Development of IoT Heartbeat and Body Temperature Monitoring System for Community Health Volunteer

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***Abstract*—Every community in Thailand has supporting groups that are responsible for routine health monitoring of all community members to reduce doctor and nurse works. IoT heartbeat and body temperature monitoring system is designed for them when they visit each house for a regular health checkup. The system consists of two parts, portable measuring device and android application. The portable measuring device can measure the heart rate and body temperature. The device uses Arduino board that connects to the heartbeat and temperature sensor. It shows the heartbeat and temperature readings on LCD display and at the same time sends them to ThingSpeak IoT platform in real-time via Wi-Fi. When both readings are uncommon, the system will send the notification to Line application. The android application can keep track of all measuring devices and community member records by using Firebase database. It also shows graph of heart rate and temperature values in real-time and in the specified interval time, e.g., a day or a week. In the paper, the different types of sensors are compared to see the different performances. The evaluation of the system performance by 3 computer experts found that the developed system was in good level ($\bar{x}$=4.47) and the evaluation of the system usage satisfaction by 40 community health volunteers found that the overall satisfaction was in good level ($\bar{x}$=4.47).**

***Keywords*—IoT realtime system, heartbeat sensor, temperature sensor, Arduino, ThingSpeak**

I. INTRODUCTION

Many countries around the world are experiencing an increase of elderly people. In 2016, the number of elderly people reached 929 million out of the total world population of 7,433 million people, representing 12.5 percent. For Thailand, it has entered the aging society since 2005 and will completely enter the aging society in 2021 that the number of the elderly population will be as high as 20 percent [1]. The government needs to allocate more elderly care budgets every year which will ultimately affect the country's economic growth. In addition, it is leading to the shortages of medical providers. The community health volunteer, who is responsible for providing advice and public health assistance to people in the community, can help to reduce the shortages. The aim of this paper is to develop a heartbeat and body temperature monitoring system to support the elderly care work for the community health volunteer.

Internet of Things (IoT) is one of the technologies that can help to support in health monitoring system. The four main vital signs regularly checked are pulse rate, body temperature, breathing rate, and blood pressure. IoT heartbeat and body temperature monitoring system is proposed in this paper to improve monitoring of two main vital signs with low-cost. With IoT, the system can send the warnings in real-time to caretakers and they can monitor and diagnosis the heart rate and temperature anywhere over the internet.

The heartbeat is the heart contraction and relaxation. In order to get a heart rate, the cardiac cycle is measured. The cardiac cycle is the time cycle between contraction and relaxation of heart [2]. Two main techniques to measure heart rate are electrical method called electrocardiography (ECG) and optical method called photoplethysmography (PPG) [3]. ECG measures the electrical signals by using the electrodes placed on the skin. The electrical signals are caused by a tissue group in the heart that control the expansion and contraction of heart muscles during each cardiac cycle. PPG measures optical variation of the light signal from the finger. The variation is caused by the infrared light through a blood vessel according to the heartbeat.

Four main types of temperature sensors are RTD, thermocouple, semiconductor, and IR [4], [5]. Resistance Temperature Detector (RTD) sensor measures the varied resistance value of metal that electrical signal flows through in the sensor. Then the resistance is converted to temperature. The thermocouple sensor has two different metals that connected together and causes the junction. When junction temperature is changed, the junction output voltage is varied too. Then the voltage is converted to temperature. The semiconductor sensor is an integrated circuit (IC) that includes many types of circuity in one chip. The temperature is calculated from the base-emitter voltage and the collector current of a bipolar junction transistor (BJT). The infrared (IR) sensor is a non-contact sensor. The photodetectors in IR sensor convert the infrared radiation emitted by human body into an electrical signal. Then the electrical signal is sent to the detector that turns this signal to temperature.

II. LITERATURE REVIEW

Heartbeat and body temperature monitoring system in literature can be divided into an offline and online mode approach. Miah et al. [6] proposed the offline system using Arduino UNO with TCRT5000 optical heartbeat sensor and LM35 temperature sensor. The heart rate and body temperature could monitor in android application via Bluetooth. Azizulkarim et al. [7] developed the offline system using Arduino UNO with optical SN-pulse sensor and DS18B20 temperature sensor. The body temperature was displayed on LCD and the heart rate was displayed on PC. Parihar et al. [8] proposed the wireless system using Arduino UNO with optical heartbeat sensor and LM35 temperature sensor. The heart rate and temperature readings were sent to other nodes via radio frequency with communication range up

978-1-7281-6398-7/20/$31.00 ©2020 IEEE

to 800 – 1,000 meters. Shallal and Anooz [9] suggested the wireless system using Arduino UNO with KY039 optical heartbeat sensor and MLX90614 infrared temperature sensor. Similar to Parihar et al. [8], both readings were sent to other nodes via radio frequency. Goel et al. [10] developed the online system using Arduino UNO with an optical heartbeat sensor and temperature sensor. The heart rate and temperature readings were shown on LCD and in Thingspeak IoT platform. Oyebola et al. [11] proposed the online system using PIC16F73 microcontroller with optical heartbeat sensor and LM35 temperature sensor. The heart rate and temperature readings were shown on LCD and were sent as text messages to mobile phones via GSM.

Most of the proposed health monitoring system is an offline system. To increase system efficiency, the online system is preferred. Some of the proposed online systems use radio frequency (RF) to send the heart rate and temperature readings to the remote node but still not cover the wide area. Some of them lack the warning system when the readings aren't normal. Some of them lack the integrated application to show readings in real-time. Our proposed system includes all these functions and also in the paper the different sensors are compared to select the best performance.

III. Proposed System

The overall framework of the heartbeat and body temperature monitoring system is shown in figure 1. Components can break down into hardware and software. Hardware consists of Arduino ESP32, heartbeat sensor (Easy pulse V 1.1), body temperature sensor (DS18B20) and LCD. Software consists of Android Studio, Firebase realtime database, Thingspeak IoT framework, Line API and Arduino IDE. The system consists of two parts, portable measuring device and android application. The device uses an Arduino ESP32 microcontroller board that has built-in WiFi support connected to DS18B20 and Easy pulse sensors. After reading both heart rate and temperature values, they are shown on LCD. At the same time, they are sent to ThingSpeak IoT platform in real-time via Wi-Fi. The platform is also able to keep historical data. When both readings are unusual, the system will send the notification via Line application in real-time. The android application keeps information of community members (i.e., name, heart rate, temperature) and measuring devices (i.e., name, status) in the Firebase Realtime Database. Firebase Authentication is applied to authenticate users to the application. There are two types of users, admin users for caretakers, and member users for each member in the community. Admin users can create, read, update, and delete (CRUD) information of community members. They can monitor the graph of heart rate and temperature of each member in real-time and specified interval. This can be done by using WebView. WebView is a view that displays a web page inside an android application. The web page displays embedded ThingSpeak graphics that are created when member measures heart rate and temperature by using proposed measuring device. Member users can monitor their own heart rate and temperature in real-time and specified intervals. They can view their own information and change their own password.

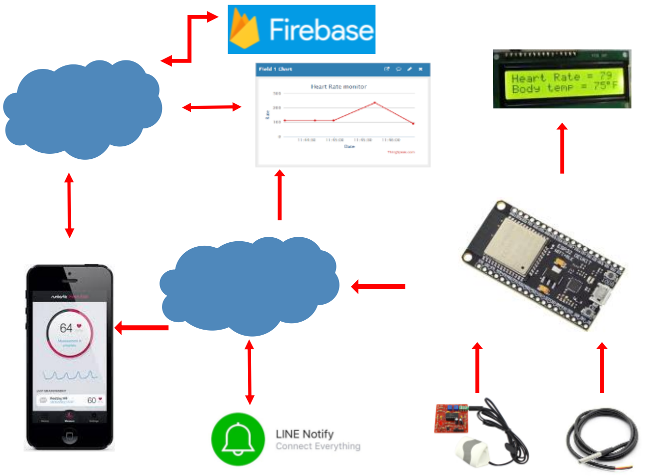

Fig. 1. The overall framework of heartbeat and body temperature monitoring system.

IV. Experiments and Results

Two experiments are conducted, the temperature and heart rate comparison, to select the best sensor in the proposed system. The temperature comparison measures 20 people's temperatures by using the commercial thermometer and two sensors, DS18B20 (digital semiconductor type) and MLX90614 (IR type). The experimental results are shown in Table 1

Table 1 shows that the average of the difference between the commercial device and DS18B20 is 0.6 and the average of the difference between the commercial device and MLX90614 is 2.3. Therefore, we select DS18B20 in the proposed system.

The heart rate comparison measures 20 people's heart rates by using commercial heartbeat device and two sensors, Easy pulse (PPG type) and Pulse Sensor Amped (PPG type). The experimental results are shown in Table 2

TABLE I. The temperature comparison between the commercial thermometer and two types of temperature sensors

	Commercial thermometer	DS18B20	MLX90614	Difference between commercial and DS18B20	Difference between commercial and MLX90614
Person #1	35.7	35.1	34.8	0.6	0.9
Person #2	36.9	36.3	32.5	0.6	4.4
Person #3	36.7	35.8	33.0	0.9	3.7
Person #4	35.6	34.5	33.0	1.1	2.6
Person #5	36.0	35.1	32.6	0.9	3.4
Person #6	36.0	35.2	33.6	0.8	2.4
Person #7	36.1	35.1	35.1	1.0	1.0
Person #8	36.0	35.6	33.1	0.4	2.9
Person #9	36.1	35.7	31.5	0.4	4.6
Person #10	36.1	35.8	32.7	0.3	3.4
Person #11	35.8	35.2	34.9	0.6	0.9
Person #12	36.6	36.1	34.5	0.5	2.1
Person #13	36.5	36.0	34.1	0.5	2.4
Person #14	35.1	34.9	34.2	0.2	0.9
Person #15	36.1	35.3	33.7	0.8	2.4
Person #16	35.9	35.1	34.5	0.8	1.4
Person #17	35.9	35.4	34.8	0.5	1.1
Person #18	36.1	35.4	34.2	0.7	1.9
Person #19	36.2	35.5	32.6	0.7	3.6
Person #20	35.8	35.6	34.7	0.2	1.1

TABLE II. THE HEARTBEAT COMPARISON BETWEEN THE COMMERCIAL DEVICE AND TWO TYPES OF HEARTBEAT SENSORS

	Commercial heart beat device	Easy pulse	Pulse Sensor Amped	Difference between commercial and Easy pulse	Difference between commercial and Pulse Sensor Amped
Person #1	67	64	77	3	10
Person #2	97	102	87	5	10
Person #3	86	90	82	4	4
Person #4	86	76	98	10	12
Person #5	82	89	83	7	1
Person #6	66	64	79	2	13
Person #7	97	100	100	3	3
Person #8	94	87	96	7	2
Person #9	75	80	88	5	13
Person #10	90	81	93	9	3
Person #11	98	87	81	11	17
Person #12	86	80	95	6	9
Person #13	86	88	81	2	5
Person #14	82	78	88	4	6
Person #15	66	77	81	11	15
Person #16	88	76	97	12	9
Person #17	94	99	88	5	6
Person #18	68	75	93	7	25
Person #19	76	83	96	7	20
Person #20	74	85	96	11	22

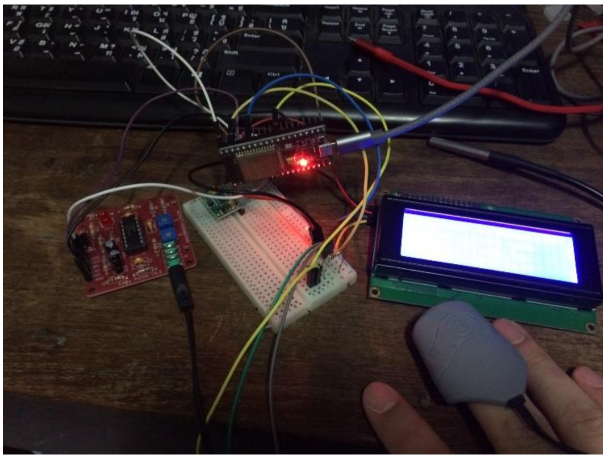

Fig. 2. The heartbeat and body temperature monitoring system implementation

Fig. 3. The heart rate and temperature are shown on LCD

Table 2 shows that the average of the difference between the commercial device and Easy pulse is 6.5 and the average of the difference between the commercial device and Pulse Sensor Amped is 10.2. Therefore, we select Easy pulse in the proposed system.The implementation of the heartbeat and body temperature monitoring system is shown in figure 2 and 3.

After the temperature and heartbeat are measured, the values are shown on LCD and at the same time they are displayed as graph in android application as shown in Figure 4. When these values are not normal, they are sent to the Line application to notify the caretakers as shown in Figure 5.

Once the development has been completed, three computer experts evaluated the efficiency of the system in 5 aspects [12]. Overall of the system performance is in a good level ($\bar{x}$ = 4.47) with the highest performance in functional test and usability test ($\bar{x}$ = 4.67) as shown in the table III.

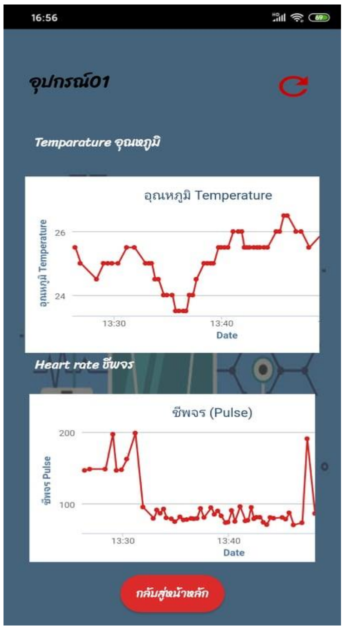

Fig. 4. Graph of temperature and heart rate are shown in android application

Fig. 5. Notification in Line application when temperature and heart rate are uncommon.

TABLE III. THE EVALUATION OF SYSTEM PERFORMANCE BY EXPERTS

Test Type	$\bar{x}$	S.D	Level
Functional test	4.67	0.58	Very good
Usability test	4.67	0.58	Very good
Functional Requirement test	4.33	0.58	Good
Performance test	4.33	0.58	Good
Security test	4.33	0.58	Good
Overall	4.47	0.58	Good

TABLE IV. THE EVALUATION OF USER SATISFACTION BY VOLUNTEERS

Construct	$\bar{x}$	S.D	Level
System quality	4.51	0.07	Very good
Usefulness	4.41	0.11	Good
Security	4.38	0.08	Good
Support and service	4.38	0.09	Good
Overall	4.47	0.58	Good

Fig. 6. User satisfaction evaluation

After that, user satisfaction evaluation was performed for the system as shown in Figure 6. The population in the satisfaction assessment is 45 volunteers in BangNamPhueng Subdistrict, Phra Pradaeng District, Samut Prakan Province, Thailand. Based on the concept of Krejcie & Morgan [13], only 40 health volunteers evaluated the efficiency of the system in 4 aspects.

Participants of user satisfaction evaluation can break down into female (85%), age 41-50 years (35%), elementary education (25%), laber worker (35%), health volunteer experience 10-12 years (30%). The participants satisfy the overall of the system satisfaction in a good level ($\bar{x}$ = 4.47). The highest satisfaction is in system quality ($\bar{x}$ = 4.51), followed by usefulness ($\bar{x}$ = 4.41), security ($\bar{x}$ = 4.38) and support and service ($\bar{x}$ = 4.38) as shown in the table IV.

V. CONCLUSION AND FUTURE WORK

Our research goal is to implement the reliable system that can monitor the heartbeat and body temperature in real time for community in Thailand. There are many sensors that can use to measure the heartbeat and body temperature. Therefore, we conduct the experiments to compare each one of them and select the best one to use in the system. Our proposed system is Arduino ESP32 connected to DS18B20 and Easy pulse sensors. The system has been implemented both portable measuring device and android application as proposed in the section III. When evaluating the system satisfaction of volunteers in BangNamPhueng, it was found that the users satisfied in response speed, processing accuracy, ease of use, beauty and modernity.

The proposed system can monitor two main vital signs, the heartbeat and body temperature. In the future, we would like to extend the system that can also monitor breathing rate, and blood pressure. The more vital signs the system can detect, the better to diagnose the health condition.

ACKNOWLEDGMENT

This study is supported by Rajamangala university of technology Tawan-ok research foundation in The medical innovation model development for caring and following-up for sickness of elderly people and bedridden patient in the community of Bang nam phueng, Pra pradaeng, Samut Prakan province research project.

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