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The Utilization of Vests for Esp32-Based Heart Rate and Body Temperature Detection Devices at the Sentul Village Auxiliary Health Center

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ABSTRACT

Health is a vital aspect of human life, and monitoring heart rate and body temperature are the main indicators to assess a person's physiological condition. However, the limitation of medical equipment and personnel in primary service facilities such as the Sentul Village Auxiliary Health Center is still an obstacle in fast and accurate health monitoring. This research aims to design and implement a heart rate and body temperature detection vest based on the ESP32 microcontroller which is equipped with MAX30102 and MLX90614 sensors and integrated with the Ubidots Internet of Things (IoT) platform. The research methods include hardware and software design, sensor accuracy testing, and *real-time* system performance evaluation. The test results showed that the MLX90614 sensor had an average error rate of 0.65% for body temperature measurement, while the MAX30102 sensor showed an error of 6.12% for heart rate. The IoT-based system is capable of stably transmitting data over Wi-Fi connectivity using the ESP32, although the battery power lasts only about 40 minutes in continuous operation. Based on these results, the system is rated as effective for basic health monitoring and has the potential to help medical personnel in areas with limited resources. Further development is recommended to increase battery capacity and integrate *machine learning* algorithms to improve the accuracy of health data analysis.

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1. INTRODUCTION

Health is an important aspect of human life, where continuous monitoring of physiological conditions has a major role in maintaining individual well-being. Heart rate and body temperature are two vital parameters that reflect a person's physical condition [1]. However, in many health facilities, especially in rural areas, the monitoring process is still carried out manually, slowing down patient handling and reducing the effectiveness of services, especially in emergency conditions. The increase in population that is not balanced by the availability of adequate medical personnel and infrastructure also worsens the effectiveness of the health care system [2].

Various studies have been conducted to integrate Internet of Things (IoT) technology in health monitoring systems. Ramadhan et al. [3] developed an IoT-based monitoring system but has not yet paid attention to accessibility for people in remote areas. Setyawan et al. [4] designed a heart disorder detection tool using the AD8232 sensor and machine learning analysis, but its accuracy and reliability still need to be further tested. Another study by Amane et al. [5] only focused on the fitness aspect without expanding its application to vital sign monitoring, while Vidyastari et al. [6] developed an Arduino-based tool but has not yet been tested in the context of public health services. Aji and Utami [7] also researched heart

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rate monitoring systems with MAX30102 sensors, but have not yet leveraged intelligent analysis based on machine learning algorithms.

From these studies, there is still a research gap in the form of the need for health monitoring devices that are economical, easy to use, and able to work in real-time in health facilities with limited resources. Most of the previous research focused on the development of wearable devices with high costs or limited testing in laboratory environments. Therefore, new approaches that are not only innovative but also relevant are needed to be used at the basic health service level such as Auxiliary Health Centers.

This research proposes the development of a heart rate and body temperature monitoring device based on the ESP32 microcontroller integrated with a vest as a wearable device. This system is designed to be able to monitor the user's health condition in real-time, send data wirelessly to medical personnel, and can be implemented at an affordable cost. This innovation is expected to improve the efficiency of health monitoring, reduce the workload of medical personnel, and support the improvement of the quality of health services in rural areas such as the Sentul Village Auxiliary Health Center. This system integrates MAX30102 sensors for heart rate and DS18B20 for body temperature, with the ESP32 microcontroller functioning as a data processor and wireless communication module via Wi-Fi or Bluetooth, thus enabling real-time monitoring of remote medical devices.

2. METHOD

This research was carried out through several systematic stages designed to ensure that the Internet of Things (IoT)-based heart rate and body temperature detection device can function optimally according to the research objectives. Figure 1 below shows the research flow that describes the stages of the process from the preliminary study to the final stage of evaluation and conclusion. Each stage in the flow is described in detail in this section.



Figure 1. Research Flow Diagram

The initial stage of this research begins with a preliminary study to identify problems and understand the background underlying the Internet of Things (IoT)-based heart rate detection device development project. This study aims to recognize the needs of the system, the operational environment, and technical

limitations in the implementation of the tool [8]. After that, a literature search is carried out to obtain relevant theories, concepts, and previous research as a scientific basis in system design [9], [10].

Based on the results of the study and literature, the next stage is system design. This activity includes the preparation of block diagrams, the design of electronic circuits, and the determination of specifications of key components such as ESP32 microcontrollers, heart rate sensors, and wireless communication modules. The selection of components is carried out by considering power efficiency, data transmission speed, and compatibility with cloud-based IoT systems [11].

The next stage is the manufacture and assembly of the device. In this stage, all components are assembled according to the design that has been set. The system is then tested to ensure that the performance of the device is performing as designed to be performed. Testing includes the acquisition of heart rate data and real-time data transmission using the Wi-Fi network integrated in the ESP32 microcontroller [12].

This study uses a quantitative method with an experimental approach through direct observation of the test results of the device. Observations are carried out to obtain data on the performance of the system under real operational conditions, including the level of sensor accuracy and the stability of data transmission [13]. The test results are analyzed quantitatively to evaluate the efficiency and reliability of the system. The results of the analysis are the basis for drawing conclusions about the success of the system in meeting the research objectives.

3. RESULTS AND DISCUSSION

3.1 Tool Design and Realization

This research resulted in an ESP32 microcontroller-based heart rate and body temperature monitoring system integrated with the Internet of Things (IoT). This tool is designed to provide convenience for medical personnel to monitor patients' conditions in real-time through the Ubidots platform.

The physical design of the device consists of several main components, namely a MLX90614 sensor for body temperature measurement, a MAX30102 sensor for heart rate detection, an ESP32 NodeMCU as a control center, an OLED LCD for data display, a push button start, a charger module, and a Li-ion battery as a power source.

Figure 2, showing the physical appearance of the designed device,



Figure 2. Physical design of the device

while Figure 3. Is a vest design with a Heart Rate and Temperature Sensor. shows the design of the tool design using *the EasyEDA* application,

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Figure 3. Vest Design with Heart Rate and Temperature Sensor

which is then applied to the wearable vest so that users can wear it practically. This design allows wireless monitoring of temperature and heart rate, supporting the concept of *wearable healthcare devices* [14], [15].

3.2. Temperature Sensor Testing MLX90614

The test was carried out to determine the accuracy and stability of the MLX90614 sensor in reading human body temperature. The sensor is connected to the ESP32, and the measurement results are displayed on the LCD and sent to the Ubidots Cloud in *real-time*. For comparison, a medical standard digital thermometer is used.

Table 1 shows the results of MLX90614 sensor tests on 20 samples with a comparison with the comparison tool.

Table 1. Sensor Test Results MLX90614

Yes	Subject	Days and dates	Termometer digital ℃	Thesis tools ℃	Differences	Error
1	Ny.A	Yours, 16 june 2025	33,7	33,4	0,3	0,8
2	Tn.E	Yours, 16 june 2025	33,5	33,2	0,3	0,2
3	Tn.D	Yours, 16 june 2025	33,6	33,2	0,4	1,1
4	Tn.R	Yours, 16 june 2025	33,9	33,7	0,2	0,5
5	Tn.A	Yours, 16 june 2025	33,7	33,6	0,1	0,2
6	Tn.B	Tuesday, 17 June 2025	33,8	33,6	0,2	0,5
7	Tn.A	Tuesday, 17 June 2025	35,6	35,4	0,2	0,5
8	Mrs. F	Tuesday, 17 June 2025	36,7	36,4	0,3	0,8
9	Ny.D	Tuesday, 17 June 2025	35,8	35,7	0,1	0,2
10	Tn.A	Tuesday, 17 June 2025	35,6	35,4	0,2	0,5
11	NY.I	Wednesday, 18 June 2025	36,9	36,8	0,1	0,2
12	Tn.R	Wednesday, 18 June 2025	36,3	36,0	0,3	0,8
13	Tn.D	Wednesday, 18 June 2025	36,4	36,3	0,1	0,2
14	N.C.	Wednesday, 18 June 2025	35,7	35,5	0,2	0,5

15	Mr. H	Wednesday, 18 June 2025	37,6	37,5	0,1	0,2
16	Tn.J	Thursday, 19 June 2025	36,6	36,4	0,2	0,5
17	Tn.A	Thursday, 19 June 2025	35,5	34,4	1,1	0,3
18	Tn.W	Thursday, 19 June 2025	36,4	35,2	1,2	3,2
19	Tn.F	Thursday, 19 June 2025	35,8	35,4	0,4	1,1
20	NY.I	Thursday, 19 June 2025	37.8	37,8	0	0
Rat-rat *error*						0,65 %

. The calculation of the error percentage and average *error* from the sensor measurement MLX90614 body temperature is as follows:

$$\%error = x = \frac{Nilai\ Termometer - Suhu\ tubuh}{Nilai\ termometer}\ x100 \quad (2)$$

Based on the formula written above, from the calculation results obtained:

The calculation below uses data number 1 with a data:

Body temperature = 33,4
Thermometer value = 33,7

$\%error = \frac{33,7-33,4}{33,7} x\ 100\%$

$\%error = \frac{0,3}{33,7} x\ 100\%$

$\%error = 0,008$ x 100%

$\%error\ x = 0,8\%$

From the difference value in table 1, the standard deviation of the tool that has been calculated can be determined using an equation, which can be seen in the following formula:

x = Rata rata $error$
$\Sigma\ xi$ = Total nilai $error$
n = Jumlah sampel data

$x = \frac{\Sigma\ xi}{n}$

$x = \frac{13}{20}$

$x = 0,65\%$

The calculation above shows that the temperature measurement error is 0.65%, the measurement difference may be due to several factors including:

1. The sensor used does not have the right position so the sensor reading is less accurate.
2. The wiring is still not neat and the wiring is too long.

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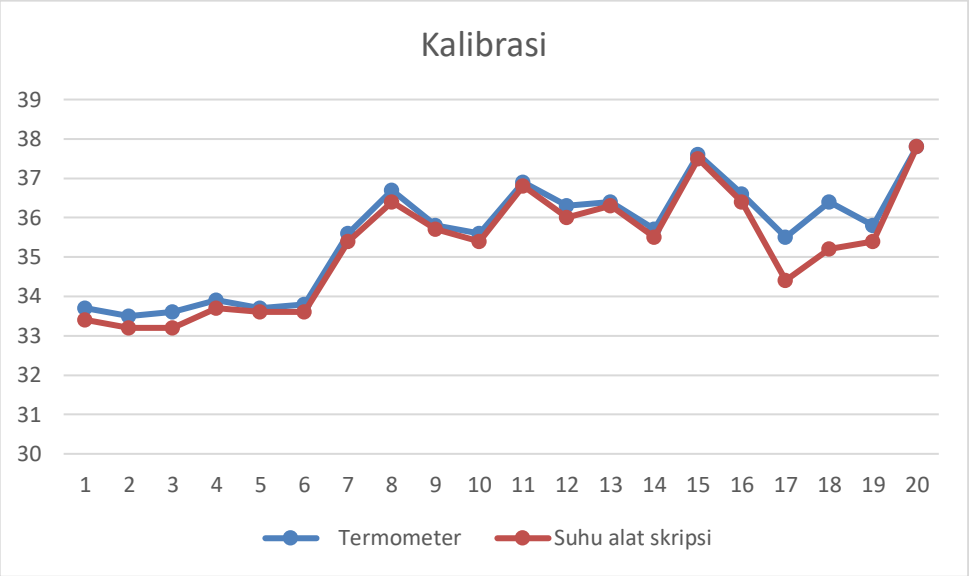


Figure 1. Calibration of the test results of the tool

3.2 Heart Rate Sensor Testing MAX30102

The sensor **MAX30102** functions to read pulse rate (BPM) with *Photoplethysmography-based (PPG)-based optical technology*. This sensor is connected to the ESP32, and the results are displayed via LCD and transmitted to **the Ubidots Cloud** in *real-time*.

The test was carried out by comparing the sensor reading results against **the medical oximeter** as a comparison tool. The test results are shown in Table 2.

Table 2. Sensor Test Results MAX30102

No	Subject	Days and dates	Oximeter BPM	BPM tool	Differences	*error*
1	Ny.A	Your,16 june 2025	60	55	5	8,3
2	Tn.E	Your,16 june 2025	80	73	7	8,7
3	Tn.D	Your,16 june 2025	80	75	5	6,2
4	Tn.R	Your,16 june 2025	81	75	6	7,4
5	Tn.A	Your,16 june 2025	79	75	4	0,5
6	Tn.B	Tuesday,17June2025	70	65	5	7,1
7	Tn.A	Tuesday,17June2025	79	72	7	8,8
8	Mrs. F	Tuesday,17June2025	80	76	4	0,5
9	Ny.D	Tuesday,17June2025	109	104	5	4,5
10	Tn.A	Tuesday,17June2025	60	56	4	6,6
11	NY.I	Wednesday, 18 June 2025	71	67	4	5,6
12	Tn.R	Wednesday, 18 June 2025	73	69	4	5,4
13	Tn.D	Wednesday, 18 June 2025	107	101	6	5,6
14	Ny.c	Wednesday, 18 June 2025	86	83	3	3,4
15	Mr. H	Wednesday, 18 June 2025	90	82	8	8,8

16	Tn.J	Thursday,19June2025	85	79	6	7,5
17	Tn.A	Thursday,19June2025	107	98	9	8,4
18	Tn.W	Thursday,19June2025	86	81	5	5,8
19	Tn.F	Thursday,19June2025	90	84	6	6,6
20	NY.I	Thursday,19June2025	102	95	7	6,8
Rat-rat *error*						6,12%

The average error obtained is **6.12%,** with calculations using Equation (2):

$$\%Error = \frac{(BPM_{ref} - BPM_{sensor})}{BPM_{ref}} \times 100 \quad (1)$$

The error value is still within reasonable limits for *wearable monitoring systems* [5]. The difference in results is due to the subject's movement during the test and the position of the finger on the sensor that is not constant.

3.3. Ubidots App Display



Figure 2. Interface in ubidots

Figure 2, above shows a body temperature and heart rate monitoring interface connected to the Internet of Things (IoT) platform. There are two main gauge-shaped panels that show the measurement results, namely body temperature of 32.00°C and heart rate of 87.00 BPM. There is a body temperature graph visualized in the form of a thermometer. This graph shows the change in body temperature over time, and there is a significant increase in temperature at the end of the measurement. Meanwhile, the heart rate graph is displayed to resemble an ECG signal, showing heart rate fluctuations over time with several peaks of activity. At the end of the graph, there is a spike in value, which indicates an increase in heart rate or the end of the measurement session.
Overall, this visualization aims to provide convenience in monitoring body condition in real-time through data sent directly from the sensor to the monitoring dashboard.

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4 CONCLUSION

Based on the results of the design, implementation, and testing of the ESP32-based heart rate and body temperature detection vest system that has been carried out, it can be concluded that this system has successfully functioned well according to the research objectives. The MLX90614 sensor showed an excellent level of accuracy with an average error of 0.65%, while the MAX30102 sensor had a fairly good performance with an average error of 6.12%. Qualitatively, the system is able to display data in real-time, responsive, and easily accessible through the Ubidots IoT platform, thus making it easier for medical personnel to monitor patient conditions. Overall, this system is considered feasible to be used as a health monitoring tool, although improvements in power efficiency are needed to extend the device's operational time.

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