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An IoT-Based Health Monitoring System for Elderly Patients

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Abstract — Internet of Things in healthcare significantly improves the provision of medical facilities to patients and assists healthcare professionals. Since many elderly people require to be checked up on frequently as they are at more risk of life-threatening diseases, using a cloud platform can help supervise their condition in real time. This paper focuses on a remote health monitoring system that tracks and updates the patient's caretaker with the data collected from the patient. This enables the patient's overseer to analyze the data being fed to them and subsequently provide treatment for the patient. The data stored in the cloud platform allows the process rate to be even quicker, thus reducing the time required to go to a hospital or waiting for treatment.

Keywords Internet of Things · Arduino UNO · Cloud Storage · Remote Patient Monitoring

1 Introduction

In China, the elderly community is on the rise. Due to the population issue, a lot of care needs to be given towards the elderly as they are more prone to diseases. In addition to this, seniors are also frail and require special aid in case they are not able to look after themselves. Healthcare for the older generation is rapidly becoming a problem as many of them are not able to make hospital visits on their own (Kai, 2017).

However, remote health monitoring (RPM) has made it possible for elderly patients to sit in the comfort of their own home and have their vitals drawn and sent to their doctor, who can properly analyze the data and ergo provide adequate treatment. Smart health monitoring involves the combination of using Internet of Things (IoT) and RPM simultaneously. In fact, this is a rapidly growing industry as smart health monitoring is seen as one of the leading application areas of ubiquitous computing (Park, 2017).

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To effectively monitor the patient, the process needs to be as noninvasive as possible so that the system being used does not disturb the patient's life (Ohta, 2002). For an unobtrusive, effectual procedure, the system will be a wearable device that can be strapped on and taken off.

Before sending information to the IoT platform, the primary data needs to be collected and this is typically done in the form of sensors. Multiple sensors are connected to an Arduino and the data gathered is prepared to be linked to the Internet. Then, the processed data is stored in a cloud-based platform. In this project, it will be stored on ThingSpeak, an open-source analytic platform.

Therefore, the objectives of this project are to:

1. To monitor a patient's health
2. To provide an alternative form of healthcare
3. To collect accurate health parameters of the patient
4. To quicken the assessment and treatment of the patient

2 Related Work

RPM is growing in popularity due to its usefulness and its ability to improve the quality of life. IoT is the act of using technology to achieve this. Combining health monitoring and IoT together gives a smart device, capable of managing and storing information (Mohammed and Ahmed, 2017).

The main aim of this project is to design and implement a fully functioning RPM device that fetches data and updates the patient's caregiver in real time. Using IoT allows for fewer hospital visits, for the patient to get treatment no matter where they are, and for keeping the patient's information safe in the cloud platform.

Without the availability of this technology, it can be difficult for doctors to supervise their patients or for the patients to keep track of their health (Khan and Hai, 2016). Patients who especially live far away from hospitals or other healthcare facilities will greatly benefit from this. The combination of a heart rate sensor, blood pressure sensor, temperature sensor, and oxygen sensor will provide the doctor with an adequate amount of information that they can use to check up on the patient.

Almotiri, S. H. et al (Almotiri et al., 2016) proposed a system where the mobile health (m-health) system is used along with IoT to collect data from patients using wearable devices. The data is stored on a cloud platform, through which it can be accessed by certain users.

Tham, O. Y., et al (Tham and Markom, 2020) proposed a system that would remotely monitor oxygen saturation and heart rate level through IoT. In this system, MAX30100 sensor was incorporated as it could provide data for both oxygen saturation as well as heart rate. By connecting it with Nodemcu ESP8266, the information could be passed to the Wi-Fi module and entered into the cloud database. To calculate SPO2 conditions, two constraints are put down: normal and abnormal. When SPO2 is 95% and above, the situation is considered as normal. Else, it is abnormal.

Nduka, A. et al implemented (Nduka and Samual, 2019) a design that integrated an Arduino board with sensors, GPS, and other components to combine multiple vital sign monitoring sensors into one system. The data gathered from these sensors would be viewed by the physician in real time. An alarm would sound if any abnormal readings were noted, which would alert the user as well as healthcare professionals. The GPS technology would enable the emergency team to locate and care for the patient.

Kodali, R. K. et al proposed a health monitoring system by employing the use of sensors, microcontrollers, and transceivers to send and receive information by using IoT (Kodali and Swamy, 2015). ZigBee, a low-cost, wireless mesh network, works by using high-level communication protocols to generate personal area networks (PAN). By using ZigBee, the temperature of the patient was constantly monitored and fed to the cloud, where it could be accessed from any part of the world, thereby making it a cheap and effective method.

3 Methodology

In this section, the architecture of the proposed model is given. The system architecture can be seen in Fig. 1, where the sensors' parameters are gathered and processed and sent to the both the Wi-Fi module and LCD display. The LCD display allows the patient to scan their own data, while the data directed to the Wi-Fi module passes to the IoT platform, ThingSpeak, from where the patient's doctor can scan it.

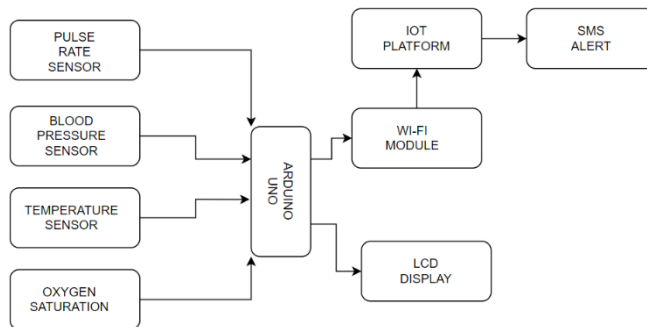


Fig. 1 Complete architecture of the system

Since this project heavily relies on the device continuously monitoring its patient, in order to provide the doctor with the most up-to-date data, the information gathered will need to be passed through an IoT platform, through which it can be clearly analyzed. However, before it is sent to the IoT platform, the data is first gathered from sensors which are couples to an Arduino microcontroller. An Arduino UNO was chosen for this project as it is a low-cost and effective form of controller.

The parts of the system are described in the following sections.

A. Sensors

The sensors are an imperative part of this model as they record the patient's vitals. In Fig. 1, the system architecture presents four sensors. These sensors are as follows:

1. Pulse rate sensor
2. Blood pressure sensor
3. Temperature sensor
4. Oxygen saturation

The pulse rate sensor is used to monitor the elderly patient's heartbeat. This can help detect signs of heart diseases or heart attacks before they happen, therefore enabling the patient to keep their health in check. Indications of low heartrate could lead to chest pain, dizziness, or fatigue and early detection can prevent this. Alternatively, high pulse rates could cause light-headedness or shortness of breath, which can also be caught ahead of time.

The blood pressure sensor can detect when the patient's blood pressure is too high or too low. High blood pressure could bring about vision problems, chest pain, or severe headaches. Whereas low blood pressure could give rise to fainting, nausea, or dehydration. These symptoms can be life-threatening for seniors; therefore, sensing it ahead of time can save lives.

The temperature sensor is used to find the patient's body temperature and ensure it is at normal body temperature. The temperature sensor's parameters were calculated using

$$temperature (^{\circ}C) = [ADC\ value \times \frac{5}{4095} - (\frac{400}{1000})] \times (\frac{19.5}{1000}). \quad (1)$$

The ADC value in (1) is first converted into digital values in Celsius by multiplying the raw value to convert it into a certain range and then subtract 400mV, which is the voltage at 0°C. The final value is multiplied by the temperature coefficient which is 19.5mV/°C.

The oxygen saturation sensor has become more important in modern times due to the spread of the novel coronavirus (COVID-19). The pulse oximeter sensor is used to observe whether the patient's oxygen saturation is between the ranges of 95% and 100%. Anything below 90%, which is also known as hypoxemia, is considered to be low and can cause problems such as headaches, obstruct the functions of the heart and brain, or shortness of breath.

B. Light-Dependent Resistor (LDR)

While it is important for the data fetched by the sensors to be delivered to the online medium, it is also essential that the patient be able to read their vitals. For this reason, Light-Dependent Resistor (LDR) is coupled to the Arduino. This allows the data to be output onto the LDR for the patient to read the information that was collected.

LDRs are a useful part of any device as they receive information directly and can be viewed instantly.



Fig. 2 Output displayed on LDR for patient to view

C. Wi-Fi Module

To pass on the data to ThingSpeak, a Wi-Fi module needs to be used. ESP8266 is a low-cost Wi-Fi microchip which is used to allow microcontrollers to obtain access to any given Wi-Fi network. In this project, ESP8266 was chosen as it is inexpensive, very compatible, and has high integration properties. This component was coupled with the Arduino board; thereby connecting the IoT platform and the sensors together to allow for easy transferring of the information.

With the sensors attached to the Arduino board and the Arduino connected to the ESP8266 Wi-Fi module, the module can send the data it has collected to ThingSpeak so that the platform can continuously update itself with the latest figures.

4 Results

The data that was collected from the Arduino was sent to the IoT platform via the ESP8266 component. This is done through sending an "HTTP" request from the chosen device to ThingSpeak, and ThingSpeak adds the data to the fields in the set channel. This information was then represented in graphical format using MATLAB analytics.



Fig. 3 Analytical graphs from ThingSpeak

The graphs shown in Fig 3. depict a person's heartbeat and body temperature taken in real time. The constant monitoring helps the graph keep a constant legend. This will allow anyone surveying the patient's vitals to be able to keep track of any abnormal activities and thereby help the patient.

This method of relaying information is clear and easy to follow. It also helps

in that a connection is built between the patient and their doctor as the back-and-forth communication through the device can enforce a strong link.

5 Conclusion

In conclusion, the system proposed in this paper is not only easily accessible but is also beneficial for seniors and other people who want to check up on their health. With the elderly population on the rise, the provision of this device will enable them to take care of themselves as they will receive real-time parameters of their vitals. RPM is a concept that is quickly spreading due to its ability to produce fast results with higher patient happiness. Diagnosing patients is also made easier, thus less time is wasted in this aspect.

The use of IoT is imperative as technology is rapidly advancing and with it being the main distributor of health care systems, there can be much progress in this field. By using IoT, many people will have the benefit of getting access to high-quality healthcare they otherwise would not be able to get.

In the future, this system can be developed even further by adding artificial intelligence (AI) aspects. This can be in the form of using AI to calculate vital parameters, having AI robots analyze and treat the patients, or using AI to diagnose patients. This can be explored through finding consistent patterns and training the AI to recognize these patterns and find a solution for it.

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