

Implementation of Internet of Things Devices for Calorie Monitoring in Cyclists

Jhanyka Yudha^{1*}, Rully Pramudita²

¹Informatics Engineering, Bina Insani University, Indonesia.

²Informatics Management, Bina Insani University, Indonesia.
jhanykay@gmail.com^{1*}, rullypramudita@binainsani.ac.id²

Abstract

This research aims to design and implement an Internet of Things-based device that is used to combine speed and calories on a bicycle without requiring additional applications. This device is designed so that cyclists can stay focused on sports activities without having to interact with smartphones that could potentially reduce concentration. The developed system consists of a speed sensor, a calorie calculation module, and hardware that directly displays information through a 16x2 LCD screen. The research method includes the hardware design stage, sensor accuracy measurement, and system performance evaluation under various usage conditions. The results show that the device is able to display speed and calorie data with a sufficient level of accuracy, so it can provide relevant information to improve the quality of cycling activities. This research contributes to the development of Internet of Things technology in the fields of sports and health, especially in providing practical, safe, and efficient monitoring devices for users.

Keywords: Internet of Things, sepeda, sensor, kalori, LCD 16x2

1. Introduction

This Cycling is becoming increasingly popular as a sport and a means of transportation that supports a healthy lifestyle. Monitoring speed and calories is an important factor in evaluating cyclists' performance. However, current monitoring methods generally rely on smartphone apps or conventional speedometers that display only basic information. Using smartphone apps can distract cyclists and reduce safety, while conventional devices lack calorie counting capabilities.

Existing technology demonstrates the potential for Internet of Things (IOT)-based speed monitoring devices, but their application to conventional bicycles remains limited, particularly in terms of ease of use without additional apps. The main challenges faced by the cycling community, particularly the RGS (Ratu Jaya Gowes Sepeda) Depok Cycling Community, are lack of awareness of calorie burn and the lack of practical and safe monitoring devices.

As a solution, this research develops an IOT device capable of monitoring speed and calories in real time using a Hall Effect sensor for speed and an accelerometer for calorie counting. Data is displayed on a 16x2 LCD display mounted on the bicycle, allowing cyclists to quickly access information without relying on a mobile device. This research aims to provide a simple, safe, and efficient solution to support cycling sports activities.

2. Research Methodology

The research model used in this study is the experimental method. This method was chosen because it allows researchers to directly test the Internet of Things-based device design they created. Its main advantage lies in its ability to observe cause-and-effect relationships through control of the variables involved. Using the experimental method, researchers can test the device under predetermined conditions, then directly measure speed and calories based on the results of the installed sensors.

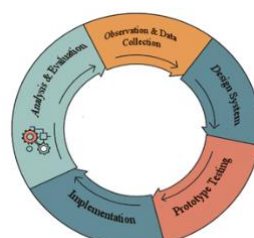


Fig. 1: Experiment Method

The experimental research stages in this study include:

1. **Observation and Data Collection**
The initial stage involved identifying the needs of users, specifically cyclists from the RGS Depok community, through field observation and interviews. The data collected included the average speed of cyclists, cycling duration, and body weight information, which was used for calorie calculations based on the MET (Metabolic Equivalent of Task) formula.
2. **System Design**
Based on the data acquired, the system was designed using Internet of Things-based hardware. The main components used include Arduino Uno R3 as the main controller, 3144E Hall Effect sensor to detect the bicycle wheel speed, MPU6050 accelerometer sensor to support calorie calculations, 16x2 LCD screen to display speed and calorie information, 18650 battery as a device power source, and Jumper cables to connect the electronic components. At this stage, electronic circuit design, Arduino microcontroller programming, and component integration are carried out so that the system can work in an integrated manner.
3. **Prototype Testing**
The device was tested under real-world cycling conditions across three speed categories: slow, moderate, and fast. The purpose of this testing was to evaluate the performance of the Hall Effect and accelerometer sensors in detecting speed and estimating calories, as well as to ensure the data displayed on the LCD was accurate.
4. **Implementation**
After the test results showed adequate performance, the device was implemented on a bicycle. The installation process was customized to avoid interfering with cycling activities. This stage included adjusting the sensor positions, arranging the cables, and configuring the system.
5. **Analysis and Evaluation**
The test data was analyzed to determine the accuracy of the speed measurements and calorie calculations by comparing them against manual data based on the MET formula. The evaluation was carried out through user feedback regarding ease of use, display clarity, and device reliability. The results of this analysis and evaluation will be used as the basis for future system development.

3. Result and Discussion

In this Internet of Things (IoT)-based speed and calorie monitoring system, a 18650 battery is used as the primary power source for the Arduino Uno board. The Arduino Uno acts as the central controller, receiving data from a Hall Effect sensor and an MPU6050 accelerometer sensor. The Hall Effect sensor calculates speed and calories based on the number of bicycle wheel rotations detected via a magnet. The MPU6050 sensor, on the other hand, functions as an accelerometer to detect the user's body movement while cycling, which is then used to estimate the number of calories burned. All data processed by the Arduino is displayed in real-time on a 16x2 LCD mounted on the bicycle's handlebars. This device is designed for users to monitor their cycling activity without needing an additional smartphone application, making it more practical and efficient.

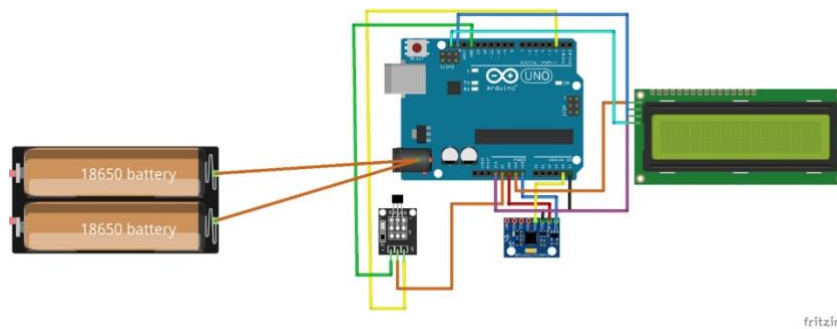


Fig. 2: Overall System Design

3.1 Main Components

Components The following are the main components of the Internet of Things-based calorie monitoring device for cyclists in the RGS Depok Cycling Community:

1. **Arduino Uno R3:** The main microcontroller used to process data from the sensors and display information on the screen
2. **Speed Sensor (Hall Effect Sensor 3144E / Encoder):** Used to detect the rotation of the bicycle wheel and calculate real-time speed.
3. **Calorie Sensor (MPU6050 Accelerometer):** Measures the bicycle's acceleration and movement to estimate the number of calories burned.
4. **Jumper Cables:** Connect the electronic components.
5. **16x2 LCD Display:** Shows real-time speed and estimated calorie information directly to the user.
6. **18650 Battery:** The primary power source for the system while cycling.
7. **Arduino IDE Version 1.8.19:** Used to calibrate the IoT device.

3.2 System Flow

The block diagram below illustrates the workflow of an Internet of Things-based bicycle speed and calorie monitoring device. This system involves a Hall Effect 3144E speed sensor and an MPU6050 (GY-521) accelerometer calorie sensor as the main inputs. Data from both sensors is processed by an Arduino Uno R3 Atmega 328P CH340 microcontroller, which acts as the system's central controller. The

processed data is then displayed in real-time on a 16x2 LCD screen as speed information and calorie estimates. This device is powered by an 18650 battery and all programming and data processing are done using the Arduino IDE platform.

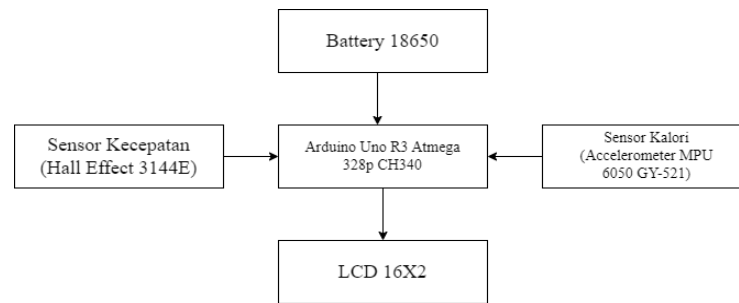


Fig. 3: System Flow

3.3. Hardware Implementation Result

The Arduino Uno R3 Atmega 328P CH340 serves as the main microcontroller that controls the entire system. This microcontroller receives data from the Hall Effect 3144E speed sensor and the MPU6050 (GY-521) accelerometer calorie sensor, then processes the data using an algorithm programmed in the Arduino IDE. The results of the data transmission are displayed in real-time via a 16x2 LCD, so users can immediately know the speed and estimated calories burned during the cycle. This device is powered by an 18650 battery, while the connections between components are supported by jumper cables that are arranged in an organized manner to minimize connection interference and ensure system stability. The Hall Effect 3144E sensor is used to detect wheel rotation which is converted into speed, while the MPU6050 sensor measures acceleration as a basis for estimating calorie burning based on the MET formula.



Fig. 4: Hardware Implementation

The 16x2 LCD displays real-time speed and calorie information during cycling activities, without requiring additional devices such as smartphones. This device works standalone, making it safer to use and not distracting the user's focus on the road. The entire integration between the Arduino Uno R3, Hall Effect 3144E sensor, MPU6050 sensor, 16x2 LCD, 18650 battery, and jumper cables forms a stable, portable, and efficient Internet of Things-based system to support cycling sports activities.

3.4 Speed and Calorie Measurement

1. Hall Effect Sensor Testing

Speed measurements on IOT devices are performed using a 3144E Hall Effect sensor, which detects the number of rotations of a bicycle wheel using a magnet. These rotations are then converted into linear velocity, which is displayed on the device. The sensor testing phase is divided into two parts: speed calculation simulation and accuracy testing. The following are the results of testing and calculating the accuracy of the Hall Effect 3144E sensor at three speed variations:

Table 1: Leisure Cycling (0-20 Km/Hour)

Testing To	Speedometer (Km/h)	Sensor (Km/h)	Duration (Menit)	Conclusion	Accuracy
1	12.0	12.1	5.0	Accurate	99.2%
2	15.0	14.8	4.0	Accurate	98.7%
3	10.0	10.2	6.0	Accurate	98.0%
4	13.0	13.0	4.6	Accurate	100%
5	11.5	11.4	5.2	Accurate	99.1%
Average :					99.0%

Calculation steps for tests 1 to 5:

$$\begin{aligned}
 &= (1 - |12.0 - 12.1| / 12.0) \times 100 = (1 - 0.0083) \times 100 = 99.2\% \\
 &= (1 - |15.0 - 14.8| / 15.0) \times 100 = (1 - 0.0133) \times 100 = 98.7\% \\
 &= (1 - |10.0 - 10.2| / 10.0) \times 100 = (1 - 0.02) \times 100 = 98.0\% \\
 &= (1 - |13.0 - 13.0| / 13.0) \times 100 = (1 - 0) \times 100 = 100\% \\
 &= (1 - |11.5 - 11.4| / 11.5) \times 100 = (1 - 0.0087) \times 100 = 99.1\% \\
 &= \underline{99.5 + 99.6 + 98.9 + 99.3 + 99.5} = 496.8 / 5 = 99.36\%
 \end{aligned}$$

5

Sensor testing at leisurely speeds demonstrated that the device can read speed fairly accurately. While there was a slight difference between the sensor readings and a standard speedometer (approximately ±0.1–0.2 km/h), overall accuracy was in the high range. An average accuracy of 99.0% indicates the device's reliability under low-speed conditions, such as leisurely walking.



Fig. 5: Relaxed Speed Speedometer



Fig. 6: Sensor At a Relaxed Speed

Table 2: Leisure Cycling (20-40 Km/Hour)

Testing To	Speedometer (Km/h)	Sensor (Km/h)	Duration (Min)	Conclusion	Accuracy
1	22.0	22.1	2.7	Accurate	99.5%
2	28.0	27.5	2.1	Accurate	98.2%
3	25.0	25.2	2.4	Accurate	99.2%
4	30.0	29.8	2.0	Accurate	99.3%
5	35.0	34.7	1.7	Accurate	99.1%
Average:					99.06%

Test calculation steps 1 to 5:

$$\begin{aligned}
 &= (1 - |22.0 - 22.1| / 22.0) \times 100 = (1 - 0.0045) \times 100 = 99.5\% \\
 &= (1 - |28.0 - 27.5| / 28.0) \times 100 = (1 - 0.0178) \times 100 = 98.2\% \\
 &= (1 - |25.0 - 25.2| / 25.0) \times 100 = (1 - 0.008) \times 100 = 99.2\% \\
 &= (1 - |30.0 - 29.8| / 30.0) \times 100 = (1 - 0.0067) \times 100 = 99.3\% \\
 &= (1 - |35.0 - 34.7| / 35.0) \times 100 = (1 - 0.00857) \times 100 = 99.1\% \\
 &= \underline{99.5 + 98.2 + 99.2 + 99.3 + 99.1} = 495.3 / 5 = 99.06\%
 \end{aligned}$$

5

At medium speeds, the Hall Effect sensor still managed to read speed with high accuracy. Small differences between the sensor and speedometer readings were due to tolerances in the rotational data readings. However, no significant deviations were found, resulting in an average accuracy of 99.06%, demonstrating the device's stability and consistency at medium speeds.



Fig. 7: Medium Speed Speedometer



Fig. 8: Sensor At a Medium Speed

Table 3: Leisure Cycling (40-60 Km/Hour)

Testing To	Speedometer (Km/h)	Sensor (Km/h)	Duration (Menit)	Conclusion	Accuracy
1	42.0	41.8	1.4	Accurate	99.5%
2	50.0	50.2	1.2	Accurate	99.6%
3	48.0	47.5	1.3	Accurate	98.9%
4	45.0	45.3	1.3	Accurate	99.3%
5	55.0	54.7	1.1	Accurate	99.5%
Average:					99.36%

Test calculation steps 1 to 5:

$$\begin{aligned}
 &= (1 - 42.0 |42.0 - 41.8| / 42.0) \times 100 = 99.5\% \\
 &= (1 - 50.0 |50.0 - 50.2| / 50.0) \times 100 = 99.6\% \\
 &= (1 - 45.0 |45.0 - 45.3| / 48.0) \times 100 = 99.3\% \\
 &= (1 - 45.0 |45.0 - 45.3| / 45.0) \times 100 = 99.3\% \\
 &= (1 - 55.0 |55.0 - 54.7| / 55.0) \times 100 = 99.5\% \\
 &= \underline{99.5 + 99.6 + 98.9 + 99.3 + 99.5} = 496.8 / 5 = 99.36\%
 \end{aligned}$$

5

High-speed testing demonstrated that the Hall Effect sensor can still provide precise readings even at high bicycle speeds. These results demonstrate the sensor system's reliability even under extreme conditions, with an average accuracy of 99.36%. This reinforces the validity of the device's use at various speeds with consistent performance.



Fig. 9: Fast Speed Speedometer



Fig. 10: Sensor At a Fast Speed

2. MPU 6050 Accelerometer Sensor Testing

Calorie calculation simulation. The calculation is performed using the MET formula, which measures the amount of energy a person expends during a physical activity, multiplied by body weight and the duration of the activity.

Calories = MET × Body Weight (kg) × Duration (hours)

MET (Metabolic Equivalent of Task) is a standard value for activity intensity. MET values vary depending on cycling speed:

Leisurely walking (≤ 20 km/h): MET = 4

Moderate walking (21–30 km/h): MET = 8

Brisk walking (31–40+ km/h): MET = 12

Body Weight (kg): A standard weight of 60 kg is used as an assumption for the user.

Duration (hours): Obtained by dividing the distance traveled by the actual speed.

Duration (Hours) = Distance (Km)

Speed (Km/h)

[Source: Ainsworth, B.E., et al. 2024]

The following is a simulation of calorie calculations while cycling at three speed categories. This simulation calculates calories while cycling leisurely, covering a distance of 1 km at a speed of 10 km/h (in the leisure cycling category). MET = 4:

Duration = $1 \text{ km} \div 10 \text{ km/h} = 0.1 \text{ hour}$

Body weight = 60 kg

Calories burned:

Calories = $4 \times 60 \times 0.1 = 24 \text{ kcal}$

If the speed increases to 30 km/h (moderate walking, MET = 8), then:

Duration = $1 \times 30 = 0.033 \text{ hour}$

Calories = $8 \times 60 \times 0.033 = 15.84 \text{ kcal}$

If the speed is 50 km/h (brisk walking, MET = 12):

Duration = $1 \times 50 = 0.02 \text{ hour}$

Calories = $12 \times 60 \times 0.02 = 14.4 \text{ kcal}$

Accuracy Testing. Testing was conducted five times for each speed category. The accuracy level between the IOT device and the smartphone application was determined using the accuracy comparison formula:

$$\text{Accuracy} = \left(1 - \frac{|\text{Manual Calories} - \text{Device Calories}|}{\text{Manual Calories}}\right) \times 100\%$$

Test 1:

Manual calories are 24.0 kcal, device calories are 23.8 kcal.

$$\text{Accuracy} = \left(1 - \frac{|24.0 - 23.8|}{24.0}\right) \times 100\% = 99.1\%$$

Test 2:

Manual calories are 15.8 kcal, device calories are 15.6 kcal.

$$\text{Accuracy} = \left(1 - \frac{|15.8 - 15.6|}{15.8}\right) \times 100\% = 98.7\%$$

Test 3:

Manual calories are 14.4 kcal, device calories are 14.5 kcal.

$$\text{Accuracy} = \left(1 - \frac{|14.4 - 14.5|}{14.4}\right) \times 100\% = 99.3\%$$

Test 4:

Manual calories are 23.5 kcal, device calories are 23.2 kcal.

$$\text{Accuracy} = \left(1 - \frac{|23.5 - 23.2|}{23.5}\right) \times 100\% = 98.7\%$$

Test 5:

Manual calories are 15.0 kcal, device calories are 15.2 kcal.

$$\text{Accuracy} = \left(1 - \frac{|15.0 - 15.2|}{15.0}\right) \times 100\% = 98.6\%$$

The smaller the difference between the manual calculation results and the results from the tool, the higher the accuracy level of the device.

Table 4: Calorie Testing

Testing To	Manual Calorie (Kcal)	Calorie Tool (Kcal)	Duration (Menit)	Conclusion	Accuracy
1	24.0	23.8	6.0	Accurate	99.1%
2	15.8	15.6	2.0	Accurate	98.7%
3	14.4	14.5	1.2	Accurate	99.3%
4	23.5	23.2	5.8	Accurate	98.7%

4. Conclusion

The test results show that the Internet of Things (IOT) device for monitoring speed and calories on bicycles is able to provide a high level of accuracy in various speed categories. Speed measurement using the Hall Effect 3144E sensor achieves an average accuracy of 99.0% to 99.36% at low, medium, and high speeds, while calorie calculation with the MPU6050 accelerometer sensor produces an average accuracy of 98.88% when compared to manual calculations using the MET formula. This system works independently without requiring additional applications on smartphones, thereby increasing user safety and comfort while cycling. The developed device can help cyclists monitor sports performance in real-time through a 16x2 LCD display, with low power consumption supported by an 18650 battery. With these results, this research makes a real contribution to the development of IOT devices in the fields of sports and health, especially in monitoring cycling activities. For further research, it is recommended that additional features such as heart rate measurement or GPS integration be added value for future devices, and that the use of other types of sensors that are more resistant to extreme conditions such as rain or off-road terrain be studied.

References

- [1] B. E. Ainsworth, W. L. Haskell, S. D. Herrmann, N. Meckes, D. R. Bassett Jr, C. Tudor-Locke, J. L. Greer, J. Vezina, M. C. Whitt-Glover, dan A. S. Leon, "Compendium of Physical Activities: 2024 Update of MET Values for Physical Activities," *Med. Sci. Sports Exerc.*, 2024, doi: 10.1249/MSS.
- [2] G. M. Migliaccio, J. Padulo, dan L. Russo, "The Impact of Wearable Technologies on Marginal Gains in Sports Performance: An Integrative Overview on Advances in Sports, Exercise, and Health," *Applied Sciences*, vol. 14, no. 15, 2024, doi: 10.3390/app14156649.
- [3] Kamlesh Kahar, Ritanshu Khatke, Pranav Bhopale, Jayesh Tayde, dan Hariom Modokar, "The IoT Based Exercise Cycle," *Int. J. Adv. Res. Sci. Commun. Technol.* (IJARSCT)*, vol. 2, no. 2, May 2022, doi: 10.48175/IJARSCT-3668.
- [4] M. Hassaan Naveed, O. B. Samin, M. Bilal, dan M. Waseem, "IoT Based Health Monitoring with Diet, Exercise and Calories recommendation Using Machine Learning," Springer, 2025.
- [5] R. Amini Gougeh dan Z. Zilic, "Systematic Review of IoT-Based Solutions for User Tracking: Towards Smarter Lifestyle, Wellness and Health Management," *Sensors*, vol. 24, no. 18, 2024, doi: 10.3390/s24185939.
- [6] V. Luder, S. Bian, dan M. Magno, "CycloWatt: An Affordable, TinyML-enhanced IoT Device Revolutionizing Cycling Power Metrics," arXiv, 2024.
- [7] V. Luder dan M. Magno, "Self-Sustaining Multi-Sensor LoRa-Based Activity Monitoring for Community Workout Parks," arXiv, 2025.