

Web-Based Wireless Monitoring System on Patient's Vital Sign

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Abstract. Examination of vital signs such as blood pressure, heart rate, and body temperature is the most basic essential function of the body in determining the health status of the patient. In general, examining vital signs performed by a doctor or nurse uses an electrocardiogram, thermometer, and sphygmomanometer. However, this tool has a weakness in terms of time efficiency and accuracy of reading vital sign data. The process of taking vital sign data for a long time, the limited number of medical personnel in handling patients, and increasing administrative costs certainly become a concern for management in improving health services. To overcome this problem, we proposed a design that can monitor the health condition of patients' vital signs efficiently and in real time. The system used in this study consisted of an HRM-2511E type heartbeat sensor in pulse units per minute (bpm), DS18B20 body type temperature sensor in degrees Celsius ($^{\circ}\text{C}$), and MPX5700AP sensor in mmHg units. This research is fundamental and is useful in helping medical personnel in monitoring patients' vital sign health conditions. The results of the proposed design showed that the heart rate, temperature, and blood pressure devices worked well with respective accuracy of 97.64%, 99.51%, and 97.53%.

Keywords: **vital sign; body temperature; heartbeat; blood pressure; raspberry pi.**

1. Introduction

Examination of vital signs is very fundamental to know the initial conditions of diseases that can occur in the body and greatly deciding the subsequent treatment process [1]. Vital sign such us heartbeat, body temperature, and blood pressure are parameters that very basic for the doctor or nurse in determining the health status of the patient It is understandable considering that the heart [2] is a vital organ in the human body that functions to pump blood throughout the body. Based on Basic Health Research data in 2013 shows that around 883,447 people in Indonesia suffer from coronary heart disease. The results of the study state that 39% of the group less than 44 years old, 22% are from the age group of 15 to 35 years.

Examination or checking of vital signs performed by medical personnel or doctors generally uses an electrocardiogram, sphygmomanometer, and thermometer. However, this device still has weaknesses in terms of time efficiency and, its use still based conventional. Examination of the patient's vital sign is done repeatedly and requires concentration in obtaining accurate values. This condition certainly affects the level of patient health services such as vital sign data retrieval processes to be slow, administrative costs increase, and the doctors' and nurses' workload become to increases. Some studies that have been conducted by vital sign researchers include heartbeat monitoring systems [3, 4], body temperature [5] using Arduino, and Android [6]. The results of the research conducted indicate that the

proposed design works well. However, researchers have not yet developed a blood pressure monitoring system.

Heartbeat and body temperature monitoring system based Bluetooth [7]. The results showed that the proposed design could help medical personnel in terms of health services, reduce the burden of medical resources, and the results of patient diagnosis information more quickly. However, the range of patient data delivery is still limited.

Research related to health monitoring has also proposed by several researchers, including analysis of quality of service (QoS) on mobile ad-hoc network (MANET) and wireless sensor network (WSN). The results showed that the OLSR protocol had better performance in dense network conditions compared to AODV, DSR, and DSDV [8, 9]. DSDV protocol only excels regarding delay [10]. In multi-hop networks, it is recommended to use the two-way MCF protocol [11]. However, the research carried out is still based on simulations and has not yet been implemented in a real device.

Improvement of health services requires a design needed that can monitor vital signs such as heart rate, body temperature, and blood pressure in real time. One of the most widely used technologies and methods for testing a patient's health condition is blood pressure measurement [12] and followed by heartbeat measurement. This study aims to improve health services in monitoring patients' health conditions, detect patient diseases early, speed up the inspection process, and support the application of professional health services involving various disciplines [13].

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2. Research methods

The process of the research phase consists of literature studies, hardware design, software design, testing and data retrieval, analysis, and conclusions. Fig 1 shows the stages of research.

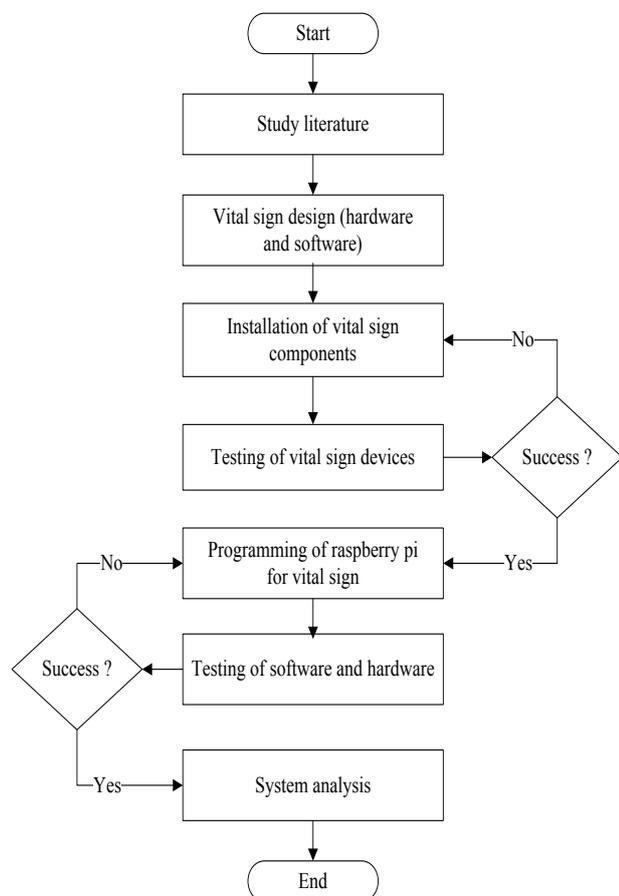


Fig. 1. Stage of research.

2.1. Study literature

At this stage, a research reference carried out related to the vital sign and material used. Reference collection aims to support research, such as measurement of heart rate, body temperature, and blood pressure, standard measures of vital signs based on age and sex.

2.2 Hardware design

At this stage, the design in the form of a layout based on the supporting components of the system built. System design consists of an electrocardiogram sensor, sphygmomanometer sensor, body temperature sensor, raspberry pi, power supply, and LCD.

Block diagram of a vital sign monitoring system using the raspberry pi shows in Fig 2. Detect the heart rate, body temperature, and blood pressure sensors using HRM-2511E, MPX5700AP, and DS18B20 type. The HRM-2511E sensor functions to retrieve heart rate data using infrared and photodiode. Infrared will emit a signal that penetrates the skin on the hand and is captured by

the photodiode. The concept is infrared, and the photodiode will capture changes in blood volume in the fingers when the heart pumps blood throughout the body. The heart rate detection results will be received by raspberry pi through the bloodstream on the fingers in a beat per minute (bpm) unit.

MPX5700AP sensor functions to measure air pressure into electrical signals using piezoresistive technology. The MPX5700AP sensor picks up blood pressure data using air pumped on the hand cuff that is wrapped around the arm until it reaches an absolute pressure. Furthermore, raspberry pi will receive a hand cuff pressure signal as a result of systolic and diastolic pressure mmHg.

DS18B20 sensor function is to detect body temperature by holding the sensor tip. Sensor detection results send digital data in the form of pulse signals in the form of certain temperatures to the raspberry pi. Furthermore, the raspberry pi module will process the data and display it to the liquid crystal display (LCD) in the form of degrees Celsius (°C).

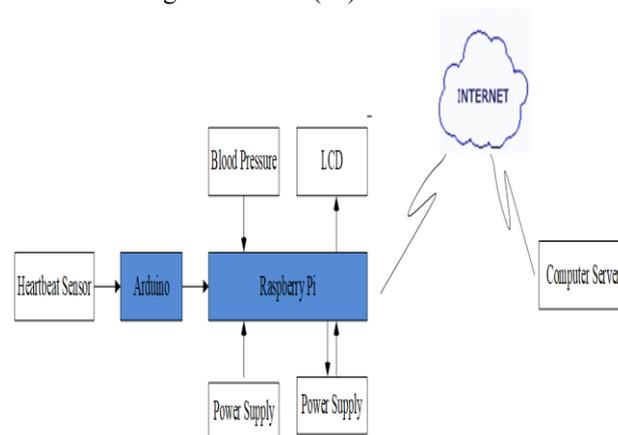


Fig. 2. Work system of vital sign monitoring.

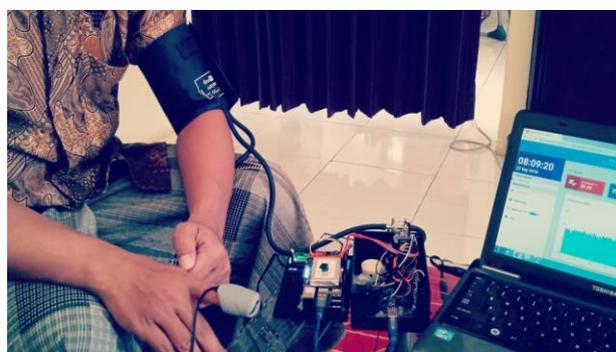


Fig. 3. Design of vital sign device.

2.3 Software design

After designing hardware, the next step is to design software using IDE for Arduino. This application is used to display sensor data through coding on the raspberry pi module with program C. Making of program listings in the form of text editors and stored in the form of .ino extension files. Web databases and systems use MySQL and PHP. Figure 4 shows the design of the software.

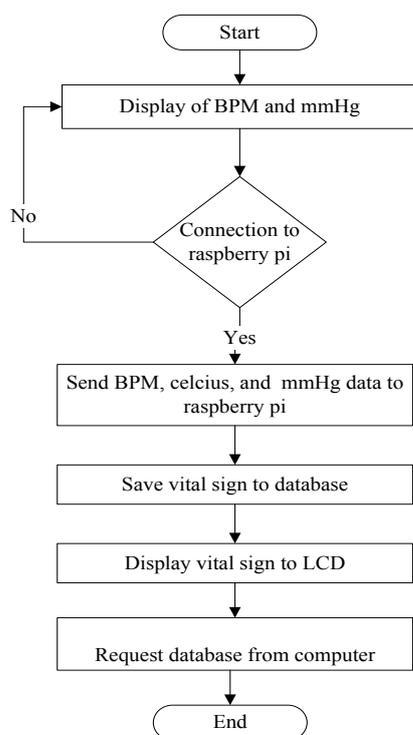


Fig. 4. Flowchart of software design.

2.3.1 Heartbeat design

Heartbeat is an examination of arteries based on the number of heart beats per minute (bpm). Heartbeat measurements usual taken at the wrist and variations in heart rate adjust the amount of oxygen needed by the body. However, in this study, the design of the heartbeat was taken on the fingers. It is designing heart rate detection, the HRM-2511E sensor used as a device that detects heartbeat signals. The generated signal will be processed by raspberry pi and forwarded to the LCD or computer server.

2.3.2 Body temperature design

Body temperature is the body's ability to produce and get rid of the amount of heat into the outside environment which influenced by age, activity, hormones, stress levels, and the types of drugs consumed. The temperature of the human body consists of core temperature and skin temperature.

2.3.3 Blood pressure design

Blood pressure is the result of pumping heart activity that takes place in contraction and relaxation. The value of blood pressure can be measured using a sphygmomanometer. Examination of blood pressure very important, considering that various diseases can occur due to abnormal blood pressure. Normal adult blood pressure ranges from 60 - 100 mmHg. The blood pressure sensor used in this study is the MPX5700AP sensor. This sensor picks up blood pressure data using air pumped on the handcuff, which is wrapped around the arm until it reaches a certain pressure within mmHg.

2.4 Vital sign testing

2.4.1 Heartbeat testing

The testing results of the HRM-2511E sensor showed that a voltage value of 4.87 volts. The resulting voltage is more or less the same as the specifications displayed on the HRM-2511E sensor of 5 volts. The next test is to observe the LED indicator on the sensor. Red LEDs provide a sign that the sensor is working normally. Likewise, vice versa, if the red led does not light, indicating that the sensor is not functioning. Furthermore, the test was carried out by taking patient data, each of which tested ten times. The purpose of this sampling is to obtain the average value of the calculation produced by the HRM-2511E sensor. The test results compared to digital heartbeat devices.

2.4.2 Body temperature testing

Testing the DS18B20 sensor is done by taking patient data through the palm and displaying the reading results on the LCD or server computer. The measurement results in patients through 10 times showed that the measured body temperature was at 36.13 - 36.93 C. Body temperature influenced by several factors such as physical conditions, activities, and the surrounding environment.

2.4.3 Blood pressure testing

Testing blood pressure sensors is a principle the same as a heart rate testing procedure. The sphygmomanometer installed in the patient's arm. Each sample tested ten times. The data displayed is analog data from a blood pressure sensor that is converted to digital by a raspberry pi. The results of testing the blood pressure sensor will compare with the value produced by a digital sphygmomanometer. The display of the mmHg value on the LCD indicates that the sensor is functioning normally.

2.4.4 Transmission signal testing

Testing of sending vital sign data do in two conditions. The condition of open space without obstacle and state of a closed space with an obstacle.



Fig. 5. Transmission signal testing of vital sign.

2.5 Retrieval of vital sign data

2.5.1 Retrieval of heartbeat data

Taking heartbeat data aims to determine the patient's heart status (normal or abnormal). The result of collecting heart rate data with 60 seconds duration is 65.46 - 91 BPM. The design of the proposed tool reaches an average error rate of 2.36% compared to other digital heartbeat devices.

Table 1. The result of heartbeat retrieval.

No.	Number of patients	Heartbeat (BPM)		Error (%)
		HRM2511E sensor	Digital heartbeat	
1.	001	65.46	68	3.74
2.	002	85	85	0
3.	003	90.5	93	2.69
4.	004	87	87	0
5.	005	80.25	85	5.59
6.	006	75.7	80	5.38
7.	007	86.3	88	1.93
8.	008	86	86	0
9.	009	91	93	2.15
10.	010	90	92	2.17
Average error				2.36

2.5.2 Retrieval of body temperature data

The purpose of measuring body temperature is as a benchmark to determine the patient's condition and diagnose the state of the body suffered. Physical factors and activities significantly affect the patient's body temperature. The results of data collection were ten patients with a duration of 3 minutes. The average value of the temperature produced is in numbers 36.40 - 36.90 °C. This value is still at the normal threshold of 36 - 37 °C for adults 19 - 69 years. The design of the proposed heartbeat device works well, and the average error rate is 0.49%.

Table 2. The result of body temperature retrieval data.

No.	Number of Patients	Body Temperature (°C)		Error (%)
		DS18B20 Sensor	Digital Thermometer	
1.	001	36.48	36.6	0.33
2.	002	36.80	36.8	0
3.	003	36.90	36.6	0.82
4.	004	36.80	36.5	0.82
5.	005	36.90	36.4	1.34
6.	006	36.60	36.6	0
7.	007	36.80	36.4	1.09
8.	008	36.90	36.8	0.27
9.	009	36.80	36.7	0.27
10.	010	36.40	36.4	0
Average error				0.49

2.5.3 Retrieval of blood pressure data

The purpose of blood pressure measurement is to determine the health condition of the patient's blood pressure. The threshold of blood pressure, which

categorized as standard for adults is between 120 mmHg systole and 80 mmHg diastole. The results of data collection obtained an average value of 116 - 127 mmHg (systole). The performance of sensors designed to function normally and the average error rate is 2.47%.

Table 3. The result of blood pressure retrieval.

No.	Number of patients	Blood Pressure (mmHg)		Error (%)
		MPX5700AP sensor	Digital blood pressure	
1.	001	119	120	0.83
2.	002	127	127	0
3.	003	125	128	2.34
4.	004	120	125	4
5.	005	124	128	3.13
6.	006	127	127	0
7.	007	120	125	4
8.	008	120	122	1.64
9.	009	116	122	4.92
10.	010	125	130	3.85
Average error				2.47

3. Results and discussion

In the monitoring system application, the vital signs menu equipped with several facilities such as login, patient data, and patient data reports, display of heart rate, blood pressure, and graph signals. Data on vital signs displayed after filling in the patient data. It is information provided in this application consists of heart rate values, body temperature, and blood pressure. The explanation of patient data can see in Fig 6.

Patient data that has processed stored on the raspberry pi device. The function of this device is to store data and send data to a notebook or mobile phone application. Patient data stored in the database can display on the vital sign monitoring system. The patient database can be seen in Fig 7.

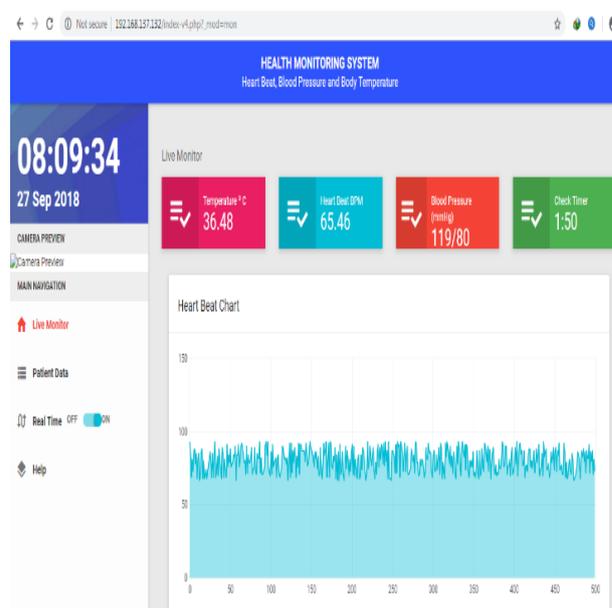


Fig. 6. Information of patient's data.

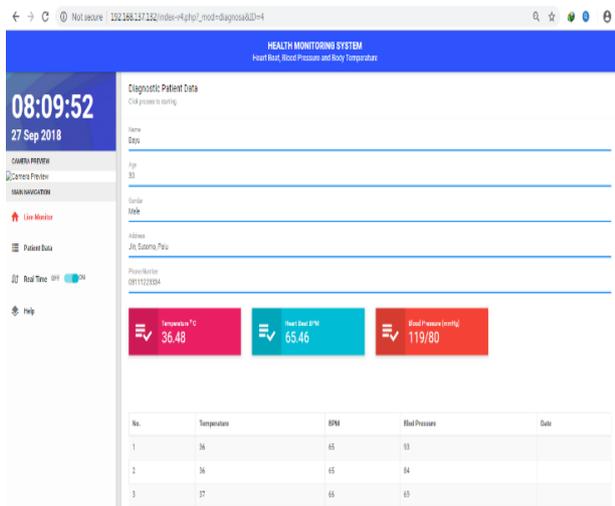


Fig. 7. Process data storage of patient's.

4 Conclusion

This research was designed to improve health services and assist medical personnel in monitoring a web-based vital sign. The system designed can be used by medical staff in real time using the facilities of a mobile phone or notebook. The test results show that the design of the proposed vital sign monitoring system works typically with an accuracy level for a heartbeat of 2.36%, blood pressure of 2.47%, and body temperature of 0.49%. This result is obtained based on comparison with digital-based vital sign devices.

Acknowledgment

Thank you to the Republic of Indonesia Research, Technology, and Higher Education (RISTEKDIKTI) have to provide financing support for the Applied Research Grant for 2019.

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