthcare issues, we have reached a whole new degree of evolution in the manner in which individuals, applications, and devices connect with one another. This evolution has allowed us to accomplish a brand new degree of evolution. [16] The Internet of Things has provided us with a fresh viewpoint as well as the tools necessary to build an integrated healthcare network, which has resulted in a significant rise in the standard of medical care.

The Internet of Things has made it possible to automate medical processes that, in the past, required a large amount of time and gave possibility for error because humans were engaged in the process. Until recently, this was not possible. The ventilation and temperature in operating rooms at many hospitals, for instance, are now controlled by pieces of technology that are connected to a network. This allows for more precision in patient care.

The Internet of Things has the potential to improve medical treatment in what seems to be an almost infinite number of different ways; nonetheless, the following are some of the most significant advantages:

- A decrease in the cost of care.
- There will be fewer mistakes made by humans.
- The removal of the constraints that are imposed by distance.
- Less paperwork and less time spent keeping records has been achieved.
- Early detection of chronic disorders allows for better treatment.
- Medication management has shown significant improvements.
- The pressing requirement for immediate medical attention.
- Better results from the treatment.

4. PROPOSED FRAMEWORK OF INTELLIGENT HEALTHCARE SYSTEM

This section of the article provides a summary of a healthcare platform that is based on the internet of things and is designed to cater to the requirements of patients who are suffering with heart failure. The platform was developed to meet the needs of patients who have been diagnosed with congestive heart failure. The incorporation of a number of different technologies, including as artificial intelligence (AI), cloud services, and the Internet of Things, is a part of the framework. The suggested organizational structure for the intelligent healthcare system is depicted in Figure 2. [17] This framework makes it possible for medical staff to easily monitor patients' health by utilizing gadgets that are connected to the internet of things. By utilizing cloud computing and the internet of things, it is feasible to get the medical records of patients who are having heart failure at any time and from any location in any part of the world. The suggested architectural layout is depicted in its entirety by the first algorithm presented in this text, which is referred to as Algorithm 1.

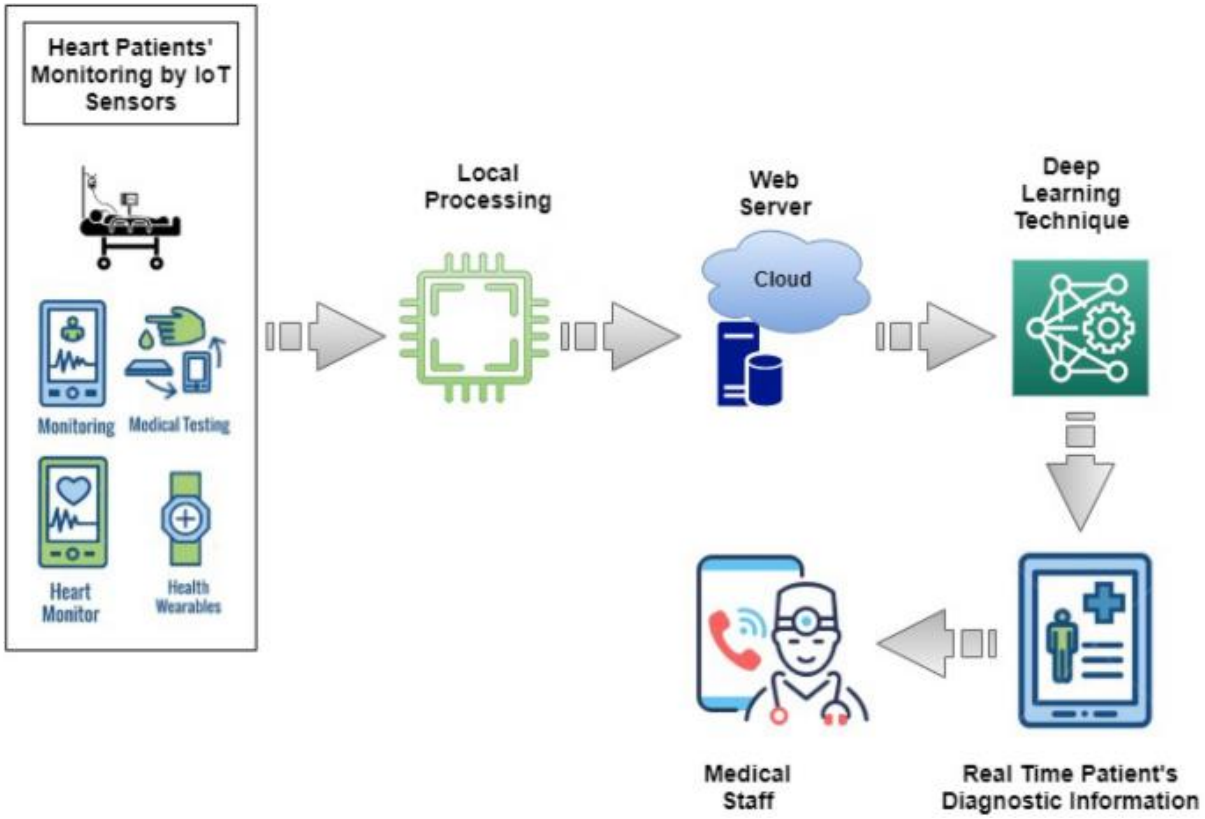


Figure 2 The Methodology Behind an Observational System Based on the Internet of Things.

Algorithm 1

1: **Read:** patient history records, prescriptions, and Medical healthcare labs.
2: **Connect:** Establish a connection to Firebase and interact with the database.
3: **Authentication:** verification from Healthcare system.
4: **if** Communication == 'True' **then**
5: Sending health data using JSON file.
6: Deep learning techniques utilize medical analysis data to generate predictive insights.
7: The generated predictions are then utilized in creating patient history reports.
8: Transfer the medical history report from Firebase cloud storage to the designated medical expert device.
9: **else**
10: The patient's medical data is also stored in the device's local storage.
11: When a successful connection is established, the local storage data is transferred to Firebase.
12: **end if**

Activities carried out as part of the method of creating an Internet of Things-based cardiac monitoring system.

Integrating security measures into the infrastructure of an intelligent healthcare system that is based on the internet of things can be accomplished with the help of Zigbee and Firebase authentication, which can be utilized in this context. [18] First, the JSON file needs to be encrypted using 128-bit keys before it can be tokenized and provided over the network for data transfer. After that, the file may then be delivered over the network for tokenization. Firebase authentication is utilized in order to validate the device token by generating a token that consists of appropriate credentials in addition to customs token claims. After that, this token is put to use in order to validate the device token. After that, this token is presented to the user for their review and authorization so that the transaction can continue. When there is a real-time data exchange between devices, the user's identity is validated by utilizing a device-generated 128-bit token in conjunction with a Firebase custom token. This is done whenever there is a data exchange between devices. These two tokens are produced by the relevant devices at the time of their use. Authentication is the first step in the authorization process, which then uses the standard Security rules provided by Firebase. The security mechanism of Firebase may be simplified into a three-step security measure, which is explained in more detail as follows:

- The device token provides the assurance that a certain request was sent from the designated device; however, it does not include any information that could be construed as being helpful to the user. Its sole purpose

is to act as the assurance that the specified device made the request..

- A user's entire data set, with the exception of their profile information, is contained within a custom token. In addition, Firebase servers are unable to depend on the authenticity of this token due to the fact that the service account that is used by our Cloud Function could not always have authorization. This is one of the reasons why the reliability of this token cannot be guaranteed at all times. For instance, there might be circumstances in which we choose to render the token useless or alter the encryption key that is associated with it.
- Utilizing the signInWithCustomToken API allows for the claims that are housed within a custom token to be subjected to validation. This may be performed in a number of different ways. When that step is complete, the backend will generate a Firebase ID token specifically for the user. This token will serve as unarguable evidence that the bearer is allowed to operate on the user's behalf and will include the user's profile information as well. This token, which is good for one hour after it has been used, cannot be rendered invalid.

Figure 2 illustrates, in the context of the Internet of Things (IoT), the method by which intelligent technologies make it possible to transfer and update patient data. This method enables intelligent systems to allow for more efficient healthcare. [19] The requirements of both the patient care facility and the hospital will be taken into consideration when selecting the various pieces of medical equipment that will be used. It will be much simpler for patients to gain rapid access to emergency medical care whenever it is necessary for them to do so because the structure that is being explored makes it possible to monitor patient data in real time. Because the information is kept in the cloud, medical experts are able to have access to it from a remote location and provide recommendations for patients depending on the patients' present physical condition.

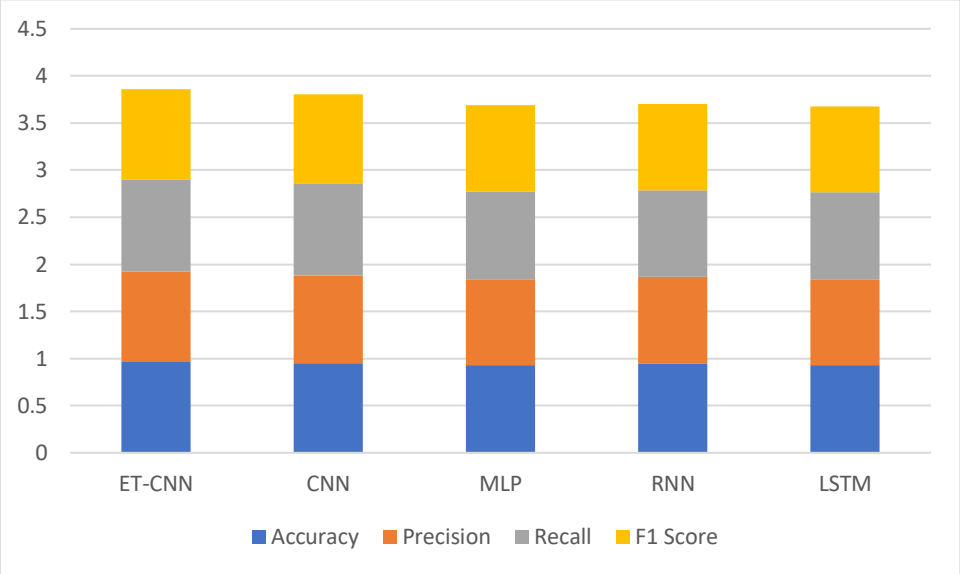
The fundamental purpose of this ingenious system is to boost the odds of patients surviving heart-related disorders by providing a monitoring solution that is not only economical but also dependable, trustworthy, and simple to use. [20-27] This is accomplished by giving a solution that monitors the patient's vital signs in a manner that can be easily understood by the patient. The proposed system will gather information from a wide variety of sources, then send that information to the cloud, where it will be processed using ML and deep learning models. Access to organized data is so made easier for medical practitioners, thereby promoting more thorough investigations and analyses.

5. RESULTS AND DISCUSSION

The results of real-time data that were analyzed using deep learning models are presented in Table 1. Because of their superior performance, deep learning models have largely supplanted traditional machine learning models as the models of choice. The projected ET-CNN model has substantial performance, exceeding MLP, RNN, and LSTM models with an accuracy value of 0.9718. The value represents the model's level of precision. Using models that make use of deep learning has a number of advantages, and this is one of them. The accuracy of the RNN model increases to 0.9449 when it is used in conjunction with the CNN model. The combination of the two models allows for the successful completion of this task. The F1 score and precision attained by the suggested CNN model are noticeably greater than those attained by any of the other models. This is the case when comparing the suggested CNN model to all of the other models. In terms of recall scores, it once again surpassed the other models, receiving the best possible score of 0.98 out of a potential 1.00. This is the greatest score conceivable.

Table 1An examination of the relative merits of various deep learning models with regard to their use of real-time data.

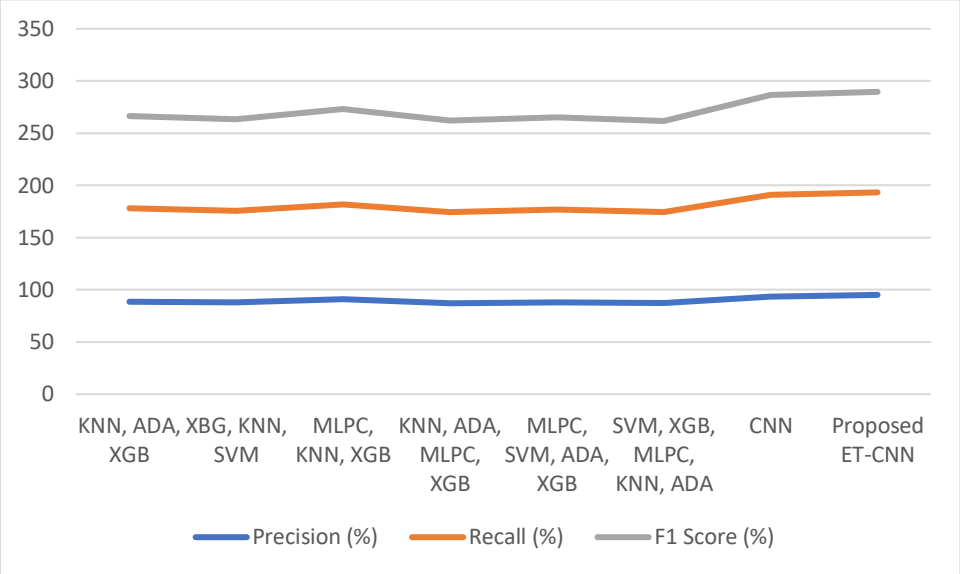
Model	Accuracy	Precision	Recall	F1 Score
ET-CNN	0.9718	0.95	0.98	0.96
CNN	0.9534	0.93	0.97	0.95
MLP	0.9302	0.91	0.93	0.92
RNN	0.9449	0.92	0.92	0.92
LSTM	0.9329	0.91	0.92	0.91



We evaluate the efficacy of our proposed healthcare monitoring strategy for cardiac patients by comparing it to the industry's presently existing well-established and forward-thinking ways. The work that was cited created an ensemble method to create a cardiovascular risk prediction system that was based on the internet of things. This system was able to forecast the likelihood of cardiovascular disease. However, it is essential to keep in mind that using ensemble approaches can result in an increase in both the complexity of the problem and the amount of computational resources needed, which may not be appropriate for health-related systems. In addition, problems with overfitting can arise from the application of these approaches if they are not carried out correctly. The performance of several models, including proposed and cited ones, is compared in Table 14. The findings make it abundantly evident that the method that was suggested is superior to the study that was described, demonstrating its superior performance as well as its effectiveness in health monitoring applications.

Table 2Comparative analysis of the proposed method's performance with that of previously conducted research.

Voting classifiers	Precision (%)	Recall (%)	F1 Score (%)
KNN, ADA, XGB	88.8	89.0	88.9
XBG, KNN, SVM	87.8	87.8	87.8
MLPC, KNN, XGB	91.0	91.0	91.0
KNN, ADA, MLPC, XGB	87.1	87.5	87.3
MLPC, SVM, ADA, XGB	88.2	88.6	88.4
SVM, XGB, MLPC, KNN, ADA	87.2	87.3	87.2
CNN	93.4	97.5	95.6
Proposed ET-CNN	95.1	98.24	96.3



CONCLUSIONS

Monitoring individuals who are experiencing acute heart conditions is extremely important in order to respond quickly in the event of an emergency. Recently, it has come to light that solutions based on the Internet of Things (IoT) and artificial intelligence could potentially be utilized to improve medical care. The implementation of IoT technology has made it feasible for medical practitioners to acquire access to the records of patients without the patients being necessary to physically visit medical institutions in order to obtain this information. The purpose of this study is to present the construction of a health monitoring system with the objective of monitoring the individuals' health status who are suffering from critical heart failure. Patients who suffer from chronic illnesses have a better chance of surviving because to the newly suggested healthcare system, which also provides monitoring that is more convenient, more cost-effective, and more dependable for cardiac patients. The information provided by patients is gathered by the technology and then uploaded to the cloud in order to undergo additional analysis. In addition, the findings of this study suggest the utilization of an extra tree classifier in conjunction with an upgraded convolutional neural network model for the aim of accurate identification of individuals who have cardiac difficulties. It is determined how well this model performs in comparison to a variety of different approaches to deep learning, machine learning, and transfer learning.

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