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IoT Based Health Monitoring System for Elderly Patient

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Abstract: The joy of the loved ones is among the key factors to happy life. People require extra attention from health monitoring point in order to stay healthy and safe. Therefore, a practical innovation product to monitor patient health such as the elderly monitoring system is developed and proposed in this article. The product is based on Internet-of-Things (IoT) where it can monitor the body temperature, pulse rate and respiratory rate of the patient on a long distance using smartphones. The proposed system uses nodeMCU as a microcontroller, three sensor units and ThingSpeak as the application platform. A smart lifestyle typically among the elderly can be developed using innovative products like this in the future. It can help doctors and guardians to monitor elderly patients from long-haul distance. The results for three males with different ages are compared and averaged.

Keywords: IoT, health monitoring system, elderly patient

1. Introduction

Nowadays, the industry 4.0 and the Internet of Things (IoT) are two great topics that attract the attention of people related to the smart automation system. IoT is an electronic monitoring and control system that connects humans and things over the Internet network. In essence, it combines the sensor units, microcontrollers, Internet networks and the applications. In addition to monitoring, IoT can turn on or off any tools through the Internet network. Thus, the communication that alerts between humans and things can occur even if they are at a long distance.

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Recently, IoT is widely used in the field of medicine to improve the quality of human life. The elderly monitoring system was developed in [1]. Two sensors are used separately to detect body temperature and pulse rate. The developed prototype can monitor the elderly at long distance including data storage capability. It uses both the Arduino Pro Mini and the Wi-Fi module to link the sensors and smartphones. In [2], the body temperature monitoring system and heart beat were developed. The system can also store patient data. It uses the Arduino UNO micro Guards to link data from sensors, LCD display and ThingSpeak. In [3] employed GSM module that allow notifications of health users via e-mail. The prototype allows doctor to monitor the patient condition via smartphone, e-mail and it also comes with patient-based data. A Wi-Fi module that connects the hardware system to the internet to monitor the patient body temperature, heart beat and blood pressure on a smartphone was proposed by [4]. In [5] the body blood pressure, oxygen and temperature monitoring system are developed. They used TQ210-based embedded coordinator to control the whole system. The results are displayed on the mobile phone and the personal assistant devices. In [6] the LabVIEW based patient monitoring system has been reported. It consists of blood pressure, temperature and ECG data. Table 1 summaries the previous works in [1]-[4].

Table 1 - Summary of the previous innovation works

Ref.	Sensors/microcontroller	Summary	Performance metrics	Drawbacks
[1]	-temperature sensor -pulse sensor -Arduino UNO	Both sensors are used to collected the datas and microcontroller send it to the cloud.	The proposed system can store the data on the cloud storage.	The system does not having a mobile applications to analyze the previous data.
[2]	-temperature sensor -pulse sensor -Arduino UNO	Microcontroller receives the datas from the sensors and send them to the web server by using GSM module.	This portable device is convinient to the patients and allowing doctor/user monitors them using handset.	The GSM based systems will cause interference with others electronic devices such as pacemakers and hearing aids.
[3]	-temperature sensor -pulse sensor -ultrasonic sonar sensor -pressure pad -Arduino UNO	Arduino will collect the datas from all sensors, then sending them to the cloud (store and analysis) and display it to doctor/user.	The system offer an accurate data collection, fast/easy access to the patient's data and reasonable in cost.	Sonar sensor has a slow sensing rate and it is very sensitive with temperature changes.
[4]	-temperature sensor -heart beat sensor -blood pressure sensor -Arduino MEGA	Microcontroller will collect the datas patient from the sensors and send them to the webserver using Wi-Fi connectivity.	Users/doctor can monitor the datas through smartphone.	However, the system cannot store the datas in the webserver.

Among the recommendations of the elderly health monitoring system are to focus on innovation products such as integration of sensors, remote monitoring through apps and patient management systems [7] - [9]. Such innovations have been discussed previously in [7] which help doctors and consumers monitor the health of older people using smartphones. The product successfully measures and monitors body temperature, pulse rate and blood pressure. It also records and stores user data readings. There is also an article that proposes the elderly monitoring system by incorporating several sensors for the purpose of remote patient monitoring [8]. Optimization of the elderly monitoring with the patient management system is also proposed by [9] using ThingSpeak application. Monitoring the health of the elderly on a regular basis is a daunting task. Others work on development of a health monitoring system are reported in [10] - [21].

However, such methods are less effective due to time and place constraints and no systematic health record. The caretaker may have trouble monitoring the health of the elderly when leaving their home for a period of time [2]. In this case, they need a remote controller such as a smartphone. The prototype developed in this work will make it easier for doctors and consumers to monitor their parents from long distance with easy use and efficient.

Generally, monitoring senior citizens requires a high level of commitment. They will be taken to the hospital if their health level is deteriorated without early monitoring. In some cases, they cannot be saved due to the delay in bringing them to the doctor. In the market, there are many high-cost senior citizen monitoring tools that burden lowincome people. In addition, most products can only measure one parameter and consumers have to buy other products separately. Some of the product has limited function. As such, this paper focuses on IoT-based body temperature, pulse and respiratory monitoring systems that allow users to monitor their health condition. This work involves the development of IoT applications and prototypes that meet low-cost and practical user needs. The readings of the proposed product (heartbeat and temperature) have been verified with the tools used in Medical Engineering Laboratory, FKEE UTHM while the respiration rate has been verified based on the data sheet provided. This product has also been tested for users and the readings have been recorded.

2. Proposed System Design

2.1 Hardware Development

The IoT-based patient monitoring system developed in this research work consists of hardware, software and IoT parts. The hardware components include sensors, power supplies, LCD screens, nodeMCU as microcontrollers and smartphones. Three sensors, namely the temperature sensor, pulse rate and respiratory sensor, are connected to the nodeMCU. The temperature sensor basically provides 9-bit Celsius body temperature measurements. It communicates over wires that requires one data line and ground for communication with the central microprocessor. It can develop the power directly from the data line eliminating the need for external power supply. Pulse rate is a human heart-rate sensor for nodeMCU. It is used to measure live heartrate human with an open-source monitoring app that graphs the pulse in real time. Respiratory sensor is a real-time sensor for human respiratory rate that can be connected to nodeMCU. nodeMCU functions as the brain of the system to control and execute commands until the data from the sensors can be sent to the cloud. Sensors measure the patient heart rate, take readings of the patient body temperature and respiratory rate. ThingSpeak is used as a cloud server to store and display all data in real time. It is compatible for any IoT-based project and can be used to aggregate, visualize, and analyse live data in the cloud. When the push button is defined, the microcontroller sends data from the sensor to the LCD screen and ThingSpeak for display processing. Fig. 1 and 2 respectively suggest the intelligent monitoring system and schematic diagrams.

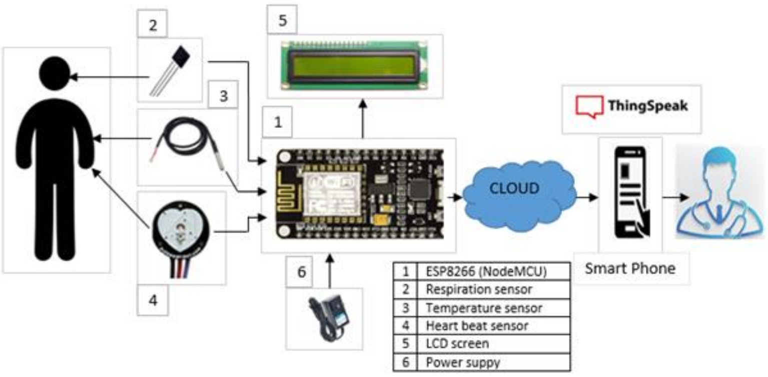

Fig. 1 - Proposed health monitoring system

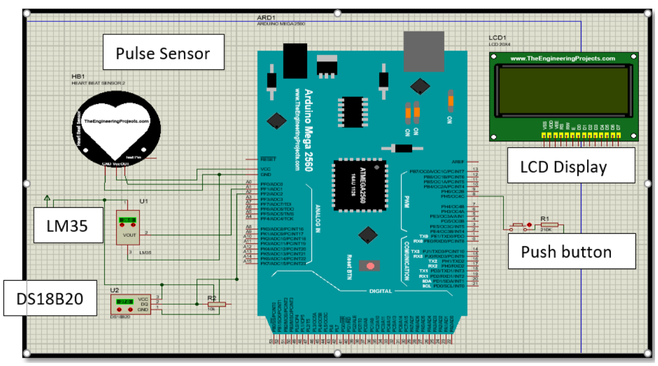

Fig. 2 - Schematic diagram of the health monitoring system

2.2 Software Development

Software development part is divided to nodeMCU board coding and cloud system configuration. In nodeMCU board, a code to read the temperatures from respiration and body patience as well as a heartbeat pulse (module) is developed. Then, the code to connect nodeMCU to existing internet hot spot to allow the data to be send to the registered ThingSpeak cloud is developed. It is done through internal Wi-Fi module. The code allows the data concurrently displaying on the LCD. The flow of the data to ThingSpeak will be through the Internet using the http protocol to connect to the cloud server. The Wi-Fi module directs the microcontroller board to any Wi-Fi hotspot by sending parameters, hotspot names and Wi-Fi names. The system is built using existing applications from the cloud provider (ThingSpeak) to monitor the transmitted data. Initially, the user needs to create a cloud account. Then, the user needs to download the app through the smart phone and configure the app using the existing account. Here, the user can monitor the real time data sent by nodeMCU.

In this work, the calibration test using pulse oximeter with plethysmograph, Lotus-500 has been carried out as presented in Fig. 3. It is similar as done in [21].

Fig. 3 - Calibration test

3. Implementation of the Proposed Health Monitoring System

The prototype development of the proposed health monitoring system consists of several sections shown in Fig. 4 and 5. These include sensor accessories, microcontrollers, power supplies, LCD screens, push buttons and smartphones along with ThingSpeak servers. All sensors are installed neatly and conveniently on the limbs of the user. The total size of the product is 8 cm × 5 cm × 5 cm, lightweight, stable, clearly labeled and portable. This size allows the components to be inserted and works well. The LCD screen is positioned so that the user can easily read the measured readings. Users can use a 5V battery or a direct connection to an external power supply. When the button at the prototype is pressed by the user, the sensor will start measure the patient body temperature, breathing and heart rate to determine their health overall status. Subsequently, the readings from the sensor are then displayed on the LCD screen. Next, the system will send these data to the storage server (cloud). Users can monitor their loved ones using their smartphones through ThinkSpeak. Fig. 6 shows the flow chart of the entire work process.

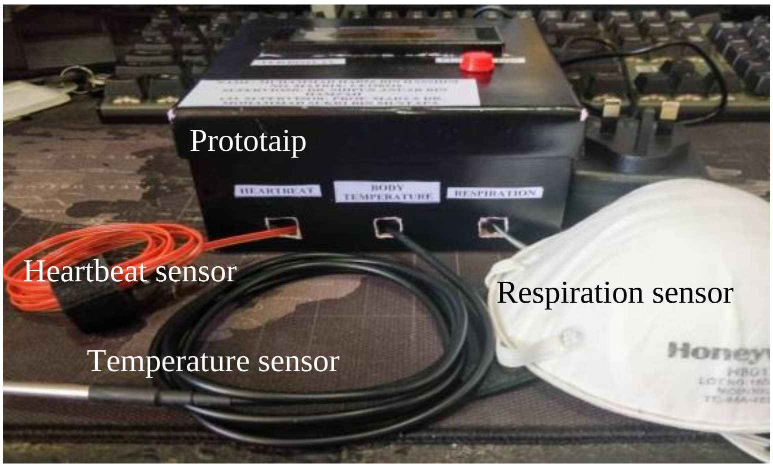

Fig. 4 - Front of the prototype of the health monitoring system

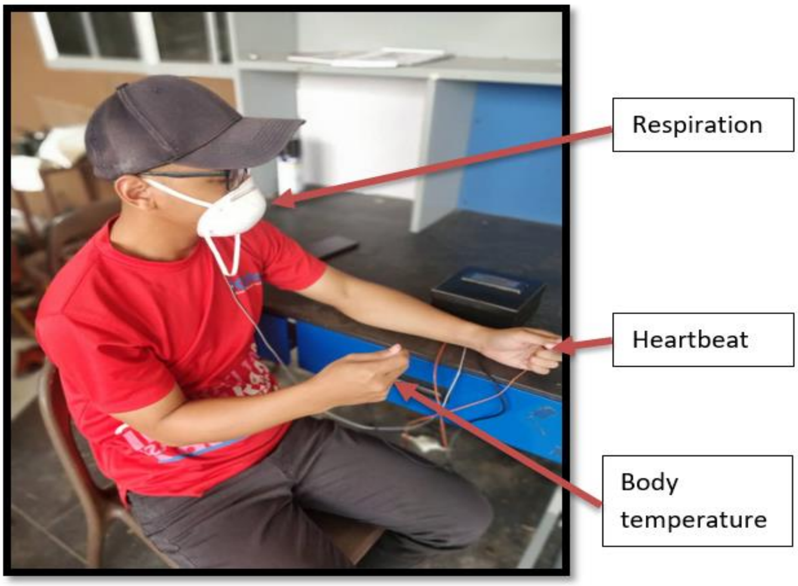

Fig. 5 - System setup

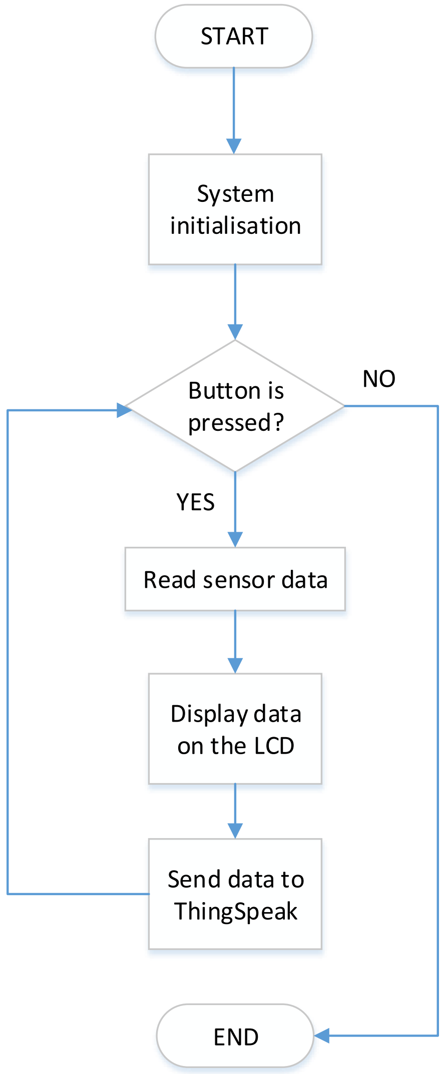

Fig. 6 - Flowchart of the whole process

4. Results and Analysis

4.1 Test Field

Fig. 5 shows the picture of the test field. The sensors are connected to the user as shown in the picture. As explained in section 3, the properly steps have been taken to ensure the measurement are correct. The reading data from the ThingSpeak app are recorded in Table 2. The measurements are made for three males with different ages. Measurement for heartbeat, body temperature and respiration rate are taken at the same time. The measurements are then repeated for every 1 hour. In total, five readings are taken for each datasets. The average value is taken to observe the differences in reading between the three persons.

Table 2 - Measurement results

User	Parameter	Reading number					Average
#1 _25 yrs, male	Heartbeat	70 BPM	68 BPM	75 BPM	73 BPM	72 BPM	71.4 BPM
	Body temperature	36°C	35°C	34°C	35°C	35°C	35°C
	Respiration	16 BPM	12 BPM	16 BPM	12 BPM	12 BPM	13.6 BPM
#2 _23 yrs, male	Heartbeat	75 BPM	72 BPM	80 BPM	71 BPM	74 BPM	74.4 BPM
	Body temperature	35°C	34°C	35°C	35°C	36°C	35°C
	Respiration	12 BPM	12 BPM	16 BPM	12 BPM	12 BPM	12.8 BPM
#3 _24 yrs, male	Heartbeat	65 BPM	69 BPM	73 BPM	70 BPM	74 BPM	70.2 BPM
	Body temperature	34°C	35°C	35°C	35°C	35°C	34.8°C
	Respiration	16 BPM	16 BPM	12 BPM	12 BPM	12 BPM	13.6 BPM

4.2 LCD Display

Fig. 7 shows the results for temperature, respiration and heartbeat displayed on the LCD screen. The data represent the results of the body temperature, respiration rate and the heartbeat of the user.

Fig. 7 - Results from the sensors

4.3 ThingSpeak Graph Results

Fig. 8 shows the vital signs reading of the male patient at the ThingSpeak cloud correspondingly. First, the first row shows the heartbeat reading which is taken from the pulse sensor. Then, the second row shows the heart rate reading taken from the temperature sensor DS18B20 and the last row shows the respiration reading taken from the LM35 sensor.

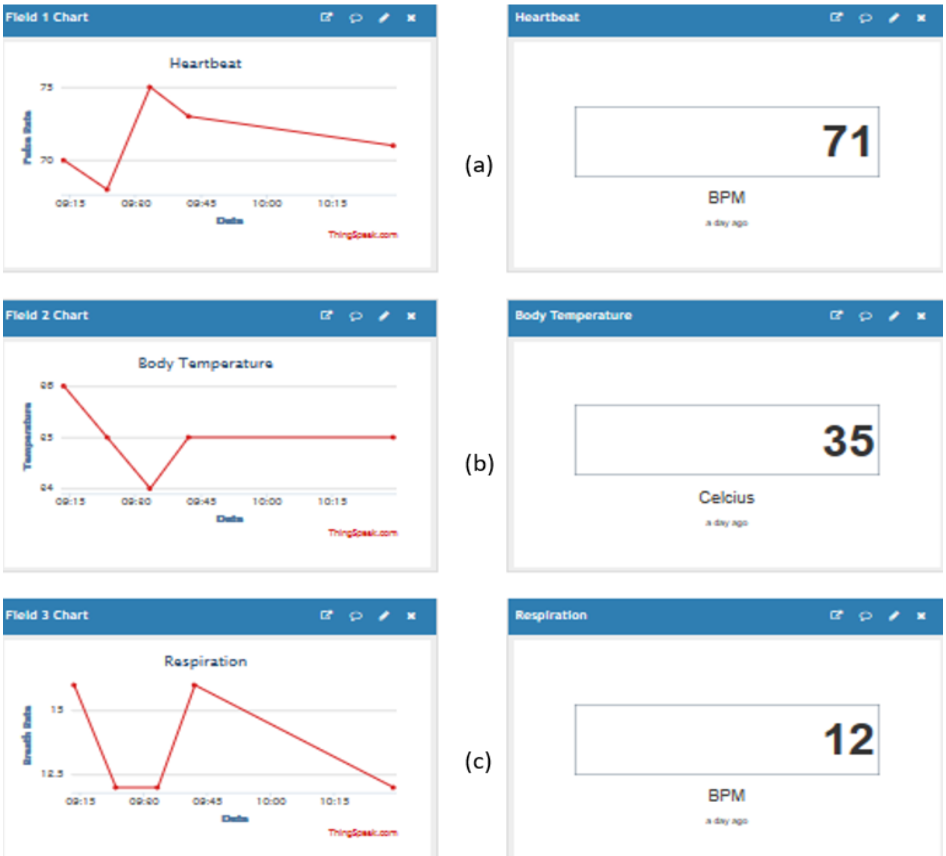

Fig. 8 - Vital signs reading of patient in ThingSpeak (a) heartbeat; (b) body temperature; (c) respiration

4.4 ThingView Android Mobile App

ThingView is an android application that is available free on Google Play. This application enabled the patient, relatives or even doctor to monitor the data that have been taken and sent into ThingSpeak perspective channels in a simple way by entering the ThingSpeak channel ID. The following figures depict the vital signs reading from the ThingSpeak cloud at the android mobile applications. Firstly, Fig. 9 shows the heartbeat reading graph. Next, Fig. 10 shows the body temperature reading graph and lastly, Fig. 11 shows the respiration reading graph.

Fig. 9 - Heartbeat graph

Fig. 10 - Body temperature graph

Fig. 11 - Respiration graph

5. Conclusion

The prototype proposed in this work have successfully measured and displayed the temperature, pulse and respiratory readings on LCD and smartphones. The results indicate that the readings obtained are accurate because they have been validated. Thus, these innovations can help doctors monitor their patients remotely while other users can better monitor their parent's health. This innovation has also resulted in a product that can measure three parameters at a time in real time. The proposed work paves the way for elderly patients monitoring system from long-haul distance with low cost and high efficiency.

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