Self-Monitoring Framework For Patients In Iot-Based Healthcare System

Mritha Ramalingam, R. Puviarasi, Elanchezhian Chinnavan, How Kok Foong

Abstract*: With the recent developments in Internet of Things (IoT) and the increase of smartphone users, patient's health can be monitored without visiting the hospital for medical services. Nowadays, the cost of healthcare is high and insufficient of workforce in the hospital caused the patient unwilling to visit the hospital. The proposed work is to design a monitoring system using sensor and microcontroller to be used by the patients at their place (eg. home). This paper discusses the designing process of the framework. This system will allow the patient to measure their pulse rate and body temperature by using sensors and data collected from the sensor are integrated by using a microcontroller. These acquired patients data could be viewed in mobile application. In addition, the system will provide features such as consultation or chat facility and medical reminder to further improve the feasibility of patients' health care system.

Keywords: health, microcontroller, monitor, mobile application, sensor.

I. INTRODUCTION

Health is a major concern to human in order to have a better life. With the increasing number of person with chronic diseases, the physiological parameters of patients' health need to be monitored for early medical treatments in order to save their life [1]. Recently, healthcare facilities such as clinic and hospital is limited in rural area which caused lack of doctors and care takers providing health service for the patient. The increasing demand of modern resources placed on the medical service providers increases the cost of in-patient care. Furthermore, because of the common reasons existing among patients such as aging, person's daily workload and diseases make them to follow irregular in-take of medication. This results in consuming longer period for a patient to recover from sickness [2].

The health monitoring of patients is becoming necessary to maximize the utilization of available resources in modern technology. Vital signs are the physiological parameters of any person to indicate the health condition. The parameters included for health care monitoring systems are body temperature, blood pressure, heart rate and respiration rate [3]. The existence of any health disorders can be identified using these physiological parameters [4].

By utilizing the current technology of Internet of Things (IoT) and with the increasing number of smartphone users around the world, a patient's health can be monitored remotely [5]. The confidential information about any patient should be stored securely in health care systems. For remote monitoring of patients, their confidential data must be stored as digital data in electronic medical record systems. This would ease the data transfer process involved in IoT-based health care systems [6].

Nowadays, the IoT is a technology which is most widely used in health care systems. With the proven advantage of IoT network, the patients' confidential data are collected, gathered and stored as digital data in electronic health record systems. In the biomedical healthcare systems, by utilizing sensors technology and microcontroller based engineering systems, the patients' data are transferred to any remote destinations in IoT environment [7]. The acquired data are used to monitor the patients' vital signs and also to alert the doctor or care takers of the patient when abnormalities are detected. These self-monitoring approaches using proactive technologies helps in enhancing the medical services provided by health care units.

Nowadays, the mobile users are greater than the desktop users and the mobile users spend more time on mobile application more than using the mobile websites [8]. By having a mobile application, customers do not need to access the mobile web browsing for their information and a much faster alternative way to get their information without the needs of online to retrieve data [9]. The data is stored in the application itself. In addition, mobile application can have many useful features for the targeted mobile application users. One of the beneficial feature is to solve the problem of patients forget to take their medication is having reminder feature to remind the patient to take medicine in time [10].

Generally, several IoT based healthcare monitoring system are designed for different targeted use. The target of any design could be utilized for remote monitoring of patients [11], data acquisition of patients, electronic record maintenance [12], etc. The health care systems in IoT are designed by using the emerging technologies such as wireless sensor networks [13, 14], cloud computing, big data technology, Global positioning system (GPS) technology, zigbee technology [15], Bluetooth technology [16], micro-electronic systems etc. The microcontrollers are usually programmed using any compatible programming languages and integrated development environment (IDE) [17].

The IoT systems involve the use of smartphone applications for monitoring purpose and also for data

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transmission [18]. In some of the applications, the data acquired from sensors are analysed and processed by the physician for diagnosis and treatment [19, 20]. In some systems, the data acquired by the sensors are displayed using liquid crystal display (LCD) or light emitting diode (LED) display units that are integrated with the IoT systems [21]. There are some systems to monitor the chronic diseases of patients. Health care system to monitor the electrocardiogram (ECG) of the cardiac patients has been developed [22-25]. For diabetic patients, the glucose level in the blood sugar need to be monitored [26].

Considering the reviewed works, it is noted that the IoT-based systems in health care world has paved feasible way for monitoring people health without having to visit hospitals. Furthermore, the data acquired by using sensor technology can be transferred to remote medical officers with low cost ensuring health monitoring by medical experts.

The rest of the paper is organized as follows. Section 2 presents the problem statement and aim of this paper. Section 3 discusses the architecture of the proposed system and the technical aspects. Section 4 concludes the paper with the proposed framework.

II. STATEMENT OF THE PROBLEM

The existing works of the related IoT-based patient health monitoring systems are reviewed. Based on the investigation, it is revealed that, the inconveniences in the traditional healthcare systems are becoming prominent. Secondly, the healthcare professionals must be on site of the patient all the time which increases the cost for human resources. Then, for the patients, to stay in the hospital is charged and the cost is not cheaper. The in-patient charge for individual is costly. Finally, the tradition of management of health records using paper form and it take time to search, retrieve and update patient information record.

Furthermore, the related works indicate that although many solutions are available in IoT-based patient health monitoring filed, the low cost self-monitoring application is still required for the patients to monitor their health by staying at home. Hence, to enhance the services provided to patients in terms of cost effective, this paper proposes a framework for the design of low cost self-monitoring application using IoT-based system.

The objectives of the proposed system are: design a system to acquire the pulse rate and body temperature of patients by using sensors. Then, pre-process the acquired data using microcontroller for self-monitoring of patients. Further, to develop a mobile application with features such as medication reminder and communication with medical officers.

III. PROPOSED METHOD

Recently, the IoT technology is getting popular and greatly use in the organization. By building a smart microcontroller to get accurate reading from the sensor, selection of equipment is important to develop the proposed system to monitor heart rate and body temperature. The engineering materials used in the proposed system design are sensors, microcontroller, electronic platform, Bluetooth module and cloud storage. The proposed system is developed to allow patient to take measurement of their heart rate and body temperature individually by using the sensors. The current design of proposed system discusses two stages: one is the design of integrating microcontroller and sensor technology and another is design of mobile application. First, the user needs to use the microcontroller to get the heart rate reading and the body temperature reading through the sensors. Next, the user needs to open the mobile application of the proposed system to allow the data get from the microcontroller can be sent and store in the user's Android smartphone through Bluetooth. Then, the health information of the user can be sent to the online web server using wireless connection and the doctors can monitor the patient condition according to the patient's health information record.

A. System architecture

The Figure 1 shows the framework proposed for the development of IoT-based self-monitoring health care system. The proposed system is aimed to be developed in four stages, namely data acquisition, data pre-processing, data transmission and features for easy medical services.

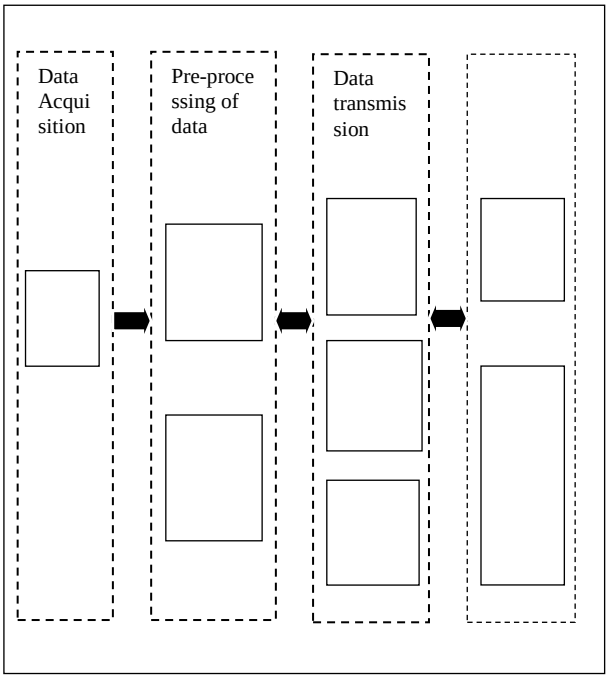

Figure 1. Proposed framework of IoT based self-monitoring system

1. Data Acquisition of health parameters

The first stage of the proposed system is to measure the health parameters such as body temperature and pule rate of patients. These parameter values are measured by using body temperature sensor and pulse rate sensor available at the patient side. Any changes in body temperature of the patient can be measured using temperature sensor. The pulse rate is the rate at which the heart contracts to pump the blood in the human system. The pulse rate of heart is measured in beats per minute.

2. Pre-processing of acquired data

Data that are measured through the sensors are acquired by a microcontroller. The data are pre-processed and displayed on the LCD screen for the patients to observe the measured parameters. The body temperature values lesser than the minimum cut-off

measurement and values higher than the maximum cut-off values might lead to patients' collapse of respiratory system. The direct measurement of health parameters help the patient to monitor their health status.

3. Data transmission

The acquired data from the microcontroller need to be transmitted to external devices through Bluetooth and internet storage such as cloud storage in order to facilitate the remote medical services. For the transfer of data over reliable communication, the proposed system is intend to use low cost technology such as Bluetooth devices. By using Bluetooth module, the collected data from microcontroller is transmitted to mobile devices. With the utilization of cloud storage, the system can transmit data over internet from mobile device to end device.

4. Alerts and additional feature

The smartphone mobile application is developed for ease transmission of data over internet storage and to communicate with the medical experts. The proposed system is aimed to provide features for reminder to patients to take medicine on time, to chat with the medical officer to make appointments for consultation.The proposed IoT System is designed to monitor patient's health parameters remotely such as patients' body temperature and pulse rate. The architecture of the self-monitoring system is illustrated in Figure 2. A microcontroller is used to collect patient's pulse rate and body temperature parameters. The acquired measurements are displayed on LCD screen. The received parameters are transmitted to the server system using wireless connection. Then, the health's reading of the patient is sent to the Internet for cloud database storage via a Bluetooth module. The data that stored in the database can be used to display in the user's mobile application and the doctors can monitor the patient condition according to the patient's health information record. Moreover, the patient can check their health status using their smartphone application for reminder feature to alert themselves to take their medication.

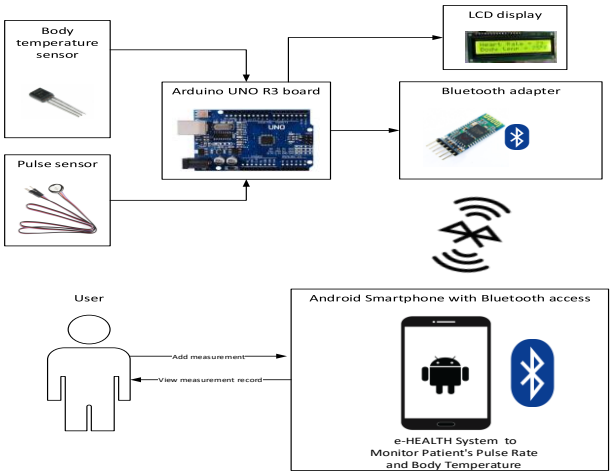

Figure 2. Proposed System architecture

B. Pulse sensor

Pulse Sensor is used to measure the heart pulse rate of human. Pulse rate is the number of times the heart beats per unit of time. It is usually measured as beats per minute. The pulse rate helps to identify the health condition of a person for early detection of any heart diseases. The pulse sensor can be worn on the human finger tips or earlobe to get the heart pulse reading. With the help of microcontroller, the measured readings are collected and displayed on the LCD screen. Pulse sensor is a portable electronic device used in the design of health care systems. The sensor module use infra-red LEDs (Light emitting diodes) to detect the changes in volume level of blood as the light intensity of the infrared LEDs changes based on the volume level of blood. The value collected by the pulse rate sensor will be processed to result in beats per minute [17].

C. Temperature sensor

Temperature sensor is used to measure temperature in an environment. For this project, the temperature is used for measure human body temperature using fingertip. The temperature sensor detects the temperature and the microcontroller is used to read and collect the data. There are many types of temperature sensor such as LM35 and LM36 are used for body temperature measurement. Based on the reviewed systems, LM35 temperature sensor is preferred. This is because, LM35 type of sensors outputs accurate measurements and calibration for the temperature sensor is easy [18]. Any temperature sensor before its use in the design, it should be calibrated for proper setting up of the analogue reading. Then, microcontroller platform is used to convert the analog voltages into digital values. LM35 is a 3 pin design with first and last pin for power supply and ground whereas the middle pin is used to convert output voltage of LM35 into temperature in °C (Celsius scale) [27].

D. Electronic design

There are three common models of electronic platform available in the market which are Arduino, Raspberry Pi and BeagleBone Black [28, 29]. These three modules are available at affordable prices and the size of the gadgets are about the same. These electronic platforms can be used to develop many kinds of digital gadgets that bring benefit to the organization.

Arduino uses a simple microcontroller requiring less power to run. Arduino has proven that it can support multiple sensor based projects. Besides that, Arduino is an open-source electronics platform in term of easy-to-use hardware and software. Arduino is used to read inputs from the sensor and turn it into an output. The Arduino can work with a wide range of input voltage and it has analogue to digital interfaces that allow user ease to connect components that output different voltages. Arduino module includes the microcontroller, which is usually programmed by using C/C++ programming languages with IDE [28].

Raspberry Pi is a small computer module which is used to develop real time applications. This module is integrated with Arduino in most of the IoT based designs. Raspberry Pi module is composed of memory in its design.

BeagleBone Black is a low cost module used for wireless communication in IoT based systems. This module is helpful in transfer of messages ThingSpeak is used in IoT environment for data accessing with embedded devices and web-based resources. It is compatible with microcontroller and Raspberry Pi modules.

The sensors are capable of delivering analogue signals as the output. The analogue measurements should be converted into digital values. So, the microcontroller is programmed to receive the analogue output of sensors and calculate the digital measurements. Then, the measurements are displayed on the screen.

E. Bluetooth module

The proposed work consists of using IoT technology by having microcontroller to collect data from the sensors and transmit the data to the network and store in the online database; the data can be accessed online by using smartphone or computer. By using Bluetooth module, it can make the microcontroller for gaining the access to any Bluetooth network and transfer collected data to the end device.

F. Display module

The health parameters that are measured such as pulse rate and the body temperature are acquired by using microcontroller. The acquired measurements are displayed using a LCD screen. A microcontroller is programmed for the display of measurements. The data acquired could also be displayed on the mobile device by using the integrated microcontroller in the IoT communication system.

G. Cloud storage

All the data captured by the microcontroller need to be stored on the cloud in the graphical form to allow doctor to view the patient's health status at any time. The patient who only need consultation then cloud server is suitable option for doctor to give consultation to the patient based on the patient status on the cloud. The cloud server can alert the doctor if detected any abnormal condition of patient's data [19].

IV. CONCLUSION

This paper presented the importance of designing IoT based health care systems for patients health monitoring. This paper proposed a new framework called self-monitoring application in IoT-based health care system to track patients' health without having wired bedside biomedical instruments for a period of time. The proposed system is aimed to provide low cost IoT-based patients self-monitoring system. By having this system, patients can monitor their health parameters themselves which can reduce medical cost. This framework will reduce healthcare cost by saving in-patient charges by staying at home and helps in monitoring the health by the services provided by health professional.

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