Uluslararası İleri Doğa Bilimleri ve Mühendislik Araştırmaları Dergisi
Sayı 7, S. 394-399, 4, 2023

Araştırma Makalesi

IJANSER
https://as-proceeding.com/index.php/ijanser
ISSN: 2980-0811

International Journal of Advanced Natural Sciences and Engineering Researches
Volume 7, pp. 394-399, 4, 2023

Research Article

Developing a Low-Cost IoT based Remote Cardiovascular Patient Monitoring System in Pakistan

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(Received: 11 May 2023, Accepted: 25 May 2023)

(DOI: 10.59287/ijanser.743)

(1st International Conference on Contemporary Academic Research ICCAR 2023, May 17-19, 2023)

ATIF/REFERENCE: Awais, M., Ali, R., Iqbal, J. & Shahzad, F. (2023). Developing a Low-Cost IoT based Remote Cardiovascular Patient Monitoring System in Pakistan**.** *International Journal of Advanced Natural Sciences and Engineering Researches*, 7(4), 394- 399.

Abstract – Several issues with conventional cardiovascular monitoring devices are intended to be addressed by a low-cost IoT-based remote cardiovascular patient monitoring system. These difficulties include the high cost of conventional devices, poor accessibility, and the requirement for repeated trips to the doctor. The system enables patients to remotely monitor their vital signs and receive real-time notifications in case of any irregularities, making it a more affordable and accessible option than traditional monitoring equipment. As a result, patients will require fewer trips to the hospital, increasing accessibility and convenience of healthcare. In case of any irregularities or trends that call for medical attention, the system also provides continuous monitoring, ensuring prompt care. The low-cost IoT-based remote cardiovascular patient monitoring system has the potential to revolutionize the way healthcare is provided, particularly in situations with limited resources. It does this by offering patients with cardiovascular problems constant, affordable, and accessible monitoring. Additionally, it can lessen the strain on medical facilities, freeing up resources and enabling healthcare professionals to concentrate on cases that are more urgent. This system is therefore necessary due to the drawbacks of conventional monitoring devices, and it can address the issues of limited accessibility and cost-effectiveness by giving patients a more practical and effective way to monitor their vital signs and receive prompt medical care.

Keywords – Cardiovascular, ECG, Cloud Computing, Blood Pressure, Heart Rate.

I. INTRODUCTION

The term "internet of things" (IoT) is used to describe a wide range of physical items and settings that are wired or wirelessly connected to the internet and may be monitored and controlled by apps on mobile devices, tablets, and personal computers. The Internet of Things (IoT) originally referred to a single identified device that employed radio frequency identification technology (RFID) in a manner akin to how the internet is organized. The Internet of Things (IoT) idea was created based on the development of more objects, a wide range of

sensors, and modules with a cloud for many applications, including smart environments, indoor navigation systems, crowdsourcing and sensing, and mobile sensor networks [1].

The Internet of Things (IoT), which combines existing frameworks, sensors, and programming, does have the possibility of completely change the healthcare sector by allowing more efficient and successful patient care in addition to bettering the administration and service delivery for healthcare as a whole. The use of sensors decreases the possibility of human mistake, assures better care and treatment, lowers healthcare expenses, minimizes the amount of space needed in the room, and enhances overall performance. Patients' daily life in Pakistan are impacted since they are not treated effectively and promptly. Hospitals may find it challenging to constantly review patient status. Patients in critical care cannot be continuously monitored. It is difficult to monitor patient circumstances without monitoring systems.

Patients with serious injuries and those from particular locations could have trouble getting to the hospital. The design and development of a trustworthy and consistent patient monitoring system is revealed in the current invention in order to enhance patient care. This system enables physicians to keep an eye on their patients whether they are at home or in the hospital [2].

The most common telemedicine use cases in the medical and scientific domains include real time monitoring, virtual radiology, online counseling, mobile medicine, and optimal control of medical medications and equipment to accomplish individual healthcare management and health information management.

Wearable biomedical gadgets for monitoring vital signs are currently advancing quickly. The development of wearable biomedical devices depends on factors like cheap cost, minimal power usage, compact size, and intelligence. Real-time perception of health data and sustainability of hospital facilities are just two benefits of wearable medical technology.

They are able to monitor human life traits and health issues in real-time, assisting individuals in understanding their medical states and spotting signs before they become serious. The price and energy usage of wearable devices have been significantly decreased because to improved microcontrollers, while their performance has significantly increased. Wearable technology now has a higher level of intelligence due to Machine learning and the IoT.

An important area of study and development in the realm of telemedicine is wearable biomedical devices. Also, it's critical to ensure the quick growth of telemedicine. The bulk of the wearable device market is anticipated to be dominated by medical and health-related wearables [3].

In Pakistan people have average income they can't afford fees of cardiovascular specialists and there are many issues related traffic if someone getting late in hospital due to traffic it may cause death of patient. Cardiovascular disease patients may not completely comprehend their condition or the drugs and therapies they are getting, which can cause them to adhere to treatment programs poorly and result in worse outcomes. To offer real-time monitoring and analysis of vital physiological indicators for patients with cardiovascular diseases is the problem statement for a cardiovascular patient monitoring system. Heart rate, blood pressure, oxygen saturation levels, and electrocardiogram (ECG) values should all be continually monitored and recorded by this system. When aberrant values are found or when people need emergency medical treatment, the system should warn healthcare professionals as well. By identifying possible problems early, permitting prompt responses, and lowering the probability of negative occurrences, this approach seeks to enhance patient outcomes. In addition, the system has to be simple for healthcare professionals to use, with understandable displays and instructions for understanding the data.

II. Literature Review

A smart and safe internet of things method for the healthcare sector that continuously and remotely tracks the patient's heart rate. The suggested method makes quick, informed judgements in an emergency situation and even identify a severe state before it even arises. Based on the testing, the suggested method is practical, dependable, and affordably secures data. Regarding the operational effectiveness of the system, the suggested algorithm performs better than alternative algorithms. It is better suited to IoT devices and other gadgets with limited processing, storage, and power [4].

The design of an IoT-based heart disease remote monitoring system dubbed Remote heart. To assess patient biological data including blood pressure, oxygen levels, ECG, PPG, and heart rate, the system makes use of Internet of Things (IoT) sensors. Periodically, the data is uploaded to a hospital information management system where machine learning techniques are used to analyzes it. For improved decision-making on the condition of patients and their care, a decision tree is built and presented to healthcare providers [5].

The Internet of Things (IoT) is being used to create a smart health monitoring system that can track a person's temperature, heart rate, blood pressure, and oxygen saturation. This approach is useful in rural or village settings where neighboring clinics may communicate with city hospitals on the medical problems of their patients. Nonetheless, the IoT system will notify the doctor or physician in the event that any changes in the patient's health based on standard values take place [6].

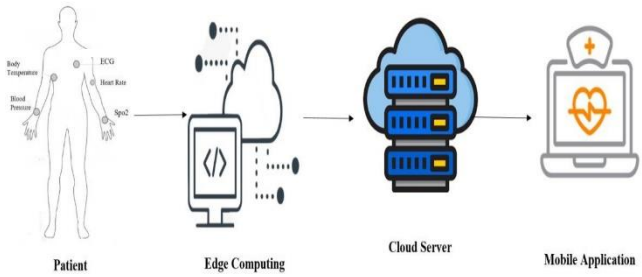
An Internet of Things (IoT)-enabled health monitoring gadget is created utilizing machine learning models to track patients' activities, such as jogging, sleeping, walking, and exercising, as well as their vital signs, such as their heart rate and body temperature, as well as their breathing patterns. To determine the patient's varied activities and examine the patient's respiratory health during those activities, machine learning models are utilized [7].

To obtain the patient's heart rate, a pulse sensor is fastened to their fingertip. Further transmission of the patient's data occurs to the microcontroller, which then sends the information to the Thing-Speak cloud service. Real-time patient monitoring is provided by SHRMS, which also assists with providing emergency aid in accordance with the patient's current needs [8].

The system will use Bluetooth to transmit data to a mobile application while also measuring a patient's body temperature, heart rate, and blood oxygen saturation (SpO2) levels [9].

The patient's relative oxygen ratio, plethysmogram, and pulse rate are the system's main areas of attention. With IoT technology, the collected data is moved from the wireless sensor network to the main database [10].

The AD8382 ECG sensor to read patient data, Arduino Uno, ESP8266 Wi-Fi module, and IoT Blynk application make up the suggested ECG monitoring system. The suggested ECG healthcare



system's implementation enables the doctor to monitor the patient from a distance using the IoT Blynk application, which is loaded on his smartphone and processes and visualizes the patient's ECG signal. Without the necessity for a hospital, the monitoring procedure may be carried out whenever and wherever [11].

Utilizing the My Signals development shield and the Lora (Low power, long range) wireless network technology, create an Internet of Things-based health monitoring system. My Signals and Lora have been utilized with oxygen saturation, body temperature, pulse rate, and electrocardiogram (ECG) sensors [12].

III. Materials and Method

System Architecture: For the system to monitor the patient's vital signs, including heart rate, blood pressure, oxygen saturation, it needs a variety of sensors (ECG). The data from these sensors is processed by a microcontroller or microprocessor before being sent to a cloud server.

Edge computing is use for the purpose with local processing and analysis, edge computing shortens the distance that data must travel from the sensors to the cloud server. This leads to quicker reaction times and lowers the possibility of crucial delays that can affect patient care. Edge computing allows for the collection and local processing of data even in the absence of network access. This raises the system's dependability and lowers the chance of data loss as a result of network outages.

By enabling data to be processed and analyzed locally, edge computing may offer an extra layer of protection by lowering the likelihood of data breaches and assaults. The cost of the patient monitoring system can be decreased overall with the aid of edge computing.

The data obtained from the IoT sensors must be stored, processed, and analyzed by the cloud server. To find patterns in the data and spot anomalies, it employs artificial intelligence and machine learning techniques. In the event of critical situations, the server can also notify medical specialists.
Patients must have a user interface to access their data, and healthcare providers must have one to remotely check on their patients' health. An online or smartphone application that provides real- time data.

Fig. 1 System Architecture

Stage Diagram: The first step is gathering information from the patient's linked IoT sensors, such as heart rate, blood pressure, and ECG. The edge computing device, which might be a tiny computer or microcontroller, receives the data from the sensors and processes it and analyses it first.
The edge computing device processes and analyses the data gathered from the sensors in the second stage. Before sending the data to the cloud server, pre-processing, filtering, and compression are involved. Edge computing aids in minimising the volume of data that must be sent to the cloud, lowering the latency and bandwidth requirements of the network.
The third stage involves further processing, analysis, and storage once the data is received by the cloud server. To find trends in the data and spot anomalies in the patient's vital signs, the cloud server employs machine learning and artificial intelligence algorithms. After processing, the material is put into a database where it may be later retrieved and examined.
The display and analysis of the data by patients and healthcare professionals constitutes the last phase. The user interface, which might be a web or mobile application, enables the user to access real-time statistics, alarms, and suggestions based on the data gathered. Healthcare professionals can remotely check on the health of their patients and use the information gathered to make wise decisions.

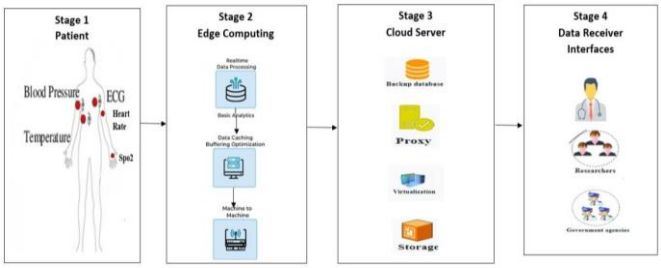


Fig. 2 Stage Diagram of System

Block Diagram: Block Diagram represents how system work and doctors can monitor the health of their patients remotely and in real-time while also minimizing the quantity of data that has to be transferred to the cloud thanks to the Low-Cost IoT based Remote Cardiovascular Patient Monitoring System that integrates both edge computing and cloud server. As a result, the system is more effective and economical.
The system is made up of sensors that are used to gather patient data, including ECG sensors, blood pressure sensors, heart rate, Spo2, and body temperature sensors.
The microcontroller, which is in charge of processing and transferring the data to the edge computing device, receives the received data once it has been collected. Real-time data processing and analysis are performed by the edge computing device. This gadget has the ability to filter data, aggregate data, and compress data. This makes the system more effective by lowering the quantity of data that must be transferred to the cloud server.
The edge computing device is connected to the internet through Wi-Fi or cellular network. This makes it possible for real-time data transmission to the cloud server. The clinician may examine the patient's data in real-time on a web-based dashboard. The doctor can make educated judgements about the patient's care because to the dashboard's full perspective of the patient's state.

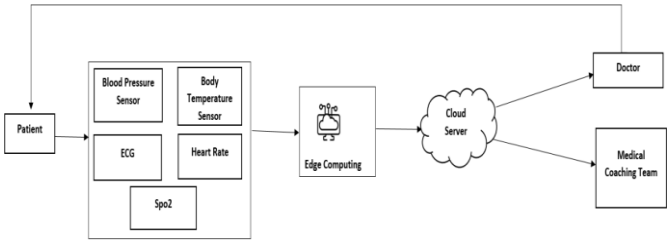


Fig. 3 Block Diagram of System

Flowchart: The process of gathering, processing, and analysing patient data in real-time while also sending alarms and messages to medical specialists in case of severe circumstances is shown in the flowchart for a Low-Cost IoT based Remote Cardiovascular Patient Monitoring System.

Fig. 4 Flow Chart of System

Working: The patient's location is equipped with the necessary hardware, such as a blood pressure monitor, heart rate monitor, spo2 monitor, ECG monitor, body temperature monitor, and IoT device. The patient's vital indicators, including body temperature, blood pressure, heart rate, spo2, and ECG, are recorded by the monitoring devices. Through Bluetooth or Wi-Fi, the IoT device receives data from the monitoring devices, and then uses an internet connection to send it to the cloud platform. The patient's data is securely stored on the cloud platform, protecting its integrity and confidentiality.

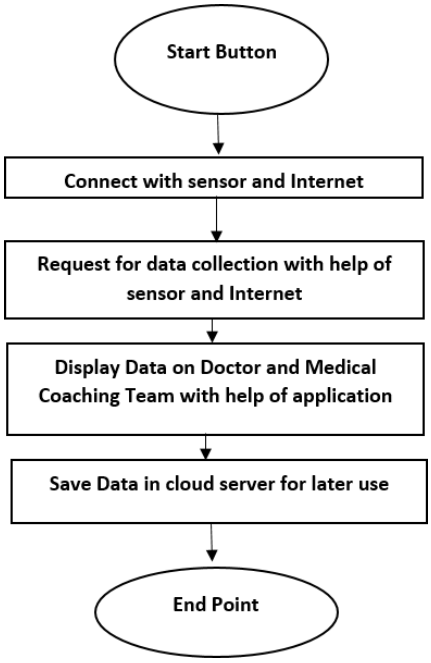
In order to find any anomalies or irregularities that might need medical attention, machine learning algorithms are used to analyse the patient's data. To help people access their information and engage with healthcare professionals, a mobile app and web portal are being created. Patients may view the information about their vital signs, get warnings for unusual readings, and contact with healthcare professionals for any medical assistance. Through a web portal, medical professionals can interact with patients and view their data. If any aberrant readings or trends are detected that demand medical attention, the system can be set up to send warnings and alerts to the patient and their healthcare professionals. The system can be configured to continually monitor the patient's medical data and to update the patient and healthcare professionals in real-time.

IV. RESULTS

For patients with cardiovascular diseases who require ongoing monitoring of their vital signs, a low-cost Internet of Things-based remote cardiovascular patient monitoring system is an achievable option. The system has a number of benefits, such as: system enables patients to speak with healthcare practitioners remotely, decreasing the need for frequent in-person visits and lowering the danger of exposure to infectious diseases. It is also affordable, continuous monitoring, real-time alerts, and accessible.

V. DISCUSSION

Patients with cardiovascular diseases who need continuous monitoring of their vital signs have a promising new option in the form of a low-cost IoT-based remote cardiovascular patient monitoring system. Patients now have greater control and understanding of their medical condition because to the system's ability to access their vital sign data from any location and at any time.



Patients who might not have enough money to pay conventional monitoring devices can use the system because it is meant to be cost-effective. The system is capable of providing continuous monitoring, ensuring that patients get prompt medical care in the event of any anomalies or patterns that call for attention. In the event of any trends or irregularities that call for medical attention, the system may immediately warn patients as well as healthcare professionals. The system makes it possible for patients to communicate with medical professionals remotely, doing away with the necessity for regular in-person visits and lowering the danger of contracting contagious infections.

VI. CONCLUSION

The low-cost Internet of Things-based remote cardiovascular patient monitoring system is a promising solution that makes use of contemporary technologies to enhance patient participation and access to healthcare. The system enables continuous

monitoring, enabling patients to check their vital sign data remotely, and delivers real-time notifications to both patients and healthcare providers in case of any irregularities or patterns that call for medical attention. By offering patients with cardiovascular problems convenient, affordable, and ongoing monitoring, low-cost IoT-based remote cardiovascular patient monitoring systems have the potential to revolutionize the way healthcare is provided, particularly in places with limited resources.

ACKNOWLEDGMENT

Thankfully, we are aware of our parent's affection for us. Last but not least, we would like to thank our family and friends whose prayers made it possible for us to finish this project.

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