

Internet of Things for Web-Based Heart Rate and Body Temperature Monitoring

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ARTICLE INFORMATION	ABSTRACT
Received : 11 – 08 – 2026 Revised : 13 – 09 – 2026 Published : 05 – 11 – 2026	Independent health monitoring is important to support the early detection of changes in physical condition. This study aims to design an Internet of Things-based heart rate and body temperature monitoring system accessible through the web. The system uses an ESP32 microcontroller connected to a MAX30102 sensor to acquire heart rate data and an MLX90614 sensor to acquire body temperature data. The acquired data are transmitted over a WiFi network to a web server developed using the Django framework for storage and real-time display on a web dashboard. Testing was conducted by comparing sensor readings with an oximeter and a digital thermometer as reference instruments. The results showed that the MAX30102 sensor achieved an accuracy of 96.16% to 97.90%, while the MLX90614 sensor achieved an accuracy of 99.08% to 99.13%. In addition, black-box testing was used to evaluate the main functionalities of the web system, including real-time monitoring data display, graphical visualization, historical data, and data storage in the database. The results showed that all system features operated as designed, enabling the system to receive, store, and display monitoring data from the IoT device in an integrated manner through a web interface.
Keywords: Internet of Things Web Monitoring ESP32 MAX30102 MLX90614	

I. Introduction

Advances in the Internet of Things (IoT) enable physical devices, such as sensors and microcontrollers, to connect to the internet and automatically collect and transmit data. In healthcare, this technology is used to monitor vital parameters, such as heart rate and body temperature, in real time, allowing continuous monitoring without requiring individuals to be at a healthcare facility [1], [2]. Information on normal heart rate and body temperature values is also important as a basis for detecting changes in health conditions at an early stage [3].

Various studies have developed IoT-based health monitoring systems using microcontrollers, such as the ESP8266 and ESP32, integrated with health sensors [4], [5]. The ESP32 is widely used because its WiFi connectivity enables devices to transmit sensor data to a server over the internet [6]. The MAX30102 sensor is used for non-invasive heart rate detection, whereas the MLX90614 sensor is used for non-contact body temperature measurement [7], [8].

Some studies use cloud platforms to display monitoring data online [3], [9], while others develop mobile application-based health monitoring systems that enable users to monitor their physical condition through personal devices [10], [11]. Graphical visualization of sensor data is also widely used to make changes in health conditions easier to understand [12]. Integrating sensors with network-based information systems also supports more efficient health monitoring [13], [14].

Nevertheless, most existing systems still have limitations, such as dependence on specific applications or the display of real-time data without structured historical storage. Therefore, this study develops an IoT-based heart rate and body temperature monitoring system integrated with a web application using the Django framework. This integration enables monitoring data to be stored, visualized, and accessed through a web dashboard using a browser without requiring additional applications.

II. Methods

This study focuses on designing an Internet of Things (IoT)-based heart rate and body temperature monitoring system integrated with a web system. The research methods include the design of the system

architecture, the system flowchart, and the testing parameters and scenarios used to evaluate system performance, as described in the following sections.

A. System Architecture

The developed monitoring system consists of three main layers: the sensor layer, the network layer, and the application layer, as shown in Figure 1. These layers work together to acquire, transmit, and present heart rate and body temperature monitoring data.

At the sensor layer, data are acquired using the MAX30102 sensor to obtain heart rate data and the MLX90614 sensor to obtain body temperature data. Both sensors are connected to the ESP32 microcontroller, which functions as a data processor and an interface to the internet, through I2C communication.

At the network layer, the ESP32 transmits the acquired sensor data to the server over a WiFi/internet connection using the HTTP(S) POST method. At the application layer, the server, developed using the Django framework, receives data through a REST API for storage in the database and presentation to users through a web dashboard. The data are visualized as real-time graphs that can be accessed through a browser to support monitoring of the user's health condition.

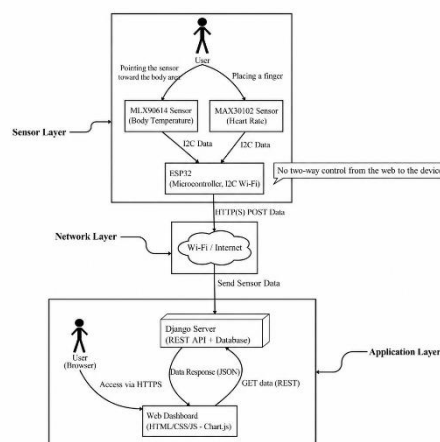


Figure 1. System Architecture

B. System Flowchart

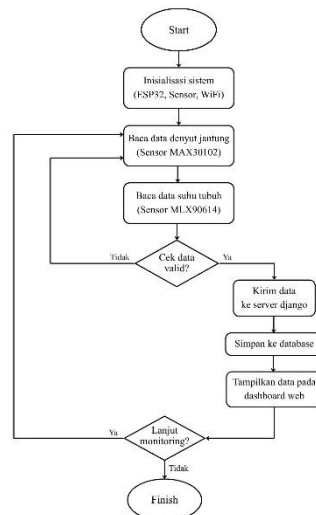


Figure 2. System Flow

The system flowchart in Figure 2 illustrates the operation of the Internet of Things (IoT)-based heart rate and body temperature monitoring system. The process begins with device initialization, including the ESP32 microcontroller, MAX30102 sensor, MLX90614 sensor, and WiFi connection. Once the system is active, the ESP32 periodically reads heart rate and body temperature data from the sensors. The acquired data are then checked to ensure that the resulting values are valid. If the data are not yet valid, sensor readings are repeated until stable values are obtained.

Once the data are valid, they are transmitted to the Django server over the WiFi network for storage in the database. The stored data are then displayed on the web dashboard as real-time graphs, allowing users to monitor them through a browser. This process repeats continuously while the monitoring system is running.

C. Testing Parameters and Scenarios

The testing parameters in this study include heart rate and body temperature measurements obtained from the MAX30102 and MLX90614 sensors. To determine system accuracy, sensor readings are compared with reference instruments: an oximeter for heart rate measurements and a digital thermometer for body temperature measurements.

Testing is performed by comparing sensor readings with the values obtained from the reference instruments. The differences between these values are then used to calculate the percentage error using the following equation:

$$\text{Error (\%)} = \frac{\text{Sensor value} - \text{Reference value}}{\text{Reference value}} \times 100\% \quad (1)$$

Sensor accuracy is subsequently calculated using the following equation:

$$\text{Accuracy} = 100\% - (\text{Mean error (\%)}) \quad (2)$$

The resulting accuracy values are then used to evaluate sensor performance in the developed heart rate and body temperature monitoring system.

III. Results and Discussion

A. Results

1) IoT Device Implementation

The Internet of Things (IoT) device developed in this study consists of an ESP32 microcontroller connected to a MAX30102 sensor for heart rate detection and an MLX90614 sensor for body temperature measurement. All components are assembled in a project enclosure and powered by a 5 V power bank, allowing the device to operate independently. The ESP32 processes sensor data and provides a WiFi connection to transmit measurement data to the web server. The IoT device implemented in this study is shown in Figure 3.



Figure 3. IoT Device

2) MAX30102 Sensor Testing

The MAX30102 sensor was tested to determine its ability to detect heart rate by comparing its readings with those of an oximeter as the reference instrument. During testing, the user placed a finger on the MAX30102 sensor connected to the IoT device [15], while the oximeter was placed on another finger so that both devices could measure heart rate simultaneously. The use of the MAX30102 sensor for data acquisition is shown in Figure 4.

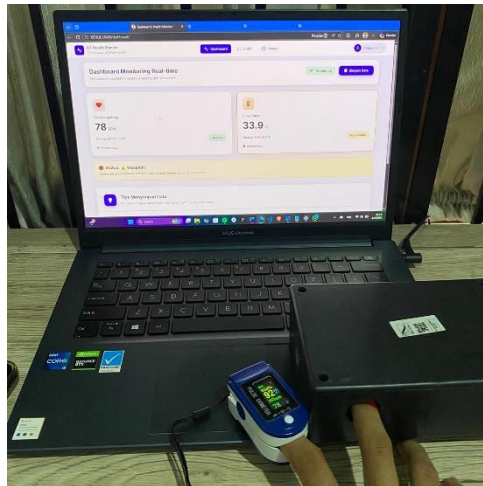


Figure 4. MAX30102 Sensor Testing

Ten tests were conducted in the sitting condition to obtain heart rate values under relatively stable physical conditions. The user remained seated without performing physical activity throughout the measurements. The results for the sitting condition are presented in Table 1.

Table 1. MAX30102 Testing in the Sitting Condition

No.	MAX30102 (BPM)	Oximeter (BPM)	Difference	Error (%)
1	74	78	4	5.12%
2	68	70	2	2.86%
3	71	70	1	1.43%
4	63	64	1	1.56%
5	69	70	1	1.43%
6	69	70	1	1.43%
7	64	63	1	1.59%
8	73	71	2	2.82%
9	67	68	1	1.47%
10	74	75	1	1.33%
Mean				2.10%

Ten tests were conducted in the leisurely walking condition. Before the measurements, the user walked at a leisurely pace for approximately 5 minutes to increase heart rate activity. Ten measurements were then taken. The results for the leisurely walking condition are presented in Table 2.

Table 2. MAX30102 Testing in the Leisurely Walking Condition

No.	MAX30102 (BPM)	Oximeter (BPM)	Difference	Error (%)
1	89	90	1	1.11%
2	91	90	1	1.11%
3	87	85	2	2.35%
4	84	85	1	1.18%
5	88	90	2	2.22%
6	84	85	1	1.18%
7	90	89	1	1.12%
8	91	85	6	7.06%
9	88	91	3	3.30%
10	90	87	3	3.45%
Mean				2.41%

Testing in the stair-climbing condition was conducted after the user had walked up and down stairs to increase the heart rate. Ten measurements were then taken. The results for this condition are presented in Table 3.

Table 3. MAX30102 Testing in the Stair-Climbing Condition

No.	MAX30102 (BPM)	Oximeter (BPM)	Difference	Error (%)
1	100	102	2	1.96%
2	93	98	5	5.10%
3	119	117	2	1.71%
4	104	105	1	0.95%
5	108	105	3	2.86%
6	96	104	8	7.69%
7	113	112	1	0.89%
8	101	114	13	11.40%
9	99	103	4	3.88%
10	101	103	2	1.94%
Mean				3.84%

Table 4. Summary of MAX30102 Sensor Testing

Condition	Mean difference (BPM)	Maximum difference	Minimum difference	Mean error (%)	Accuracy
Sitting	1.50	4	1	2.10%	97.90%
Leisurely walking	2.10	6	1	2.41%	97.59%
Stair climbing	4.10	13	1	3.84%	96.16%

3) MLX90614 Sensor Testing

The MLX90614 body temperature sensor was tested by comparing its readings with those of a digital thermometer as the reference instrument. Measurements were taken by pointing the MLX90614 sensor mounted on the IoT device toward the user's forehead at a distance of approximately 5 cm. Measurements were taken simultaneously using the digital thermometer to obtain body temperature values at the same time. The MLX90614 sensor testing procedure is shown in Figure 5.



Figure 5. MLX90614 Sensor Testing

Ten tests were conducted under normal room conditions to obtain body temperature values at an ambient temperature of approximately 32 °C. The sensor was directed toward the user's forehead at a distance of approximately 5 cm until the readings stabilized. The body temperature test results under normal room conditions are presented in Table 5.

Table 5. MLX90614 Testing under Normal Room Conditions

No.	MLX90614 (°C)	Thermometer (°C)	Difference	Error (%)
1	36.8	36.8	0	0%
2	36.1	36.8	0.7	1.90%
3	36.4	36.9	0.5	1.36%
4	36.3	36.8	0.5	1.36%
5	36.7	36.8	0.1	0.27%
6	36.3	36.8	0.5	1.36%
7	36.5	36.8	0.3	0.82%
8	36.6	36.8	0.2	0.54%
9	36.6	36.8	0.2	0.54%
10	36.4	36.8	0.4	1.09%
Mean				0.92%

Ten tests were conducted under cool room conditions at an ambient temperature of approximately 24–26 °C. The MLX90614 sensor was directed toward the user's forehead at a distance of approximately 5 cm, while the digital thermometer was used as the reference instrument. The body temperature test results under cool room conditions are presented in Table 6.

Table 6. MLX90614 Testing under Cool Room Conditions

No.	MLX90614 (°C)	Thermometer (°C)	Difference	Error (%)
1	36.8	36.9	0.1	0%
2	36.6	36.9	0.3	1.90%
3	36.4	36.9	0.5	1.36%
4	36.7	36.8	0.1	1.36%
5	36.4	36.9	0.5	0.27%
6	36.7	36.9	0.2	1.36%
7	36.4	36.9	0.5	0.82%
8	36.5	36.9	0.4	0.54%
9	36.5	36.9	0.4	0.54%
10	36.7	36.9	0.2	1.09%
Mean				0.92%

Table 7. Summary of MLX90614 Sensor Testing

Condition	Mean difference (°C)	Maximum difference	Minimum difference	Mean error (%)	Accuracy
Normal room	0.34	0.7	0	0.92%	99.08%
Cool room	0.32	0.5	0.1	0.87%	99.13%

4) Web System Functionality Testing

Web system functionality testing was conducted on several key system features. The results of the web system functionality tests are presented in Table 8.

Table 8. Web System Functionality Test Results

No.	System Feature	Test Scenario	Expected Result	Result
1	Monitoring Dashboard	The system receives data from the IoT device	Heart rate and body temperature data are displayed on the dashboard in real time	Passed
2	Data Visualization Graphs	Open the graph page in the system	Graphs showing changes in heart rate and body temperature data are displayed	Passed
3	Historical Health Data	Open the historical data page	The system displays historical measurement data in a table	Passed
4	Data Storage	Press the save data button	Measurement data are stored in the database	Passed

Web system functionality testing was conducted to ensure that each system feature operated properly. Based on the results in Table 8, the web system can display heart rate and body temperature data from the IoT device through a dashboard, data visualization graphs, and historical data. The system interfaces are shown in Figure 6(a) for data monitoring, Figure 6(b) for data graphs, and Figure 6(c) for historical data.

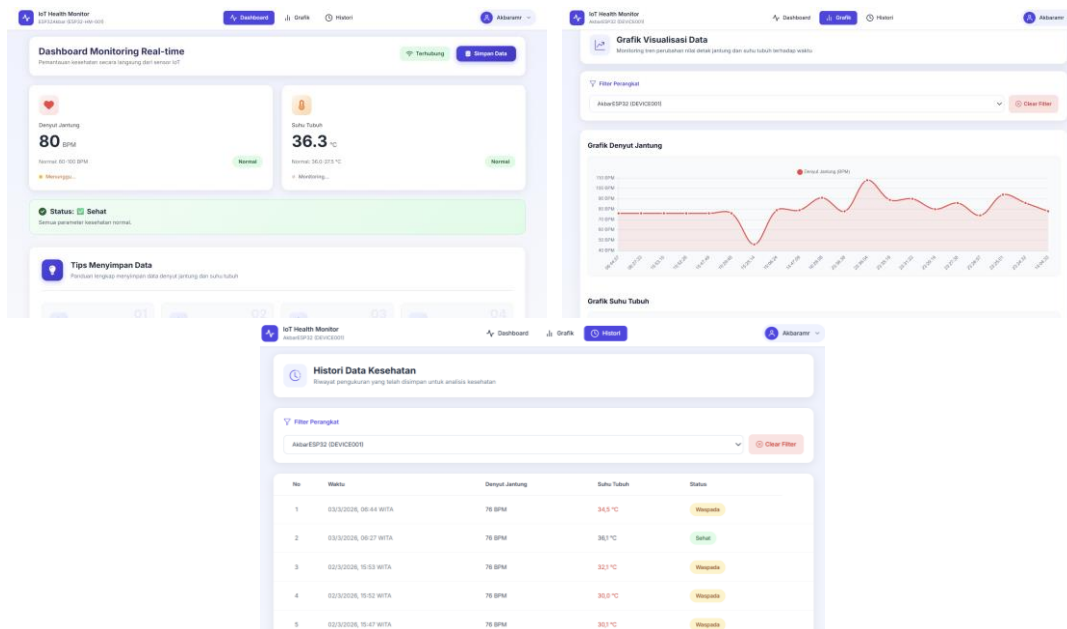


Figure 6. (a) Data Monitoring, (b) Data Graphs, and (c) Historical Data

B. Discussion

The results show that the web-based Internet of Things system for heart rate and body temperature monitoring was successfully implemented using an ESP32 microcontroller connected to MAX30102 and MLX90614 sensors. The device can read data from both sensors and transmit them over the WiFi network to the web server, allowing heart rate and body temperature information to be displayed on the web dashboard in real time. The integration of the IoT device and the web system enables users to monitor their health condition directly through a browser.

Based on the test results, the MAX30102 sensor produced mean errors ranging from 2.10% to 3.84%, with accuracy ranging from 96.16% to 97.90% under different user activity conditions. Meanwhile, the MLX90614 sensor showed a mean error of 0.92% under normal room conditions and 0.87% under cool room conditions, with accuracy ranging from 99.08% to 99.13%. In addition, web system functionality testing showed that the system can receive, store, and display monitoring data in real time through a dashboard, graphs, and historical data, thereby supporting easier and more structured health monitoring.

IV. Conclusion

This study successfully developed an Internet of Things-based heart rate and body temperature monitoring system using the ESP32 and MLX90614 and MAX30102 sensors integrated with a web system. The test results showed that the MAX30102 sensor achieved an accuracy of 96.16%–97.90%, while the MLX90614 sensor achieved an accuracy of 99.08%–99.13%. The web system can also receive, store, and display monitoring data in real time through a dashboard, graphs, and historical data. Thus, the developed system can facilitate health monitoring and has the potential to serve as an easily accessible tool for independent health monitoring that supports long-term analysis of health conditions.

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