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Heartbeat and Body Temperature Monitoring System Based on Artificial Neural Networks

Tan Suryani Sollu[1], Alamsyah[2], Eko Setijadi[3]
[1,2]Department of Electrical Engineering, Tadulako University, Palu, 94118, Indonesia
[3]Department of Electrical Engineering, Sepuluh Nopember Institute of Technology, Surabaya 60115, Indonesia

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ABSTRACT

Heartbeat and body temperature are vital sign parameters for paramedics in strengthening the diagnosis of a disease. Medical staff generally use an electrocardiogram and thermometer to check the heart rate and body temperature. These tools are still manual and require concentration to get accurate values. This examination system is less useful because it requires a long time to collect data, increasing the burden on medical personnel and rising operational costs. To improve health services optimally, the authors propose the manufacture of heart rate and body temperature monitoring devices for the elderly based on wireless using the Artificial Neural Network (ANN) method. The proposed method can assist medical personnel in diagnosing heart attacks with three conditions (normal, low risk, and high risk). This study aims to assist medical staff in monitoring patients 'health conditions and diagnosing patients' heart disease in real-time. This system uses PPG HRM-2511E sensor to detect heart rate and a DS18B20 sensor to detect body temperature. The data detection process uses a raspberry pi, and the decision-making system uses the ANN method. The results of testing the success rate of detecting the heartbeat of 97.90%, and the body temperature of 99.51%. The heart rate and body temperature data processing using ANN went as expected.

Corresponding Author:

Tan Suryani Sollu
Universitas Tadulako, Palu, 94118, Indonesia
Email: tansuryani@yahoo.com

1. INTRODUCTION

Vital sign examination, especially heartbeat and body temperature, is critical for every human being to do [1] to strengthen the medical diagnosis [2, 3] and the subsequent treatment process [4]. The heart is one of the vital health organ parameters [5] in the human body, which functions to pump blood throughout the body. Based on data from the World Health Organization (WHO), it mentioned that the cause of death globally is caused by heart attacks. In 2014 in Southeast Asia, especially in Indonesia, the death rate reached 35% due to heart disease and 39% experienced by those under 44 years of age. One of the factors causing the high mortality rate in heart disease is the slow handling of examining the patient's disease condition [6].

Checking vital signs such as heartbeat and body temperature is a top priority that the health service centre must consider to make early prevention [7] and reduce mortality. Equipment used by medical personnel to carry out vital sign checks, such as electrocardiograms and thermometers, at hospitals. However, this equipment still has weaknesses related to time efficiency and manually [8]. This condition affects the level of health services such as the slow disease diagnosis process, the data processing not in real-time [9], high operational costs, and the workload of medical personnel increasing. To improve

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health services optimally. The researchers designed medical devices that we're able to monitor and display diagnoses of elderly heart conditions in real-time [10].

Several researchers have proposed studies related to vital signs [11], such as monitoring heartbeat [12, 13], body temperature [14], blood pressure [15-17], and breathing [18]. Research results show that the proposed design works well, with an accuracy of 0.7% for heart rate [19] and a body temperature of 0.085% [20]. Proposed vital sign monitoring can be applied to car drivers [21] and prescribing [22] sent in real-time to each patient. However, the authors have not designed decision-making systems using artificial intelligence (AI) methods. Developing a decision-making system using AI methods will facilitate medical personnel in diagnosing patients' illnesses.

2. LITERATURE REVIEW

2.1. Vital Sign Monitoring

Vital signs are the most basic measurement of body functions to help determine a person's health status, especially in medically unstable patients. Vital sign monitoring is an examination related to vital signs to assess a person's physical health, which generally leads to the stage of recovery and helps diagnose the disease early. Vital sign monitoring is essential to monitor the condition of patients undergoing inpatient and outpatient treatment. Typical vital signs change with age, sex, weight, and exercise tolerance. Vital signs can use to monitor the patient's body temperature and heartbeat.

2.2. Body Temperature

Body temperature indicates the presence of metabolism in the human body. Heat production that occurs as part of metabolism and during exercise is balanced by heat loss mainly through evaporation of sweat. Factors that affect body temperatures include biological rhythms, hormones, exercise, stress, and medications. Body temperature can be measured using an analogue or digital thermometer. Average adult body temperature ranges from 36.5 - 37.2 ^{0}C. Checking body temperature is crucial to know a person's physical condition and is a routine part of almost all clinical assessments. This examination describes the severity of the disease, such as infection. In this study, the body temperature sensor used is the DS18B20 type.

2.3. Heartbeat

Heartbeat is the number of heartbeats per unit time or beats per minute (bpm). When the heart beats where the heart pumps blood through the aorta and peripheral blood vessels. This pumping causes the blood to press against the artery walls, creating pressure waves as the heartbeat that are felt peripherally as a heartbeat. Furthermore, this heartbeat can palpate to assess the heart rate, rhythm, and function. The normal heartbeat for adults is between 60 - 100 bpm. This study uses the PPG HRM-2511E type of heartbeat sensor.

3. RESEARCH METHOD

The stages of research begin with the development of research concepts based on the references. Furthermore, planning hardware and software systems. Figure 1 shows the process of the research stages. Data information includes the HRM-2511E pulse sensor as the heartbeat input and the DS18b20 sensor as the body temperature data input in real-time. Sensor data will process in the Raspberry Pi module. The next stage is to create a system design script using python programming on the Raspberry Pi IDE. Sensor input data that the server has processed and received will display on the smartphone.

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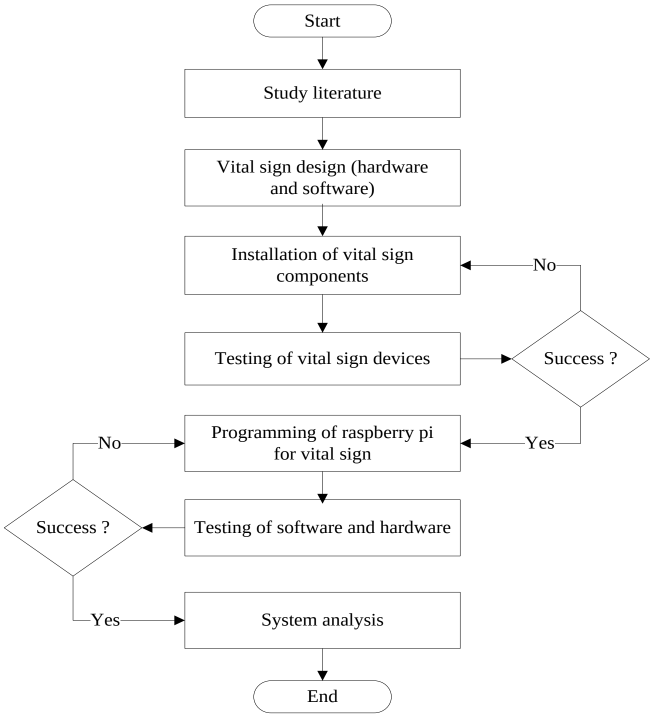

Figure 1. Stage of research

3.1. Block Diagram System

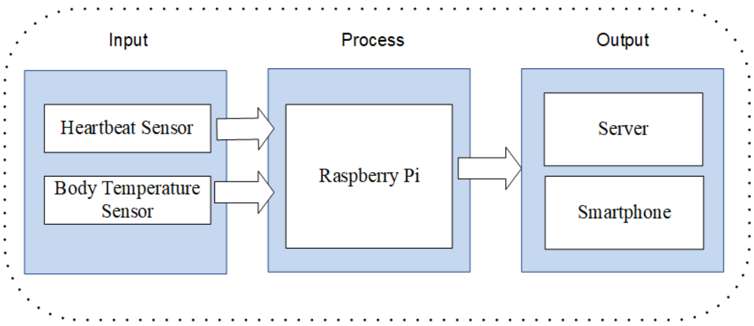

Figure 2. Block diagram system

Figure 2 shows the overall heart rate and body temperature monitoring system using ANN consisting of input, process and output units. On the input unit there is an HRM-2511E sensor which functions as a heart rate detection, and a DS18b20 sensor which works as a body temperature detection. The results of the sensor data input will process by the Raspberry Pi module, which functions as a data processor. The Raspberry Pi module is a liaison between the input and output unit. The data processing results from the Raspberry Pi will display on the server and smartphone.

3.2. Algorithm System

The system's initial state reads sensor data and sends data from the Raspberry Pi module to the server. Data sent and stored on the server will retrieve by software that has been made. The software processes the data and displays it on a smartphone. Any data changes that occur, the raspberry pi module will respond to these changes according to the designed algorithm. If there is no change, the automatic process will repeat itself back to the operation of reading and sending data that will carry out on the system.

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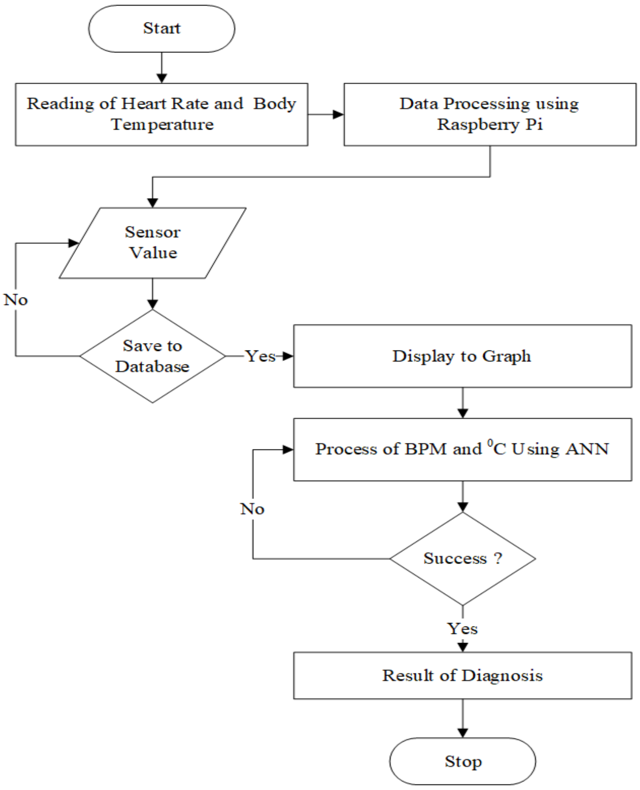

Figure 3. Flowchart of system algorithm

Figure 3 shows the working principle of this system is monitoring the heartbeat and body temperature in real-time.

4. RESULTS AND DISCUSSION

4.1. Testing of Heartbeat Sensor

Figure 4. Retrieval of heartbeat data

The process of testing the data is done by checking the pulse sensor response on each finger first so that the finger has better accuracy. The heart rate sensor used in this test is PPG HRM-2511E.

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Table 1. Pulse sensor response on each finger

Number	Finger	Heartbeat (BPM)
1	Thumb	83
2	Index Finger	78
3	Midle Finger	80
4	Ring Finger	79
5	Little Finger	78

Table 1 shows that each finger's pulse sensor response did not differ significantly. The testing takes data from 10 objects with five sampling times. The purpose of receiving data 5 times is to produce the average value of the calculation generated by the sensor. The calculation results from the sensors are then compared with the results of calculations from digital devices for 10 seconds for each object. An estimate of the number of heartbeats using digital tools is done as a benchmark to determine the accuracy of the proposed sensor design. Table 2 obtained the most significant error value of 4.88% and the smallest error of 0%, where the average error of the pulse sensor testing of ten objects is 2.10%.

Table 2. Testing result of heartbeat data

Id Number	Heartbeat (BPM)		Error (%)
	HRM-2511E	Digital Heartbeat	
001	92	94	2.13
002	86	89	3.37
003	95	97	2.06
004	90	93	3.23
005	87	87	0
006	78	82	4.88
007	89	89	0
008	89	91	2.19
009	92	92	0
010	91	94	3.19
Average Error			2.10

4.2. Testing of Temperature Sensor

Figure 5. Retrieval of temperature data

Figure 5 shows the body temperature sensor used in this test is DS18B20. Testing by holding the sensor by hand for 2-3 minutes. Body temperature sensor testing is taken data from ten objects five times. Retrieval of data 5 times aims to produce the average value of the calculations generated by the sensor. The calculation results from the sensors are then compared with the digital thermometer calculations for 2-3 minutes for each object. Estimating body temperature using a digital thermometer is a benchmark to determine the accuracy of the proposed sensor design. The results of table 3 obtained

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the most significant error value of 1.34% and the smallest error of 0%, where the average error of body temperature sensor testing of ten objects is 0.49%.

Table 3. Testing result of temperature data

Id Number	Temperature (^{0}C)		Error (%)
	DS18b20	Thermometer	
001	36.48	36.60	0.33
002	36.80	36.80	0
003	36.90	36.60	0.82
004	36.80	36.50	0.82
005	36.90	36.40	1.34
006	36.60	36.60	0
007	36.80	36.40	1.09
008	36.90	36.80	0.27
009	36.80	36.70	0.27
010	36.40	36.40	0
Average Error			0.49

4.3. System Testing

Figure 6. Testing result of device

Figure 6 shows system testing done by sending ten sensor data to the server. System testing determines whether the system is designed to function as expected. The overall test results are carried out by sending data to the server. Table 4 shows the data from ten results sent to the server. System testing aims to determine the entire system, including the interface designed to display data from the sensor.

Table 4. Data testing

Time (AM)	Heartbeat (BPM) HRM-2511E	Temperature (^{0}C) DS18b20	Status
10:07:25	92	36.48	Normal
10:07:28	86	36.80	Normal
10:07:33	95	36.90	Normal
10:07:35	90	36.80	Normal
10:07:40	87	36.90	Normal
10:07:45	78	36.60	Normal
10:07:48	89	36.80	Normal
10:07:50	89	36.90	Normal
10:07:55	92	36.80	Normal
10:07:58	91	36.40	Normal

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4.4. Heartbeat and Body Temperature Monitoring Using Artificial Neural Network (ANN)

The heartbeat and body temperature monitoring design include the login menu facilities, data entry (id_number), name, age, gender, address, telephone number, data reports, data collection process, and data storage.

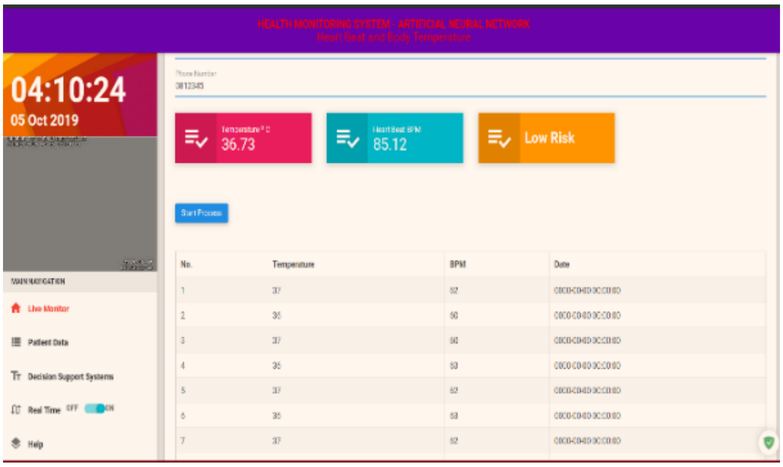

Figure 7. Monitoring system using ANN

Figures 7 show the method of processing heartbeat data and body temperature using the ANN method. Means of collecting data and inputting patient data. After entering patient data, insert the HRM-2511E sensor into the fingers. The DS18b20 sensor stuck to the palm. Next, enter the value of data duration into the time menu and choose the process menu. Patient data that has been processed will display on the monitor screen with BPM (heartbeat) and ^{0}C (body temperature) values. The heartbeat and body temperature obtained can save in the save menu. Display patient data can do by entering patient data based on id number. The results of the incoming sensor data will be processed using the ANN method with three conditions. The conditions displayed in the system include normal circumstances, a little risk, and a high risk of an occurring heart attack.

5. CONCLUSION

This research is designed to improve health services and assist medical personnel in monitoring heartbeat and body temperature. The system design can be used by medical staff in real-time using smartphone facilities. The test results show that the design of the proposed heart rate and body temperature monitoring system works with an accuracy rate of 2.10% heartbeat and 0.49% body temperature. The use of the ANN method in the application can run well by predetermined rules.

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