



Design and Development of Smart Bracelet System for Heart Health Monitoring Based on Internet of Things (IoT)

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ABSTRACT

Body health is essential for supporting various aspects of human life. In making a diagnosis, anamnesis (communication to obtain information about the disease) is followed by a physical examination, which includes general assessments. Key parameters for determining health conditions are heart rate, oxygen saturation, and body temperature. This paper presents the design of a Smart Bracelet Heart Health Monitoring System based on the Internet of Things (IoT) using Telegram for remote health monitoring. A quantitative experimental method was employed for system design and data analysis. The system's performance was compared with data from a Pulse Oximeter and a Thermogun. The Smart Bracelet Heart Health Monitoring System achieved heart rate measurements with an error margin of 3.8%, oxygen saturation with an error of 2.9%, and body temperature with an error of 2.7%. The measurement results are displayed on an OLED LCD and transmitted to Telegram. The system classifies patient status into three categories: Normal (heart rate > 80 BPM), Abnormal (heart rate 70-80 BPM), and Emergency (heart rate < 70 BPM). In case of an emergency or abnormal condition, data is automatically sent. Additionally, data can be manually sent by pressing a push button on the smart bracelet or sending the text "INFO" to the Telegram bot. The data transmission speed ranges from 2 to 22 seconds. The device also features GPS functionality with high positional accuracy.

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1. INTRODUCTION

The development of technology in the modern era is now growing very rapidly. In today's era, almost all aspects of life use elements of technology that make equipment more practical, reliable, effective and efficient. One of them is in the field of Health, where in the field of Health which is an important component in life is also inseparable from technological support.

Health is a vital element in supporting various lives. One of the most vital organs in our body is the heart. Therefore, checking heart health as early as possible is very important, so that heart problems can be recognized early on, so that the treatment can be done immediately [1]. Because of this, routine vital sign checks are very important, including blood pressure, pulse, respiratory rate and body temperature [2]. A person is said to be healthy if he has a heart rate of 60 to 100 BPM, oxygen saturation of 90% to 100% and a body temperature of around 36.5 to 37.5 degrees Celsius [3-5].

Several studies related to heart rate monitoring devices have been conducted, such as those conducted by Arsyia Riszky et al. By creating heart rate monitoring that has an error accuracy result in heart rate measurement of 4.12%, oxygen saturation measurement with an error value of 1.27% and body temperature measurement with an error of 0.35% [6].

The difference in the study conducted by Arsyia Riszky et al is the use of three sensors and the use of the web to display the data obtained. Another study was conducted by Elindawati et al, by producing a heart rate reading value with an error of 1.89% and a body temperature reading error of 1% [7]. The study conducted by Elindawati et al, used firebase and the mit app application as a place to display the data obtained.

Arif Widodo et al also conducted study on making heart rate monitoring devices with an error of 1.54%, oxygen saturation with an error of 1.20%. The sensors used are Max30102 sensors and DS18B20 sensors to read heart rate and

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oxygen saturation [8]. Data in this study the data obtained is displayed on the web and smartphone using the mit app.

Similar study was conducted by Adrian Mitra Perwira et al by monitoring heart rate, oxygen saturation, body temperature and tension. By using three sensors, namely the Max30102 sensor, gy-906-bcc sensor and sensor to read heart rate, oxygen saturation, body temperature and tension [9]. The data obtained in this study will be displayed on the web only.

Based on the explanation above, this study will discuss how to make a device that can monitor heart health that can be accessed remotely or using IoT technology [10]. In this study, to read heart rate, oxygen saturation and body temperature, only one sensor is used, namely the max30102 sensor [11] [12]. This study is also not only able to monitor heart health, this study can also classify the status of patients based on their heart rate values. The data obtained will also be displayed on the OLED LCD [13]. In addition, the data will also be sent to the telegram application.

2. METHODOLOGY

This study adopts an experimental method [14], where this approach is applied to system design and data analysis. The results will be compared with data generated by the Pulse Oximeter and Thermogun.

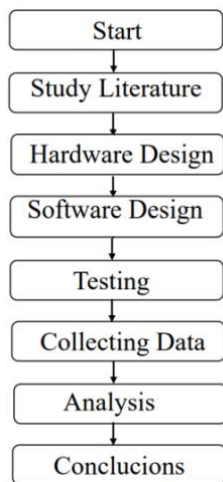


Fig. 1. Flow chart

In this study, the method used is experimental [15]. Figure 1 shows how the stages of this study were carried out, starting with conducting a literature study, hardware design, software design, tool testing, data collection and analysis [16]. Hardware design is done by assembling all the components used according to the wiring diagram in Figure 3.

Then the next stage is to collect data and analyze data whether the resulting system is stable and in accordance with the tools available on the market, so that the system used has the same functional value as the existing measuring instrument. Software design begins with creating a program used using the Arduino IDE application which is then uploaded to the wemos d1 mini.

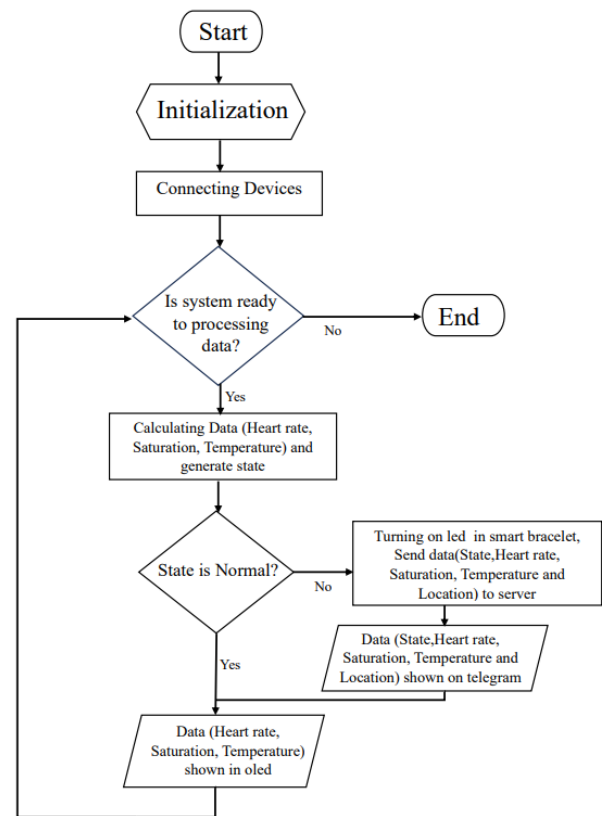


Fig. 2. Flowchart for the system

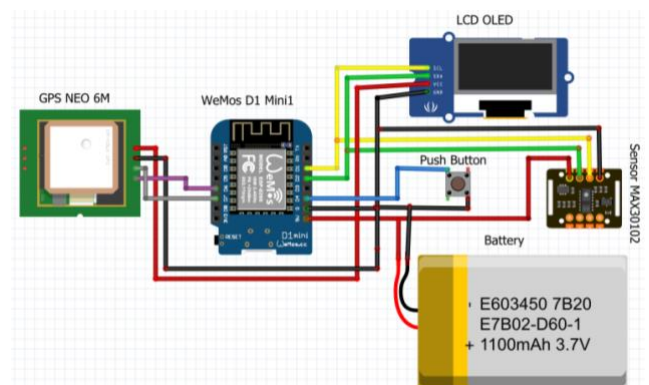


Fig. 3. Wiring diagram for system

The hardware design for the smart bracelet utilizes the Wemos D1 mini microcontroller as its brain controller and its wifi connection module [17]. The smart bracelet to detect oxygen saturation, heart rate and body temperature uses the Max30102 sensor which will later display the measurement results on the OLED LCD. In addition to the data being displayed on the LCD, the data is also sent to Telegram in three ways, pressing push button in smart bracelet, sending text ("INFO") in telegram bot message and automatically send data when user condition is abnormal or darurat.. In this study, a battery that is connected to the charger module was used so that it would be easier when this device runs out of power.

3. RESULTS AND DISCUSSIONS

This study was conducted on June 3 to June 6, 2024. The location of this study was in the city of Cirebon, Jalan Pemuda with three different locations, namely Rumah (-6,761,705,108,528,488), Kejaksaan (-6,709,166, 108,559,609), and Tuparev (-6,708,590,108,520,916). This tool was tested by five different respondents with an age range of 20 years - 50 years. After taking measurements with this tool to compare measurement results, the five respondents were also measured using a pulse oximeter to measure heart rate and oxygen saturation while body temperature was measured using a thermogun [18]. And these measurements were taken in three different locations to determine the accuracy of the GPS that was sent.



Fig. 4. Example of data retrieval

Table 1. Data From Oxygen Level (SpO2) Measurements

No.	Age	Gender	Max30102 (SPO2)	Pulse Oximeter (SPO2)	Error(%)
1	20 years	Woman	98	98	0%
			102	99	3%
			103	98	5%
2	22 years	Man	99	98	1%
			93	98	5%
			97	98	1%
3	23 years	Man	99	98	1%
			99	98	1%
			98	97	1%
4	30 years	Man	98	97	1%
			95	97	2%
			92	98	6%
5	55 years	Woman	95	98	3%
			84	94	10%
			100	96	4%
Error					2,9%
Accuracy level					97,1%

Based on Table 1, the results of oxygen saturation measurements between the max30102 sensor and the pulse oximeter comparison tool obtained an average error of 2.9% with an accuracy level reaching 97.1%. The lowest error rate reached 0% and the highest 10%, while the highest accuracy reached 100% and the lowest 90%.

Table 2. Heart Rate Measurement Result Data

No.	Age	Gender	Max30102 (BPM)	Pulse Oximeter (BPM)	Error (%)
1	20 years	Woman	71	74	4%
			74	79	6%
			78	74	5%
2	22 years	Man	65	64	1%
			75	75	0%
			66	62	6%
3	23 years	Man	86	85	1%
			77	76	1,3%
			84	80	5%
4	30 years	Man	71	75	5,3%
			62	61	1,6%
			61	64	4,6%
5	55 years	Woman	68	65	4,6%
			78	70	11,4%
			67	68	1,4%
Error					3,8%
Accuracy level					96,2%

Based on Table 2, the results of heart rate measurements between the max30102 sensor and the pulse oximeter comparison tool obtained an average error of 3.8% with an accuracy level reaching 96.2%. The lowest error level reached 0% and the highest 11.4%, while the highest accuracy reached 100% and the lowest 88.6%.

Table 3. Data Body Temperature Measurement

No.	Age	Gender	Max 30102 (°C)	Thermogun (°C)	Error (%)
1	20 years	Woman	36	34,8	3,4%
			36	34,1	5,5%
			35	33,8	3,5%
2	22 years	Man	35,5	35,3	0,5%
			35,6	35	1,7%
			35,1	35,2	0,2%
3	23 years	Man	36,7	35,8	2,5%
			37	34,9	6%
			37	34,9	6%
4	30 years	Man	37	36	2,7%
			36	35	2,8%
			34	34	0%
5	55 years	Woman	36	36,7	1,9%
			36,8	36,3	1,3%
			37	35,9	3%
Error					2,7%
Accuracy level					97,3%

Based on Table 3, the results of body temperature measurements between the max30102 sensor and the thermogun comparison tool obtained an average error of 2.7% with an accuracy level reaching 97.3%. The lowest error level reached 0% and the highest was 6%, while the highest accuracy reached 100% and the lowest was 94%.

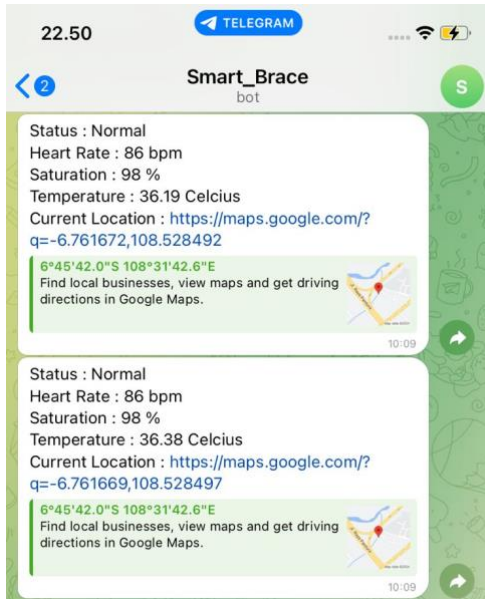


Fig. 5. Sample notification on Telegram

In figure 5 is a display of data sent to the telegram admin. The telegram admin is the closest relative or person who can monitor the health of the smart bracelet user by logging into the telegram bot account that has been registered on the smart bracelet. This display shows that the system is working well, there is information about the status or condition of the smart bracelet user equipped with heart rate values, oxygen saturation, body temperature and the location of the user of this device.

Table 4. GPS test results

No.	Location	GPS by Smartphone		GPS Neo 6	
		Latitude	Longitude	Latitude	Longitude
1	Home	-6.761.705	108.528.488	-6.761.703	108.528.487
2	Field	-6.709.166	108.559.609	-6.709.167	108.559.460
3	Tuparev Street	-6.708.590	108.520.916	-6.708.590	108.520.872

Based on Table 4, the results of the GPS accuracy test show that the reading of the location coordinates is correct according to the position of the device.

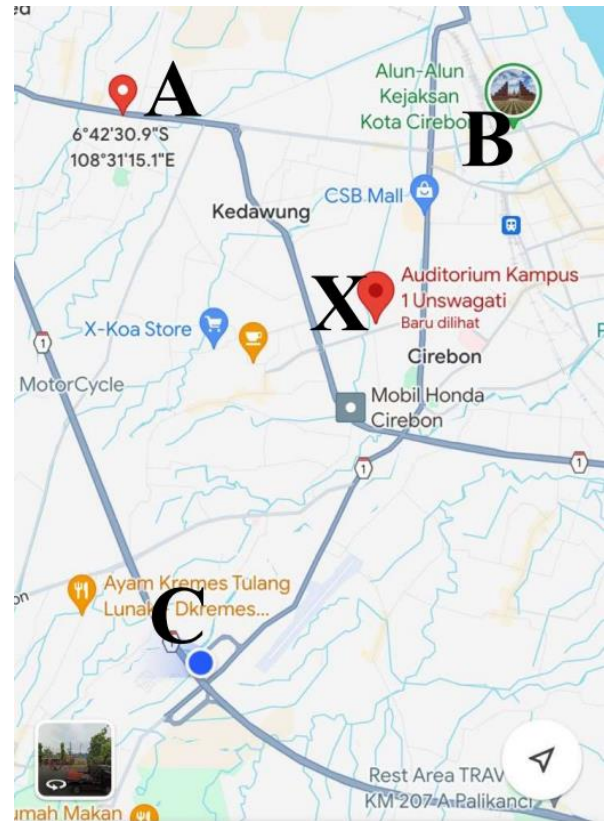


Fig. 6. Measurement location map

Table 5. Data Speed Test Results

No	Location	PUSH BUTON	Send "INFO"	Automation	Distance
1	Home	15 s	8 s	2 s	3,9 km
2	Field	12 s	22 s	9 s	2,7 km
3	Tuparev Street	13 s	20 s	10 s	3,5 km

In the Delivery Speed test, data sending was carried out in three ways, namely by pressing the push button on the smart bracelet, sending text ("INFO") in a telegram bot message and automatically sending data when the user's condition is abnormal or an emergency.

Figure 6 shows a location map when data measurements were taken where points A, B and C are the locations of the smart bracelet users while point X is the point where the telegram admin is located. With a distance of point A to X of 3.5 km, point B to X of 2.7 km and point C to X of 3.9 km.

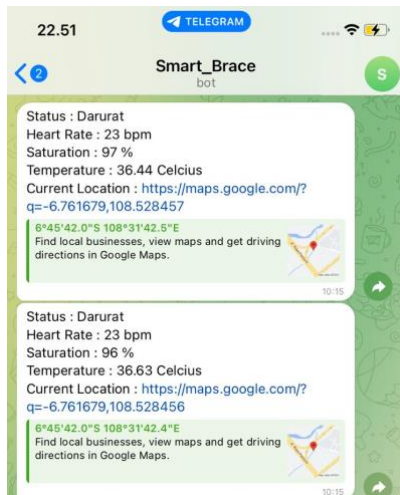


Fig. 7a. Automatic notifications on telegram (Emergency)

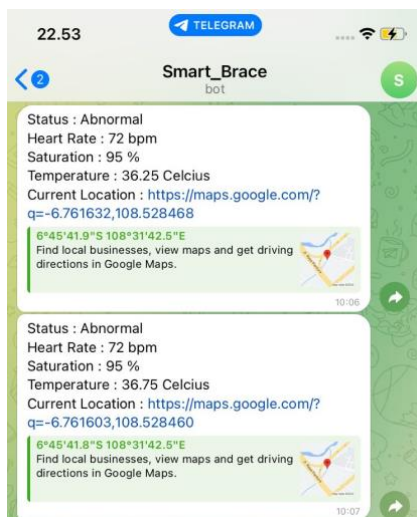


Fig. 7b. Automatic notifications on telegram (Abnormal)

In automatic system testing, the system will send data to the telegram bot when the condition or status of the user of this device is in an abnormal state (abnormal and emergency). In general, a healthy person has a heart rate of 60 to 100 BPM [2]. Because it is quite difficult to test on users who are in an abnormal condition, we assume the value into the following classification. When the heart rate > 80 BPM is said to be Normal, a heart rate of 80-70 BPM is said to be Abnormal and a heart rate below 70 BPM is said to be Emergency. And the data will be sent automatically When BPM is said to be Emergency and Abnormal, the data display that appears on the telegram is shown in Figure 7a and Figure 7b.

4. CONCLUSION

From this study, a heart health monitoring system based on Internet of Thing (IoT) has been built using Wemos D1 mini as a microcontroller and telegram as an IoT system. The result of this study is a heart health monitoring tool using three indicators, namely heart rate, oxygen saturation and body temperature. The sensor used to read the three indicators is the Max30102 sensor. This study produced heart rate measurements with an error of 3.8%, oxygen saturation with an

error of 2.9% and temperature with an error of 2.7%. The measurement results are not only displayed on the OLED LCD, the data is also sent to Telegram. This study can classify patient status into 3 categories, namely Normal for those with a heart rate > 80 BPM, Abnormal for a heart rate of 80-70 BPM and Emergency with a heart rate below 70 BPM. When the patient is in an emergency or abnormal state, the data will be sent automatically. In addition to sending data automatically, data can also be sent by pressing the push button on the smart bracelet and sending the text "INFO" to the telegram bot. With a data transfer speed of 2 to 22 seconds. This tool also has a GPS feature that has precise position accuracy.

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