Smart Bed Design in Assisting Routine Control of Patient Health

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ABSTRACT

Recently, healthcare institutions have started using robots and various sensors to improve service quality and work efficiency. There is no mattress or bed that can automatically control its patients regularly by monitoring pulse, temperature in one system. Can help care for patients who are experiencing hospitalization with the Smart Bed control. This Smart Bed will help health workers to monitor the condition, especially the patient's vital signs, and the results will be obtained in real time so that patients can be treated optimally. The MLX90614 sensor test results show an average error of 1.35% for the first person's body temperature (35.02 °C), 2.42% for the second person (34.56 °C), and 2.16% for the third person (35.24 °C). The MAX30100 sensor had an average error of 3.45% for the first person's pulse rate (81.2 bpm), 3.65% for the second person (82.4 bpm), and 4.08% for the third person (86.4 bpm). The MLX901614 temperature sensor had an average error of 0.37% when compared to the thermogun, showing an accuracy of about 99.63%. While the MAX30100 pulse sensor, compared to a pulse oximeter, has an average error of 1.82%, with an accuracy rate of about 98.18%. So it can be concluded that the smart bed is in the working order.

INTRODUCTION

Introduction Patient mobilization is essential for treatment, requiring patients to be turned every 2 hours with assistance. However, due to mobility challenges and pain for nurses, this is seldom done. An affordable, automatic device for real-time remote patient monitoring is needed. Nowadays, Healthcare institutions are now using robots and sensors to enhance service quality and efficiency. Devices include manual robots for mobilization, tools for moving patients, and automated beds that adjust bed sheets. In addition, many beds have been developed such as air mattresses, alternating pressure mattresses, and side-rotating mattresses to prevent pressure sores(TaryTaryudi, T., Lindayani, L., & Darmawati, I. (2022). Smart-bed with Internet of Things for Pressure Ulcer. . However, it is still energy-intensive and time-consuming. No mattress or bed can automatically monitor patients' pulse and temperature in one system, and they still rely on batteries instead of a direct power supply(Muhammad et al., 2021). Can help care for patients who are experiencing hospitalization with the Smart Bed controller. This Smart Hospital Bed will help health workers to monitor the situation, especially the patient's vital signs(Goyena, 2021). So for the smart bed made this time there are differences in terms of sources that are more efficient and the tool can be moved anywhere.

RESEARCH METHOD

In this chapter there will be several stages such as depicting the research flowchart and the flowchart of the tool's work system, designing software and hardware, designing the components to be used, and designing the wiring in the tool.

1.1. Research Steps

In determining the research that will be used in making this Smart Bed, there will be several stages that will be carried out which are contained in Figure 1 in the form of the following flowchart.

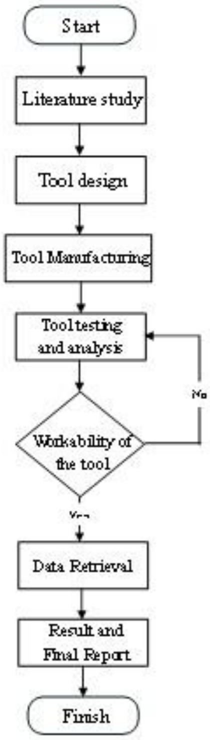

Figure 1. Research Flow Chart
Source : personal documents

The following is an explanation of the research diagram as follows:
1. Conduct a literature review of recent journals and articles..
2. After gathering references, we will design the tool, determining the hardware and software before proceeding further.
3. Build and adjust the tool as needed.
4. After the tool functions correctly, we will collect data from the tests.
5. Summarize the results and data analysis in the final report.

1.2. Create Tool Planning Schematics

This stage determines the flow rate of the components used. The following figure 2 in the planning of the tool lane scheme at the tool scheme planning stage:

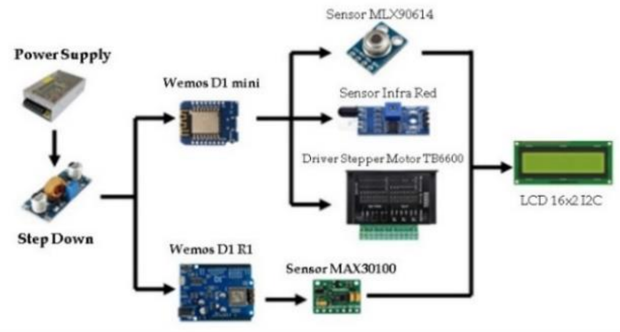

Figure 2. Tool Planning Scheme

Source : personal documents

In this scheme, a power supply will provide power to the Arduino, which is connected to three sensors (MLX90614, MAX30100, infrared), an LCD, and a stepper motor(Iqbal et al., 2020)with a motor driver as a motor controller using a step down to reduce the DC voltage from the power supply.

1.3. Tools Work

To create a tool, we will start by setting a starting point and defining the maximum limits for each sensor. After programming these into the tool, someone will lie down to measure their body temperature and pulse rate. The person places their finger on the pulse sensor, and the infrared sensor detects their hand, activating the stepper motor to measure body temperature. The results are sent to MQTT and displayed on an LCD, and a notification with the measurements will appear on a mobile phone, completing the process.

1.4. Schematic of Microcontroller Design

In designing the tool circuit, a power supply will be used as a source. The choice of power supply is that it can be useful in 24 hours because it can be connected to a power source directly. The following are components in the circuit that will be used such as Wemos D1 R1(Suhermanto & Aribowo, 2023), Wemos D1 Mini(Abrianto & Sari, 2021), MLX90614 temperature sensor(Alam et al., 2022), MAX30100 Pulse Sensor(Rahmawarni & Harmadi, 2021)(Aditya & Riska, 2020), and Infra Red Sensor (Suryana, 2021)seen in Figure 3.

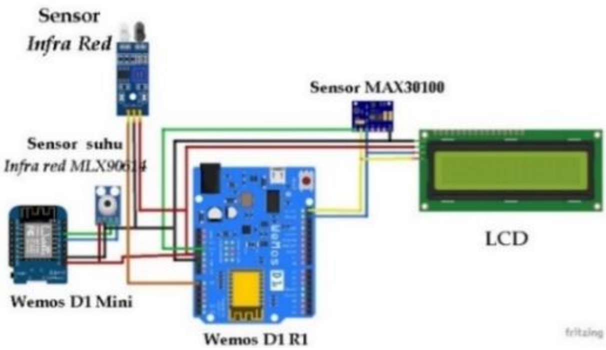

Figure 3. Microcontroller Circuit Schematic
Source : personal documents

RESULTS AND DISCUSSION

Researc This research test aims to determine and analyze the value of a person's pulse and body temperature in the sensor value and the conventional tool value. In this research, it is intended to be used more flexibly which can be used to the bed that requires it.

1.5. Tool Design Results

Figure 4 of the smart bed prototype hardware results shows the use of angle iron (0.1 mm thick, cut to 46 cm x 57 cm), plywood (0.3 mm thick, cut to 40 cm x 46 cm), and PVC foam board (0.1 mm thick). A 3D design draft was created and adjusted using Sketch Up.

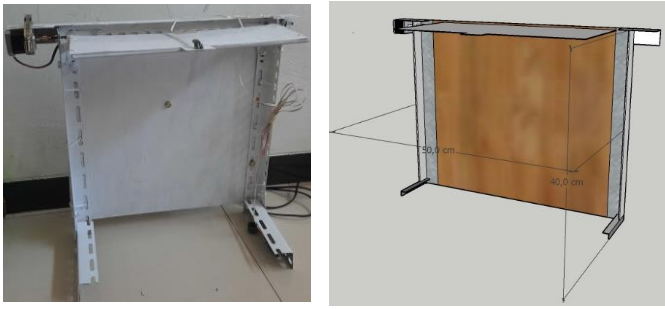

Figure 4. Realization of smart bed design
Source : personal documents

1.6. Software Design Results

In this section, the results of creating a program to MQTT are made through the Arduino IDE software. MQTT is an efficient and structured communication protocol between connected devices and systems(D. A. Awwal et al., 2023). The program that has been uploaded will read the sensor, namely the MLX90614 sensor, which reads the status of hyperthermia, normal and hypothermia(Cahyadi et al., 2021) while the MAX30100 sensor reads the pulse status, namely bradycardia, normal and tachycardia(Akbar et al., 2018)(Setiarini et al., 2021)(Prayogo et al., 2017)MQTT display in Figure 5.

Figure 5. Measurement view on MQTT
Source : personal documents

1.7. Testing the difference in value of MLX90614 Infra Red Temperature Sensor and Thermogun

This test aims to determine the level of accuracy of the tool when implemented in real circumstances. Based on the tests that have been carried out, the measurement results obtained have been measured using the MLX90614 Infra Red sensor and thermogun.

Table 1. Testing temperature measurement in the 1st person

No	Experiment	MLX90614 Sensor (°C)	*Thermogun* (°C)	Difference (°C)	Precentage *Error* (%)
1	First	35,3	35,4	0,1	0,28

No	Experiment	MLX90614 Sensor (°C)	*Thermogun* (°C)	Difference (°C)	Precentage *Error* (%)
2	Second	35,2	35,3	0,1	0,28
3	Third	34,6	34,8	0,2	0,57
4	Fourth	35,2	35,3	0,1	0,28
5	Fifth	34,8	34,9	0,1	0,29
Average measurement error					0,34

Source : personal documents

1.8. Testing the difference between the value of the MAX30100 Pulse Sensor and the Pulse Oximeter

In this next test, it aims to determine the level of accuracy of the tool on the sensor used when implemented in actual circumstances. Based on the test results that have been carried out and shown in table 2, the measurement results obtained using the Pulse Rate MAX30100 sensor and Pulse Oximeter.

Table 2. Testing the Pulse Rate measurement of the 1st person

No	Experiment	MAX30100 Sensor (bpm)	Pulse Oximeter (bpm)	Difference (bpm)	Precentage *Error* (%)
1	First	85	83	2	2,41
2	Second	83	82	1	1,21
3	Third	84	81	3	3,70
4	Fourth	82	82	0	0
5	Fifth	81	83	2	2,41
Average measurement error					1,94

Source : personal documents

1.9. Discussion in the form of graphs

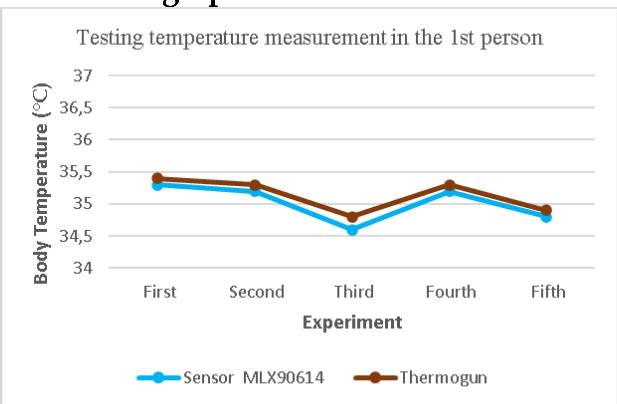

Figure 6. Graph of temperature measurement values of MLX90614 and Thermogun in 1st person

Source : personal documents

Figure 6 shows that the measurement results from the MLX90614 sensor obtained an average of 35.02°C. From the graph of the temperature measurement difference between the MLX90614 sensor and the thermogun, it can be seen that the majority of the differences are in the range of 0.1 to 0.2 degrees Celsius. Overall, this graph shows that the MLX90614 sensor has a stable and consistent performance in body temperature measurement compared to the thermogun.

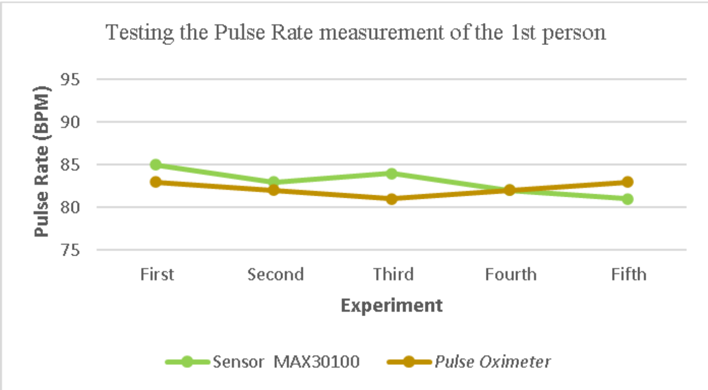

Figure 7. Graph of temperature measurement values of MAX30100 and Pulse Oximeter in the 1st person
Source : personal documents

In figure 7, it can be seen that the average pulse rate measured using the MAX30100 sensor which is about 83 bpm is slightly higher than that measured using the pulse oximeter which is 82.2 bpm. However, the difference is not very significant in the example data given.

CONCLUSION

Based on the results of research on the research title of the smart bed design tool in helping routine control of patient health, conclusions can be drawn, namely:

1. From the test results of the MLX90614 infrared contactless temperature sensor by comparing the results with measurements using a thermogun, the test results show that the MLX90614 sensor has an accuracy rate of 99.63%. This means the average measurement error rate is only 0.37%.
2. From the test results on the MAX30100 pulse sensor by comparing the measurement value of the pulse reading in bpm on the pulse oximeter, the test results and data collection concluded that the MAX30100 pulse sensor has an average measurement error of 1.82%. Therefore, the accuracy of the sensor can be considered as 98.18%.

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