IoT-based remote monitoring of critical COVID home patients' health

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Abstract: Recent years have been difficult because of the COVID-19 pandemic related health problems. Nowadays, almost majority of positives must be quarantined because of virus's rising population dissemination. That becomes crucial to keep an eye upon those patients' temperature levels while they are on their own. In order to remotely record or monitor temperatures this research proposes to develop a reduced, cost effective Body Area Network (BAN). Seniors and COVID sufferers can both benefit from this suggested monitoring program. A remote management device will prevent clinicians from directly interacting with COVID patients who are being monitored for diseases. An LM-35 sensor, which is combined into a single device for patient's medical monitoring is used to record information of body temperature. Effective testing and recording of the sensor information is done over ThingSpeak interface. For data monitoring, Wi-Fi routers and serial monitors are both employed. During the COVID era, the data is tested on actual patients.

Keywords: IoT, Health Monitoring, COVID, Body temperature, Data Logger, Sensors, Cloud.

I. INTRODUCTION

Development of Internet of Things (IoT) systems has enabled us to be connected to healthcare treatments to be used in diagnosing and treating remote people. During pandemic days, the highly infectious COVID-19 infection is a global health concern. During the pandemics, huge patients have to be quarantine in home due to lack of bed availability in hospitals. This creates serious demand of patient monitoring remotely. This paper focuses to measure human body temperature remotely using IoT cloud server.

According to estimates, an IoT-based remote health monitoring system (IBRHMS) can assist to treat more patients while utilizing limited resources by significantly reduces mortality rates. Consequently, an IoT application for health monitoring is proposed in this work. Manual monitoring of the temperature data may not have authenticity and may leads to wrong diagnosis of the severness of the patients. Thus it becomes essential for the recent times to design the efficient low cost solution to remote measurements. A basic architecture of a system for health monitoring to client as well as beneficiaries have been discussed through Figure 1 as well as at affordable cost. Both regular patients and remote patients can be monitored by the suggested method. Patients who live far away from the hospital will wear a health monitor and an activity monitor to track their health and activities, sending the information to the hospital's cloud server via Wi-Fi or cellular connection. For typical patients, sensors will be placed to them to track body temperature, respiration rate, blood pressure, and oxygen saturation. The information will be sent to a local database that is linked to the cloud by Wi-Fi and ZigBee, enabling the medical personnel to monitor the situation in real time from any location with an Internet connection. The database will also make it possible to look up a patient's medical background. The system would quickly notify and warn the medical team if it discovered any irregularities in a patient's state, allowing for either prompt treatment or the dispatch of an ambulance for the distant patient.

Sensors for measuring core temperature of body will be studied in relation to the health monitoring program as a whole. By utilizing these sensors, a reliable, portable, and reasonably priced health monitoring equipment can be created to gather and evaluate patient records.

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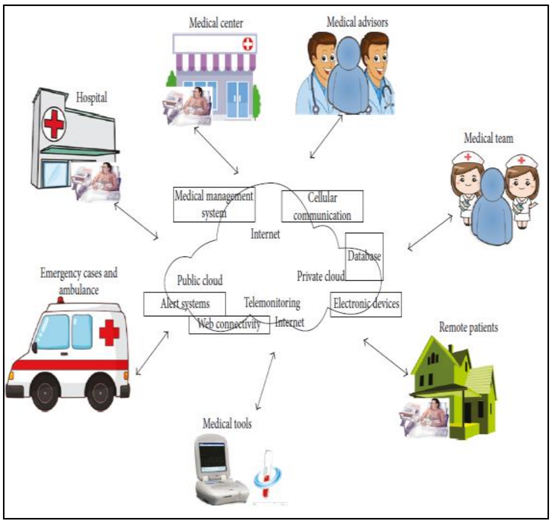

Figure 1. Architecture of the health monitoring system

Various difficulties in designing Remote Health Monitoring (RHM) systems are discussed in section 2. Section 3 reviews and summarizes brief connected works towards Health Monitoring (HM) systems for patient temperature monitoring. The contributions of current paper is discussed in Section 4. Part 5 presents the architecture of the proposed HM system. The practical results on temperature monitoring over cloud are provided in Section 6. The conclusion and future work are finally mentioned in Section 7.

II. CHALLENGES IN REMOTE SYSTEMS

The use of remote health monitoring (RHM) has the potential to dramatically alter patient care. If broadly adopted, it will transform the patient experience and make it possible for healthcare providers to manage their resources far more efficiently than they do currently by relieving the strain on healthcare systems all around the world. But there will be difficulties in implementing RHM. This essay will examine some of the most significant entrance obstacles for RHM technology that have not yet been removed. The top 5 difficulties that Remote Health Monitoring must overcome are:

(i) Data Protection: Strong data management procedures, distinct ownership boundaries, and unbreakable security mechanisms are essential for data communicated over any RHM platform to be secure enough to comply with the requirements demanded of the healthcare industry. Patients run the danger of having their data stolen since large portions of the data management process may be handled by other parties. Hospitals have similar difficulties since they run the risk of integrating a third-party system that may be compromised, endangering the security and privacy of their patients.

(ii) Data Reliability: Data accuracy is arguably the most difficult issue for RHM adoption. Many of these issues are perception-based, affecting both patients and medical professionals. On the basis of the available data, frontline medical staff will be required to make diagnoses and administer treatments to patients. To take the type of quick and immediate action required, particularly in the treatment of chronic and sometimes deadly illnesses, they must also have the utmost confidence that it is accurate. The enormous amount of patient data that may be gathered and sent to physicians and nurses is another factor to take into account in this situation. This could end up being too much to handle. The amount of data supplied and the way in which it is presented will determine how well they are able to swiftly determine which data points are most important. Because of this, it is exceedingly difficult to estimate the margin for error and the precision of choices based on this data.

(iii) Real-time Data Access: The information transfer necessary for RPM to function might be a time-consuming, difficult operation that involves several transfers. First, information from the patient's device has to be gathered and uploaded. If this device is connected to a mobile network, the data must then pass through the infrastructure of the mobile network provider, out into the internet, and finally into the network of the service provider, likely via many data centres and the RPM platform network. The data may not arrive at its destination right away if any of these hops are missed or if there is a problem at any of the stops along the way. There is no guarantee that mobile networks will always be accessible. When it is truly a matter of life and death, as it may be for a patient, it is crucial that data be provided reliably and promptly. This is perceived as an issue when mobile users are unable to access Instagram for an hour or two.

(iv) Integration of systems: Systems integration would not be as problematic if every healthcare provider in the globe utilized the exact same systems on the same network. Sadly, nothing could be further from the truth than that. For instance, the healthcare industry frequently employs antiquated software stacks and a maze of various systems for various purposes. The addition of a remote monitoring platform would thus need to be handled very carefully to prevent the corruption of current patient information and to guarantee that any upcoming system migrations would not conflict with the RPM platform.

(v) Devices' Price: Hospitals may opt to deploy RPM devices on their own rather of collecting data from an app or third-party device to attempt and lower security risk and simplify integration.

Numerous health monitoring systems have been built as in past. However, almost majority of earlier health-monitoring devices relied on different resolutions

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sensing models. Some of major challenges are identified based on our study are as follows:

1) As a consequence, a minimal tolerances sensor must be developed in order to develop an appropriate health monitoring system that has high precision.
2) The majority of systems for health monitoring are bigger, therefore it is necessary to develop user-friendly, lightweight, affordable health monitoring systems.
3) There are some illnesses that require constant monitoring and study of human health indicators like body temperatures as in the case of quarantine COVID patients.
4) These factors differ substantially between age brackets. In order to identify diseases, it is necessary to determine the accurate timely values of these parameters.

III. RELATED WORK

Numerous studies have been conducted to increase the effectiveness of systems for remote health monitoring. The various sensors that are employed to track the various aspects of human health are listed in Table 1. The patient monitoring systems are based on wearable technology, including watches with sensors, home-based systems for monitoring elderly and physically challenged patients, and hospital ICU room-based systems.

Table 1. Sensors used in Remote health monitoring systems

Sector	Application	Sensor Utilization	References
Health Care and Medical application	Wearable	Biomedical belts and watches, temperature, and ECG, sensors. Glucose sensor	[1], [2]
	Home Based	Location, biomedical sensors, systems for physically challenged people and elders	[3], [4] [6]
	Hospital based systems	Humidity, RFID, sensors for hospital, BP and oxygen monitoring for ICU units remotely.	[5], [7] and [10]

Table 2. Summary of the Review of RHM systems

S. No.	Authors	Methodology	Description
1	Shola Usha Ran et al [1]	IoT based health monitoring system	Uses Amazon Web Server (AWS) server and MQ Telemetry Transport (MQTT) protocol which was bulkier.
2	S. Nookhao et al [3]	Smart temperature and heart sensor.	Used Wifi LM-35 and the ECG sensor module which was displayed on LCD.
3	B. Priya et al [3]	Remote wireless health monitoring	System uses the GSM modems using BS II .
4.	Proposed model	Monitoring Remote health with IoT	Using AD8232 and LM35 with boot loader which is of low cost, low power consumption

IV. CONTRIBUTION OF WORK

A study was carried out to investigate the prior research. The thermocouples had been created and put to the test on people. The cloud server continually receives sensed data collected by the sensor modules after successful IoT-based testing on the database. Then doctors can use it to warn patients with hidden issues while making diagnosis on their health.

V. PROPOSED IOT BASED RHM SYSTEM

In order to address these challenges, an HM system is proposed and test conducted via the proposed model to be utilized further for monitoring of COVID patients. The structure of proposed system block diagram of HM system is presented in the Figure 2. The node MCU board is used to monitor the health and activities of remote patients, and it transmits the information to the hospital's cloud server through Wi-Fi or cellular signal. For typical patients, sensors will be placed to them to track body temperature, respiration rate, blood pressure, and oxygen saturation. The data will be sent to a nearby database that is linked to the cloud through WiFi, enabling real-time monitoring.

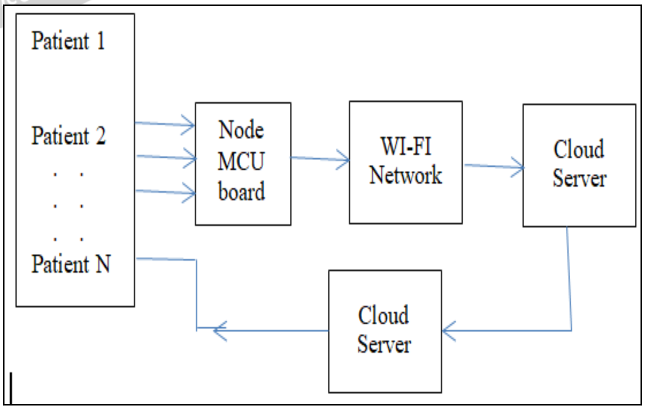

Figure 2. Proposed Block diagram of the HM system.

The data gathered from either the sensors is evaluated, therefore irregular patient's medical behaviour could be early diagnosed by doctors. This enables them to prepare for emergencies and lowers critical moments in hospitals. To verify the accuracy and precision of a variable

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monitoring through IoT cloud, it is suggested to create a single entity with simultaneously multiple sensors from an analysis standpoint. There are many sensor modules available for temperature measurement, which are compatible to Arduino devices and therefore are easily readable. The LM35 is utilized in the current work to determine the temperature. Figure 3 below lists the sensor investigation utilized. Similar findings were found in a later analysis of research encompassing 17,515 adults and youngsters with COVID-19 to monitor their health.

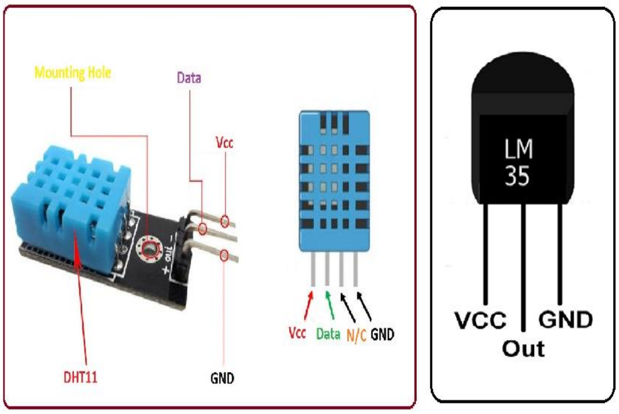

Figure 3. Sensor used or temperature data monitoring.

Features of LM-35: The electrical output of the LM35 integrated analogue temperature sensor is proportional to degrees Celsius. For usual accuracies, the LM35 Sensor doesn't need any extra trimming or calibration. Because of the LM35's low output impedance, linear output, and exact intrinsic calibration, it is particularly simple to interface with readout or control circuitry. It offers liniarity upto 10 mV/°C range. The relative accuracy is 0.5°C at around 25 °C and higher precision range. It is good enough to use in remote environment. It requires 4V minimum voltage for operation.

Features of DHT11: The widely used DHT11 temperature and humidity sensor has an exclusive NTC for temperature measurement and an 8-bit microprocessor to output the temperature and humidity measurements as serial data. It has best uses at 0°C -50°C temperature readings and has good accuracy of ±1°C.

A. Temperature Sensor Monitoring

A flow chart of the body temperature monitoring using LM 35 sensor is shown in the Figure 4. It can be observed that the device libraries are initialized and the device is connected using the pin description of the sensors. The data is loaded to the cloud using IoT network via the available WiFi network.

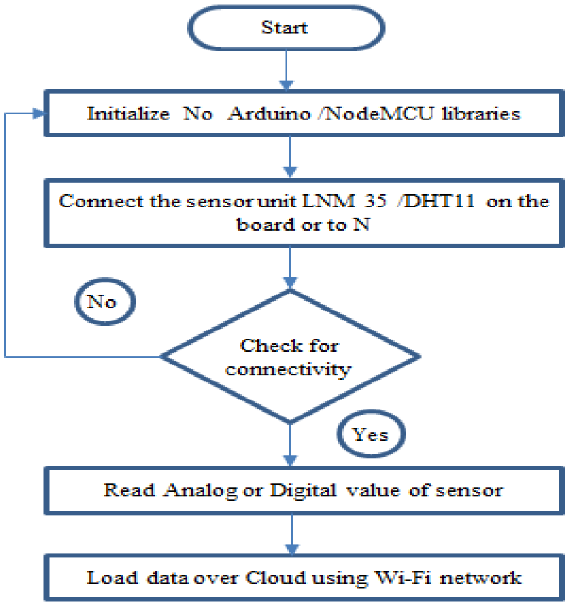

Figure 4. Flow chart of the proposed temperature monitoring methodology using LM35 sensor and Arduino interfacing with NODE MCU.

The proposed circuit representation for the temperature monitoring is shown in the Figure 5 below. First arduino send a start signal to DHT module and then DHT gives a response signal containing temperature and humidity data.

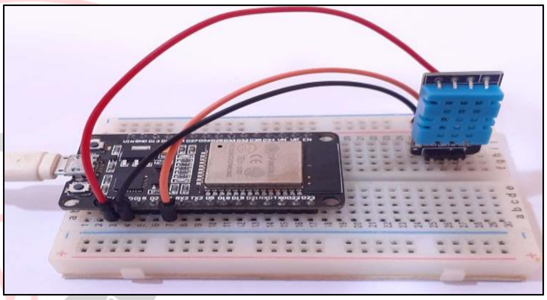

Figure 5. A snapshot of the temperature monitoring using DHT 11.

VI. RESULTS AND EVALUATION OF CAPACITY

The heart beat monitoring system and the temperature are recorded over the cloud server. The channels are creted over the ThingSpeak Cloud server. The HTTP protocol is used for taking the data over the cloud server. In addition, the serial communication is used to take the ECG data over the monitor. Better results can be ensured with early testing. The results of the recorded temperature sensor data of LM 35 is shown in Figure 6 over the cloud using IoT for two patients using RHM system with Arduino boards and NODE MCU router.

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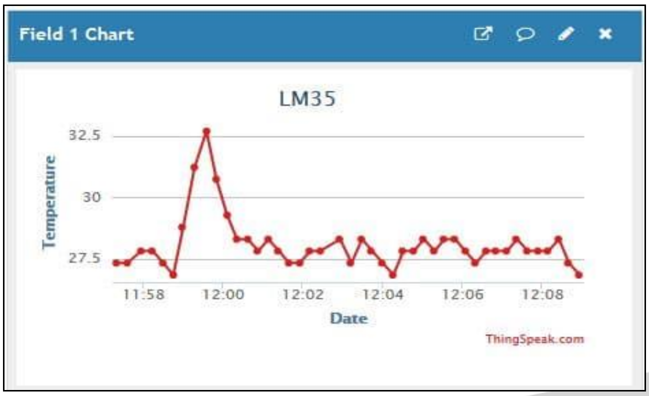
a) Validating Temperature by LM-25



b) Real time testing on humans

Figure 6. Results of the temperature data monitored over the cloud server using IoT based RHM system using Arduino boards and NODE MCU.

VII. CONCLUSION

An very effective technique separates IoT-based health monitoring systems from traditional healthcare systems. As a result, using IoT to get the desired results and performances becomes quite difficult. The embedded world and working with IoT are connected because sensors employ electronic data signals. Sensors, detectors, monitors, and microcontrollers are first linked to one another for synchronisation. The signals are picked up by the sensors and detectors in analogue form, which has to be transformed into digital form. The microcontroller carries out the internal analogue to digital conversion to obtain the data in the appropriate digital format. Data storage is carried out after data conversion. Data are being transmitted to a server or the cloud. In this study, a local server is employed, which displays the fluctuations of the simultaneous measurements' values or readings. Data are being transmitted to a server or the cloud. In this study, a local server is employed to display fluctuations in the values or readings obtained concurrently.

For COVID patients, an IoT health surveillance system that measures temperature has been created in this paper. The system keeps track of the patient's body temperature and notifies users via SMS when conditions are serious. The serial monitor is used to test a low-cost data logger, and ThingSpeak server is used to save the data on a cloud server. The suggested system concept is effective and gives clinicians the ability to remotely monitor patient health.

The research presented in this study makes a substantial contribution to the testing of patient remote health, and it will be used in the future to classify patient activity data employing data loggers.

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