

Development of a Wireless Communication Enabled Device for Monitoring Heart Rate and Body Temperature for Independent Use

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ABSTRACT

Human health conditions can be seen from their heart rate and body temperature. Research aims to make it easier for health workers and humans in general to know their heart rate and body temperature. Therefore, a portable heart rate monitoring device was designed that uses an IoT system. The portable design aims to make the tool practical, and the use of IoT makes it easier for health workers to see patient conditions remotely. The MAX30100 sensor is used to determine heart rate while the DS18B20 sensor is used to determine body temperature which is connected to the microcontroller. It is hoped that this research will make it easier for health workers and humans to receive immediate treatment during emergencies.

Keyword : Body Temperature Monitor, Heart Rate Monitor, Health Iot System Article Process

INTRODUCTION

In current conditions, development in the health sector does not only include health science, but also has an impact on the use of health technology which is experiencing rapid development. Some human jobs in the health sector are starting to be replaced with renewable technology that uses automated systems [1]. The form of implementation of these technological advances is the creation of an automatic system which until now could only be run manually and in one place [2]. This paradigm shift underscores the critical role of technological innovation in modern healthcare, offering opportunities to enhance efficiency, accessibility, and quality of care.

In response to this evolving landscape, the present research endeavors to contribute to the ongoing advancement of health technology by developing a Wireless Communication Enabled Device for Monitoring Heart Rate and Body Temperature for Independent Use. This initiative recognizes the increasing demand for automated systems in healthcare settings, aiming to streamline and optimize the process of health monitoring.

Doctors and nurses carry out examinations of the patient's condition periodically and regularly, especially for examinations that have a high risk if regular monitoring is not carried out. Therefore, a prototype was created with the hope of making it easier for health workers and individuals in general. The proposed device seeks to augment existing healthcare practices by providing a convenient and reliable solution for continuous monitoring of vital signs, mitigating the need for manual, periodic assessments.

The significance of monitoring heart rate and body temperature lies in their utility as indicators of overall health and well-being. Changes in heart rate can signal physiological stress, physical exertion, or potential cardiovascular abnormalities, while variations in body temperature may indicate the presence of infection, inflammation, or other health conditions.

By continuously monitoring these parameters, individuals can gain valuable insights into their health status and take timely action to address any abnormalities or concerns.

Furthermore, the emphasis on wireless communication enables seamless data transmission and accessibility, facilitating real-time monitoring and remote health management. This feature is particularly advantageous for individuals leading busy lifestyles or those requiring continuous monitoring due to medical conditions.

Through the design, development, and evaluation of the proposed device, this research aims to contribute to the fields of wearable health technology and remote patient monitoring. Ultimately, the goal is to empower individuals with the tools and knowledge necessary to proactively manage their health and well-being, leading to improved overall quality of life and health outcomes.

METHODS

The heart is one of the vital organs in the body, its function is as the pump of blood throughout the body. Therefore, the heart has a heavy task as the most important member of the body. The condition of the heart can be influenced by activities performed and age can also be affected by the condition of the heart. Normal heart rate in humans ranges from 60-100 beats per minute. In addition to the heart, body temperature or heat is equally important as the heart. Body temperature above or below normal limits certainly needs attention, as this could be a sign of someone suffering from certain diseases or serious illnesses. A person's normal body temperature can vary depending on the activities they do or their body condition. Nevertheless, the normal body temperature generally ranges from 36.5–37.2 degrees Celsius.

In the portable Heart Rate and Body Temperature Monitoring Prototype, the entire process is in the system box. This system box requires input from the user in the form of commands to turn the system on or off, and also in the form of body temperature and heart rate and this system requires electricity to turn on the components inside. The following is a system design chart:

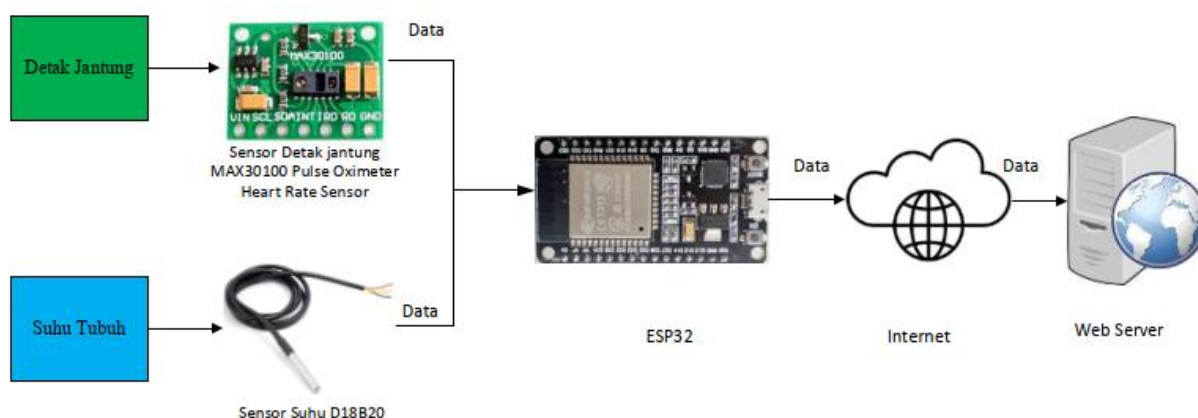


Figure 1. Design Chart of Portable heart rate and body temperature

The heart rate detection component used in this Portable Heart Rate and Body Temperature Monitoring Prototype is the MAX30100 Pulse Oximeter Heart Rate Sensor Module. The MAX30100 sensor is the primary choice for heart rate detection in this heart rate and body temperature monitoring system for the following reasons:

- Widely available in the market as it is commonly used.
- Relatively low cost compared to other types.
- Requires relatively low input voltage and current.

- Compact sensor size.

The temperature detection component used in this Portable Heart Rate and Body Temperature Monitoring Prototype is the D18B20 sensor. The D18B20 sensor is the primary choice for temperature measurement in this portable heart rate and body temperature monitoring prototype for the following reasons:

- Widely available in the market as it is commonly used.
- Requires relatively low input voltage and current.
- Compact sensor size.

The microcontroller component used in this portable heart rate and body temperature monitoring prototype is the ESP32. The ESP32 is the primary choice as the microcontroller in this portable heart rate and body temperature monitoring prototype for the following reasons:

- Widely available in the market as it is commonly used and relatively easy to use.
- Requires relatively low input voltage and current.
- Compact microcontroller size.

In the formed system, two sensors are used: the D18B20 temperature sensor and the MAX30100 Pulse Oximeter Heart Rate Sensor, both of which use a voltage of 3.3 volts supplied by the microcontroller. The microcontroller itself can use voltage from a battery with a voltage of 3.3 volts, and there is a 3.3V pin on the microcontroller used to supply voltage to the sensors used. Therefore, all components are supplied with 3.3 volts from the microcontroller or ESP32, connected in parallel to the 3.3-volt pin and connected to the temperature sensor and heart rate sensor. In connecting the SDA and SCL pins, the heart rate sensor is connected to pins D21 and D22 on the microcontroller, while the data pin from the temperature sensor is connected to pin D4 on the ESP32.

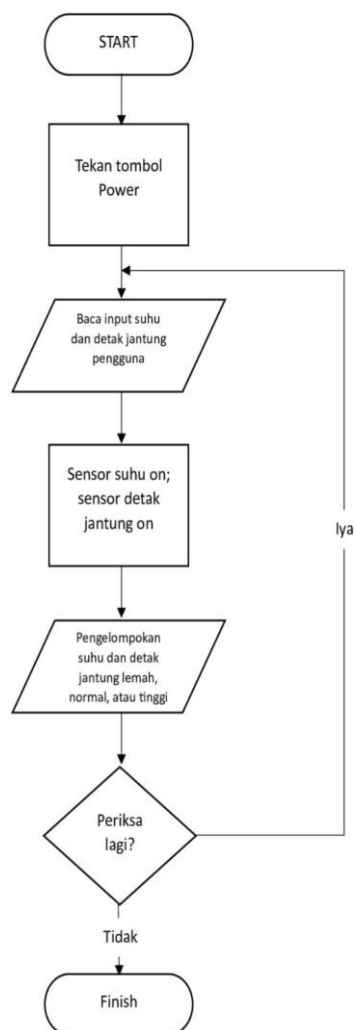


Figure 2. Flowchart of software system

Furthermore, programming is conducted to enable wireless functionality for this device. Additionally, programming is implemented to categorize the heart rate and body temperature values as either within the normal range or not. This categorization employs artificial neural network methods. Figure XX illustrates the software flowchart.

This system can be utilized well in monitoring human heart rate and body temperature [3]. The microcontroller is able to work well and produce readings that are obtained without any problems both in terms of accuracy between the microcontroller and the sensor used to obtain the data [4]. The monitoring system prototype can be used very easily and effectively in monitoring the speed of the user's heartbeat and body temperature. This application can be run via the web or smartphone to monitor and the reading of measured sensor values can be monitored properly.

RESULT AND DISCUSSION

Data was obtained by testing teenagers and adults with random samples in the age range 16 – 53 years. The measurement results from the MAX30100 Sensor with its comparison tool, namely Pulse Oxymetry, may contain differences and to determine the percentage error. The error is calculated using the formula:

$$= \frac{\text{Oxymetry result} - \text{MAX30100 result}}{\text{oxymetry result}} \times 100$$

Data was obtained from groups of teenagers of different ages. The collected data was taken from 5 random data points, namely at the ages of 16, 18, 20, 22 and 25 years.

Table 1 Heartrate in group of teenager

		Heart Rate				deviation	Percentage (%)	Error
Age (years)	Weight	Pulse Oxymetry		Sensor MAX30100				
		BPM	SpO ₂ (%)	BPM	SpO ₂ (%)			
16	40 kg	80	97	79	96	1	1,3	
18	42 kg	77	98	75	96	2	2,6	
20	44 kg	82	98	80	96	2	2,5	
22	46 kg	79	96	78	95	1	1,3	
25	50 kg	76	97	74	95	2	2,6	
Average						1,6	2,1	

In Table 1, heart rate examinations were conducted on cohorts of adolescents with varying ages and body weights. The gathered data has undergone processing to derive the mean values of these measurements. The table presents the average disparity between a 16-year-old adolescent weighing 40 kg and a 25-year-old adolescent weighing 50 kg. A 2.1% margin of error was recorded. The most notable discrepancy occurs at the ages of 18, 20, and 25 years, with a difference of 2. Heart rate is considered normal in adolescents if it falls within the range of 60 – 100 beats per minute (Bpm), with an O₂ saturation value above 90%.

Subsequent data collection involved individuals of varying ages. The compiled data encompassed five data sets from age cohorts of 40 years, 43 years, 44 years, 50 years, and 52 years.

Table 2 Heart rate measurement in the elderly

Age (years)	Weight	Heart Rate				deviation	'percentage (%)	Error
		Pulse Oxymetry		Sensor MAX30100				
		BPM	SpO ₂ (%)	BPM	SpO ₂ (%)			
40	50 kg	87	96	84	98	3	3,4	
43	60 kg	90	97	87	97	3	3,3	
44	64 kg	88	98	88	98	0	0	
50	60 kg	64	96	62	96	2	3,1	
52	50 kg	76	97	74	98	2	2,6	
Average						1,6	2,5	

Based on Table 2, heart rate measurements were conducted on elderly individuals, categorized by age and body weight variations. The collected data has been averaged to obtain the mean values of these measurements. The table reveals differences between sensor readings and device measurements for adults aged 40 years weighing 50 kg and adults aged 50 years weighing 60 kg. The average error percentage observed is 2.5%. The most significant disparity occurs at ages 40 and 43, with a difference of 3. Heart rate is deemed normal in elderly individuals if it falls within the range of 50 Bpm to 100 Bpm, with oxygen saturation values above 95%.

The performance evaluation of the prototype revealed promising results in terms of functionality and reliability. The heart rate sensor, MAX30100 Pulse Oximeter Heart Rate Sensor Module, demonstrated accurate and consistent heart rate measurements across various users and conditions. Similarly, the body temperature sensor, D18B20, provided reliable temperature readings, allowing for timely detection of any deviations from the normal range[5].

Despite the promising results, several limitations were identified during the testing phase. One limitation was the need for further validation and calibration of the sensors to ensure accuracy and consistency across different user demographics and environmental conditions.[6]

Additionally, the prototype's battery life and power management system could be further optimized to prolong usage duration and enhance portability.

Future research directions could focus on refining the prototype design to address these limitations and improve overall performance. This may involve exploring advanced sensor technologies, optimizing data processing algorithms, and enhancing energy efficiency. Moreover, conducting clinical trials or longitudinal studies involving larger sample sizes could provide valuable insights into the device's efficacy and potential applications in healthcare settings.

CONCLUSION

From the testing of the system and hardware of the IoT-based fish pond monitoring device, it can be concluded that monitoring with DS18B20 and MAX30100 functions smoothly in integration with the microcontroller, enabling the created system to operate automatically and be monitored online. Testing conducted on the generated monitoring prototype has yet to determine whether it meets consumer expectations, as further testing has not been conducted.

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