Industrial Engineering Journal
ISSN: 0970-2555
Volume : 50, Issue 9, No. 1, September : 2021

Cloud-based IoT-enabled e-Healthcare system for remote patient care

Y.HARINATH
Assistant Professor
harinath5404@gmail.com

T. KRISHNA MURTHY
Assistant professor
taticherla.krishnamurthy@gmail.com

NAMBURI UPENDRA BABU
Assistant Professor
upendraalts@gmail.com

Abstract. This study presents a low-cost system architecture for an e-healthcare service, encompassing both software and hardware components. From the patient's location, vital signs are measured and communicated with a licensed medical expert for consultation. Temperature and heart rate are the primary signals acquired from a patient during the system's early development. Data is sent to a server in the cloud, where processing and analysis are offered for the medical professional's review. A safe transmission and distribution of data via the cloud server is provided, as well as an authentication system and a secure storage server for the cloud that the patient may operate from a mobile device. All the system's components are included into a prototype for testing, and the obstacles of implementing the system in real time have been highlighted.

Keywords: Arduino UNO; healthcare; heart rate sensor; temperature sensor, FFT

1 Introduction

Modern medical care is very expensive, difficult, and time-consuming. With an increasing population, hospitals are always overcrowded, and patients must wait a long time to see a doctor. Although worthy people get emergency medical attention, others are continually waiting in line. Existing systems function in such a manner that patients are required to through a rigorous process even if they do not need significant care. Likewise, hospitals are mostly found in urban areas. People living in rural places benefit from telemedicine technologies that link them to hospitals in urban areas for consultations with experienced physicians. If a person or community is equipped with simple, cost-effective gadgets that capture a measurement of vital signs and send it to a licensed doctor for online consultation, then not every case requires immediate hospitalization. The physician may assess the severity of the patient's condition and, if required, prescribe a direct consultation and further testing.

In order for this system to function, the gadget must offer measurements comparable to clinical instruments. Such gadgets may alter the landscape of healthcare such that individuals have access to medical treatment anywhere, at any time. In this paper, an end-to-end system with a patient portal and a doctor portal housed on a cloud server is suggested to be linked to a basic healthcare device capable of uploading measured data to a secure cloud. Further components may be added to the device for additional measures, and data can be sent to a cloud server. This low-cost technology can link a registered patient with a registered doctor 24 hours a day, seven days a week using a low-bandwidth internet connection. In lieu of numerous hospital visits, the system may be utilized for post-medical care and follow-up services that may be provided in the patient's home. In order to construct a system of this kind, several obstacles must be resolved. To guarantee the privacy of patient data, physicians' cooperation, a secure cloud service provider, and a standard are required. Many service providers have begun offering software assistance for expanding healthcare services online despite the inherent challenges. As the internet of things architecture continues to evolve and cloud software suppliers continue to embrace this functionality, it is anticipated that a portion of hospital-based medical treatment will be made accessible online.

2 Background and Motivation

Over the last several decades, progress on remote medical assistance has been steady. Using biosignals collected with a smartphone, healthcare units were used in [1] to monitor elderly patients. The majority of Arduino medical assistance applications focus on body temperature, body location, heart rate, etc. [3]. Using a well-equipped tool, the projects' emphasis has been carried out in the most efficient way possible [6]. They are able to lessen the effort for both patients and physicians by using the most recent technology. [4]. For those living in rural locations with limited hospital access, researchers have suggested developing remote medical health care [5]. The results of research on examining body temperature, posture, glucose levels, and other parameters are provided in [2]. By developing a portable gadget [9] with wireless connection that can be used on any patient, medical professionals may create facilities. Additionally, research was developed [7] that has been integrated with android and may be used to collect personal data. Projects like [8] are being developed for personal health as well as for evaluating diabetes. In order to collect the crucial information on temperature and heartbeat, the suggested system investigates the integration of smart sensors with inexpensive hardware platforms.

3 Proposed System Design

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 50, Issue 9, No. 1, September : 2021

The suggested system includes an Arduino board, sensors, and a cloud service that links to patient and doctor portals that are operating on smartphones as software. Figure 1 illustrates the model's design. The sensors are used to measure the patient data, and the arduino board handles transferring the data to the cloud service. A healthcare practitioner may examine the data on a smartphone. The system checks the patients' temperatures and heart rates. The cloud service is used for any data analysis on the observed data. Both the patient and the doctor should first sign up for the cloud service. For each consultation, the patient must expressly consent to the healthcare provider seeing his profile and data. The observed data cannot be delivered to the cloud service until the patient is enrolled in the system. A medical professional may evaluate the information and make a determination on the seriousness of the patient's health condition. Below is a description of each module of the suggested system.

3.1 Interactive Cloud Storage

Authorized patients are asked to upload their data to the server for further processing when the cloud service receives the signal from the Arduino board. Continuous data uploading makes sure that new data is added to previously supplied data, allowing for the creation of a record of observations over time. After processing, the data is graphed. Separating the signal patterns to project the signal's properties is part of the analysis report on the data. Examining patients online is a difficult task, but our system is designed to be simple to use for both patients and doctors. They may choose the appropriate course of action for a follow-up by analyzing the observed facts. The benefit is that when a sickness is genuinely demanding, it is simpler to control and recognize the need for direct medical help. Every time a consultation is sought via the service, patients may utilize the user interface to give a healthcare professional permission to view the information supplied to the cloud service.

3.2 Healthcare Device

The hardware elements can measure the patient's temperature and heartbeat. For the protection of patient data during transmission, the signals are encrypted before being forwarded to the server. During patient registration, access control, device authentication, and data access, data is encrypted. For all services, the patient may utilize a smartphone. In order to get sufficient medical treatment, people may maintain a tight relationship with a healthcare provider because to its ease of use and simplicity. 4 software elements make up the system.

4.1 Patient Portal

Fig. 1. Patient Interface

Through the patient portal, a patient may establish a profile and user account in the cloud service with the necessary papers and photos. Patients may always access any added information or their profile. Whenever a patient uploads any data during a session with a connected healthcare professional, the linked professional is notified. When dealing with a critical illness, the system serves as a temporary healthcare aid. On demand, the system makes the patients' whereabouts available. Additionally, the technology allows for a chat session for straightforward communication between the participants.

4.2 Physician Portal

Any allocated patients and their data for analysis are viewable on the doctor's interface. The doctor will see the basic analytical results on the measured data. The use of graphical analysis makes it simple to spot anomalies in data. Without much lag, the data are plotted so the doctor may monitor changes in the data in real-time. Data may be commented on by doctors, and these comments, together with the analysis report, are given to the patients. To facilitate a doctor's diagnosis, the technology allows for the simultaneous and individual charting of many graphs.
Interface for the Interactive Cloud (4.3)

Only the cloud server is used to analyze the observed patient data. Since the cloud server receives the raw data that is sent by the patients, it. The cloud server serves as an analyst for the doctor in this system, which is crucial. The doctor might alter the reporting on the data. In order to identify any aberrant fluctuations in the recorded signals, FFT is used to the patient data. We may locate the irregularities in the frequency using these strategies.

Data Security 4.4

The cloud service receives patient signals from a smart device through Wi-Fi. The patient may use their login information to upload their data to the server after they have registered with the

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 50, Issue 9, No. 1, September : 2021

system and been authenticated by it. Once they have completed the procedure, the doctor receives an SMS notice automatically. On both the patient portal and the doctor portal, all data that is transmitted to the server and that is received from the server is encrypted to ensure safe data transfer. The physician can see where the patient is. If the patient's vital signs indicate any abnormalities, their location might be drawn for any emergency scenarios. Additionally, it is tailored such that the patient is motivated to report their present location. If necessary, a chat session for the doctor and patient's interface will allow them to interact. Both sides may easily communicate information during a session using this method. The patient's data is kept in an encrypted format on the cloud server. The patient must transmit a code created by the system in order for the doctor to examine the data. This authentication makes sure that no one may access patient data without the patient's consent. Each physician and patient must register as a user of the whole program. For a certain session, both the doctor and the patient will need to be verified. Each user is given a unique ID that may be used to identify between a patient and a doctor. When a follow-up appointment is needed, patients may directly request the same physician.
Five hardware elements make up the system.

A person's fingertip is utilized as a sensor for temperature and heartbeat. The gadget was created using an Arduino-compatible microcontroller as well as a number of additional technologies. Figure 4 depicts the hardware configuration of the medical device.

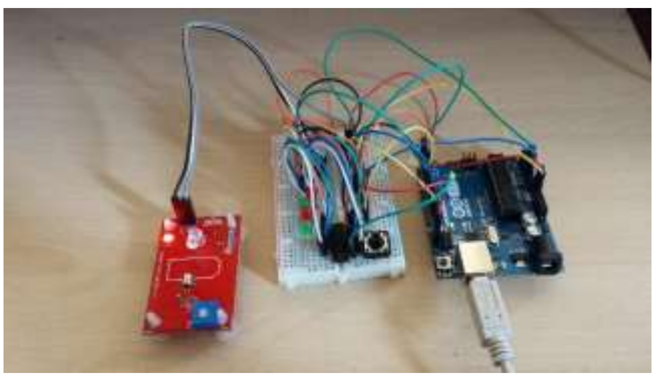

Fig. 2. Physical view of the device

This project uses an Arduino UNO microcontroller, which includes a variety of services for interacting with a computer. The ATmega328 connects to the computer through a virtual com port and achieves serial connection over USB. Additionally, it was difficult to design a gadget that was more advanced than a low-cost device with numerous restrictions, such as memory capacity. When the finger is positioned over the heart beat sensor, 660nm digital impulses are sent. With each heartbeat, the detector causes the LED light to flicker. The microcontroller uses the data from the sensor to help it measure the heartbeat frequency every minute (BPM). The heart sensor is made up of a light detector and a very bright red LED, which can pass the most light for the detectors to pick up. The blood arteries in fingers seem opaque while the heart pumps blood. Arduino creates a baseline of signals, recognizes the peaks, and filters out the noise using two successive operational amplifiers. The temperature is measured using a temperature sensor from the LM35 series, which features a linear temperature sensor, records temperatures in Fahrenheit, and is not affected by constant voltage scaling. Additionally, they do not need any kind of external calibration in order to provide the temperature ranges. The physical and electrical environment, temperature range, precision, reaction time, and thermal coupling all affect the sensor's features. The sensor has three analog pins and has a temperature range of 0°C to 1000°C. It produces a linear output of 10mV0/C with a +/-1.50°C accuracy rate.

6 Result and Analysis

Figure 3 shows the temperature change for a specific patient over time. The doctor may use this information to determine how often the patient's body temperature varies. The odd thing about these graphs is that they can be zoomed in on and the numbers can be seen for up to two seconds. Figure 4 displays the patient's heart rate fluctuation over a predetermined period of time. The sensor data that is collected as a result is sent to a server where it is processed. They may zoom in to the graph to track the signal's tiny fluctuations because of the way it is drawn. It has been able to pinpoint the patients' anomaly from the observed data. Both the average temperature and heart rate are known. The physicians are able to detect even the smallest change in the data. Temperature is expressed in degrees Fahrenheit and heart rate is expressed in beats per minute in this system. A healthy person's body temperature varies from 97.3 to 99 degrees Fahrenheit, and their heart rate is between 60 and 110 beats per minute..

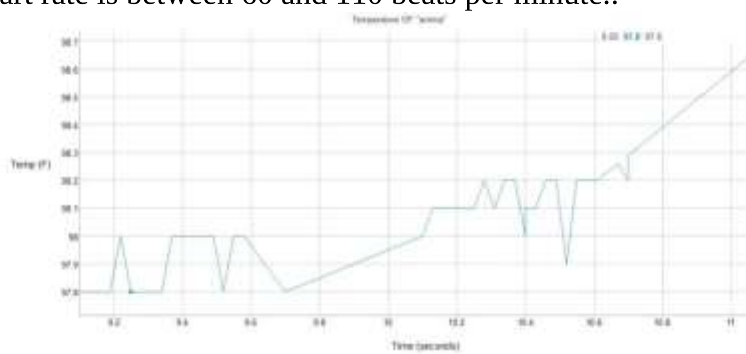

Fig. 3. Temperature Sensor Data

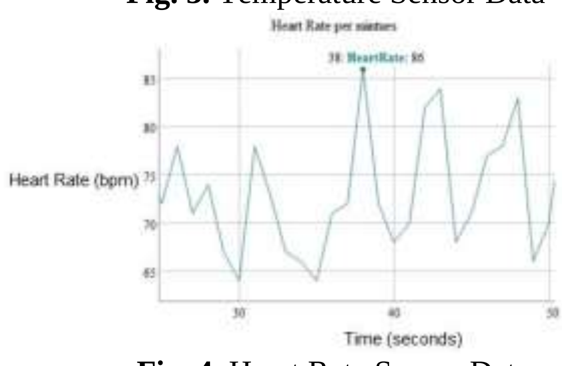

Fig. 4. Heart Rate Sensor Data

Here, we have identified the fundamental conditions of the patients, and for future works, we try to incorporate future modification on the data that are attained and tries to check the condition of the patients and analyze in line with that. These values can vary depending on gender, age, physical ability, etc. Methods using the Fast Fourier Transform (FFT) have been utilized to analyze signal data. Since this method is utilized to analyze even very little variations in the collected data, it aids in the analyses of medical professionals. The created FFT graphs also

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 50, Issue 9, No. 1, September : 2021

prove useful for any further patient analyses. Figure 5 depicts the FFT graph over a certain time period.

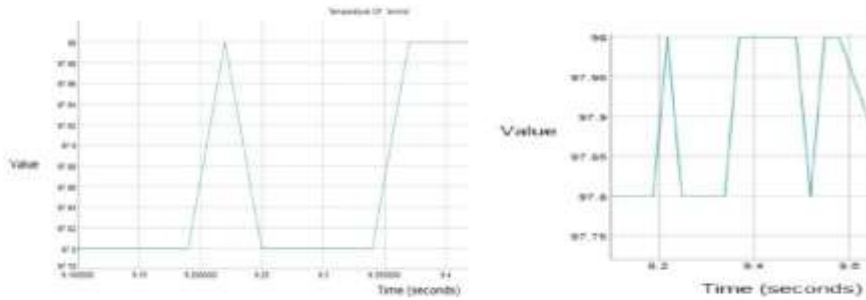

Fig. 5. Analysis using FFT in the temperature graph (a) peaks during the time interval (b) variation during the time intervals

Figure 6 shows the doctor's ability to access specific patient information for an analysis of the patient's present condition. Additionally, users may use the submit button to communicate their feedback to the patient. They may also use a chat window if they wish to speak with the patients for a longer period of time. The see image tab is used to examine all of the information that patients have contributed, including files, reports, and images in the formats of jpg, document, CSV, and pdf.

7 Security and Privacy Concerns

The difficulty is in how safely data is kept on the cloud. Encryption has been used to safeguard information transit, but the primary goal is to secure data storage using low-cost techniques. To remedy the existing problem, better solutions must be found. Another problem that is crucial to the system's functioning is the security of the transferred data. To make the system safe enough to send the data, it is accomplished here via code generation. The data transmitted from the patient side will thus be encrypted in the future, and only the physicians will be able to decode the data. Data encryption and decryption must be quick since we are attempting to operate in a real-time context. For the accuracy of the data sent for system registration, a more professional authentication function has to be found. Effective validation of the submitted data must be performed.

The system is user-friendly to provide patient health care with satisfaction and total value via tighter connection between healthcare professionals. Additionally, this may lessen patient stress and emergency hospital visits. Instead of being hospitalized, patients may utilize this gadget at home for their healthcare, which significantly lowers the number of hospitalizations. Modern healthcare goods have shown the need for better patient management capacity and healthcare amenities for the patient. A single healthcare practitioner may support a big patient population. Any smart device with internet connectivity may access the system at any time, anywhere for personal health care. With the aid of this equipment, the patient may have a better health monitoring system that analyzes data and conditions.

8 Conclusion

Utilizing sensor data routing, the system is designed for patient care that is affordable. A cloud server receives and stores patient data for processing. The ability to monitor patient data and do patient data analysis are both accessible. With the current approach, the user (patient or assistance) has access to the gadget and may utilize the sensors to take pictures or record data. For assessing the vital statistics of the human body, we may integrate a variety of different sensors, including ECG and galvanic skin resistance. These sensors generate images or signals of the blood arteries using conventional techniques. By using the existing IoT infrastructure, this project may be developed in the future based on an IoT base device. This kind of service is being presented with the goal of offering people basic medical care locally at a low cost.

References

1. AltafHamedShajahan, A.Anand. "Data acquisition and control using Arduino-Android Platform." IEEE. 2013. 2.
2. HermawanKemis, Ndibanje Bruce, Wang Ping, Tony Antonio, Lee Byung Gook, Hoon Jae Lee. " Healthcare Monitoring Application in Ubiquitous Sensor Network: Design and Implementation based on Pulse Sensor with Arduino." IEEE. 2.
3. I. Orha, S. Oniga."Study regarding the optimal sensors placement on the body for human activity recognition." 20th International Symposium for Design and Technology .

Romania: 2014 IEEE, 2014. 2.

4. Julio, MscTelecom.Yair Enrique Rivera. "DEVELOPMENT OF A PROTOTYPE ARDUINO MOBILE IN AREA OF TELEMEDICIN FOR REMOTE MONITORING DIABETIC PEOPLE." Colombia: 2015 Asia-Pacific Conference on Computer Aided System Engineering, 2015. 1.
5. Lee, Y.D. and Chung, W.Y. (2009) "Wireless Sensor Network Based Wearable Smart Shirt for Ubiquitous Health and Activity Monitoring", Sensors and Actuators B: Chameical, Vol. 140, No. 2, July, pp. 390-395
6. Niewolny, David. " Freescale medical solutions ." Medical Applications Guide, 2010-2015: 17.
7. Nishigandha D. Agham, Vijaya R. Thool, Ravindra C. Thool. "Mobile and Web Based Monitoring of Patient's Physiological Parameters using LabVIEW." 2014 Annual IEEE India Conference (INDICON). IEEE, 2014. 1.
10. S. NurHidayahMalek, W. Suhaimizan Wan Zaki, A. Joret, M. Mahadi Abdul Jamil. "Design and Development of Wireless Stethoscope with Data Logging Function." IEEE. Malaysia: IEEE International Conference on Control System, Computing and Engineering, 2013. 1.