Sri Lanka Institute of Information Technology

Internet of Things -IT4030

Project report

GROUP ID: AG 88

Name	IT Number
Perera G.M. T	IT 21196638
Bhagya E.M.P	IT 21211478
Liyanage E.S. T	IT 21309724
Athukorala D.T.A.	IT 21195334

Table of Contents

List of Figures

Introduction

The rapid advancements in the Internet of Things (IoT) have enabled the creation of innovative solutions to monitor and improve various aspects of daily life. This project focuses on developing an IoT-based step counter using the **ESP8266 microcontroller** and the **MPU6050 accelerometer and gyroscope sensor**. The primary objective is to build a cost-effective and accurate step monitoring device that can track physical activity, particularly step counts, which are crucial in both fitness tracking and healthcare, especially for rehabilitation patients.

The MPU6050 sensor captures real-time motion data, which is processed by the ESP8266 to calculate step counts. The step count data is made accessible through two interfaces: a dynamic web interface and an OLED display. The web interface, hosted on the ESP8266, allows users to view their step count in real time via any web browser connected to the local Wi-Fi network. This interface is refreshed every second using JavaScript, ensuring that users receive up-to-date step count information without needing to reload the page. Simultaneously, the **OLED display** provides a quick and immediate visual readout of the step count directly on the wearable device, enhancing its user-friendliness.

This report delves into the design and implementation of the system, covering the selection of hardware components, communication protocols, and step detection algorithms. Additionally, it outlines the development of the web and display interfaces, along with testing results and future enhancement possibilities. The project showcases the integration of IoT hardware, sensor technologies, and user-centric interfaces to create a practical, real-time step counter, offering insights into potential improvements for wearable technology.

Project overview

This project aims to develop a comprehensive IoT-based step counter by integrating both hardware and software components. The primary purpose of the project is to create a device that accurately monitors physical activity through step counting, catering to the needs of fitness enthusiasts and individuals undergoing rehabilitation.

The hardware components of the system include the ESP8266 microcontroller and the MPU6050 accelerometer and gyroscope sensor. The ESP8266 serves as the central processing unit, handling data collection and communication, while the MPU6050 is responsible for detecting motion and calculating step counts. The use of the MPU6050 ensures a high level of accuracy in step detection, leveraging both accelerometer and gyroscope data.

On the software side, the project features a dynamic web interface that allows users to access their step count in real time. This web interface is hosted directly on ESP8266, enabling connectivity via a local Wi-Fi network. Users can view their current step count without the need for additional hardware, providing a convenient solution for monitoring physical activity.

In addition to the web interface, the project also incorporates an OLED display, which presents the step count directly on the device. This dual display approach enhances user experience by allowing immediate access to step count information, whether through a web browser or the OLED screen.

Overall, this project integrates innovative hardware and software technologies to deliver a practical and user-friendly solution for step counting, demonstrating the potential of IoT applications in health and fitness monitoring.

Components and Architecture

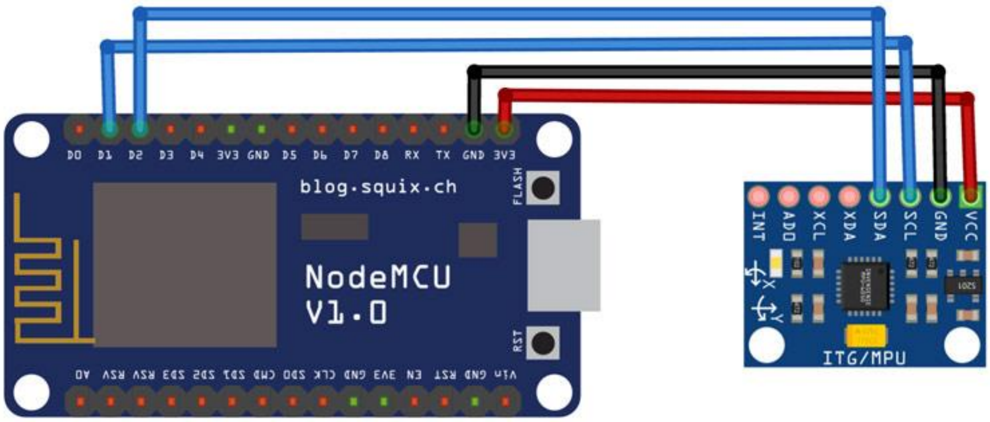

Figure 1 Architecture

Hardware Components

ESP8266:

The ESP8266 is a low-cost Wi-Fi microcontroller that serves as the brain of the step counter system. It handles data processing and communication between the MPU6050 sensor and the web interface. By hosting a web server, the ESP8266 enables users to access their step count through any web browser connected to the local network. Its Wi-Fi capability allows for seamless data transmission and real-time updates.

MPU6050:

The MPU6050 is a 6-axis motion tracking device that combines a 3-axis accelerometer and a 3-axis gyroscope. This sensor is crucial for detecting motion and calculating the number of steps taken by the user. The MPU6050 communicates with the ESP8266 via the **I2C protocol**, providing continuous accelerometer and gyroscope data that is used for step detection algorithms. Its high accuracy makes it ideal for applications in fitness and rehabilitation.

System Architecture

1. **Sensor Data Collection**:

   The MPU6050 collects accelerometer and gyroscope data and sends it to the ESP8266 via the **I2C protocol**. ESP8266 processes this data to detect steps based on predefined algorithms.

   The I2C (Inter-Integrated Circuit) protocol is used for communication between the MPU6050 and the ESP8266. In this setup, the ESP8266 acts as the master, requesting data from the MPU6050, which serves as the slave. This protocol enables efficient data transfer for accurate and timely step detection.

2. **Data Processing and Communication**:

   The ESP8266 acts as a web server, handling HTTP requests from users accessing the web interface. It processes incoming data from the MPU6050 and updates the step count accordingly.

   ESP8266 connects to a local Wi-Fi network using the provided SSID and password, allowing it to serve the web interface. Users can access their step count by entering the IP address assigned to the ESP8266 in a web browser, enabling real-time monitoring of physical activity

3. **User Interface**:

   The web interface allows users to view the current step count in real time, providing a convenient way to monitor physical activity.

Code and Algorithms

WIFI setup

The ESP8266 is configured to connect to a local Wi-Fi network, allowing it to function as a web server. The connection is initiated using the WiFi.begin() function, which requires the SSID and password of the network. The ESP8266 continuously checks for a successful connection, and once connected, it prints the assigned IP address to the Serial Monitor for access to the web interface.

```
const char* ssid = "Your_SSID";
const char* password = "Your_Password";

WiFi.begin(ssid, password);

while (WiFi.status() != WL_CONNECTED) {
    delay(1000);
    Serial.println("Connecting to WiFi...");
}
Serial.println("Connected to WiFi, IP address: " + WiFi.localIP().toString());
```

Step Detection Algorithm

The step detection algorithm leverages data from the MPU6050's accelerometer, which provides readings on the X, Y, and Z axes. It calculates the vector magnitude using the formula:

$$Magnitude = \sqrt{(x^2 + b^2 + c^2)}$$

```
float vectorMagnitude = sqrt(sq(accelX) + sq(accelY) + sq(accelZ));
if (abs(vectorMagnitude - previousVector) > accelThreshold) {
    stepCount++;
    Serial.println("Step detected!");
}
previousVector = vectorMagnitude;
```

Web Interface

ESP8266 hosts a web server using the **ESP8266WebServer** library, which handles HTTP requests. Two primary routes are defined: the root route (/), which serves the HTML page displaying the step count, and the /step route, which provides the current step count as plain text.

When a user accesses the root route, the ESP8266 responds with an HTML page that includes JavaScript for dynamic updates. The JavaScript code uses the fetch() API to request the current step count from the /step route every second, allowing the displayed count to refresh without a full page reload.

```
server.on("/", handleRoot);
server.on("/step", handleStepCount);

void handleRoot() {
    String html = "<html><body><h1>Step Counter</h1><div
id='stepCount'>0</div></body></html>";
    server.send(200, "text/html", html);
}

void handleStepCount() {
    server.send(200, "text/plain", String(stepCount));
}

// JavaScript in HTML for automatic updates
<script>
    setInterval(function() {
        fetch('/step').then(response => response.text()).then(data => {
            document.getElementById('stepCount').innerHTML = data;
        });
    }, 1000);
</script>
```

Testing and Validation

Testing Results

Testing of the step counter involved multiple trials to ensure accurate step detection. The system was initially calibrated in a controlled environment, where it was subjected to various walking speeds, including normal walking, brisk walking, and jogging.

To validate the step count accuracy, the device's readings were compared against a standard pedometer during 10-minute trials. This comparison allowed for identifying any discrepancies in step counts, leading to adjustments in the detection algorithm when necessary.

Validation

In real-world scenarios, the step counter performed reliably, accurately detecting steps across different activities. It effectively distinguished between walking, jogging, and running, with high accuracy and minimal false positives.

During trials, as the user transitioned from walking to jogging, the device accurately reflected these changes in step count. The testing demonstrated the system's robustness, consistently providing reliable readings under various conditions.
Overall, the step counter proved to be a valuable tool for monitoring physical activity, with potential applications in fitness tracking and rehabilitation. Future enhancements could focus on refining the step detection algorithms for improved accuracy in more complex movements.

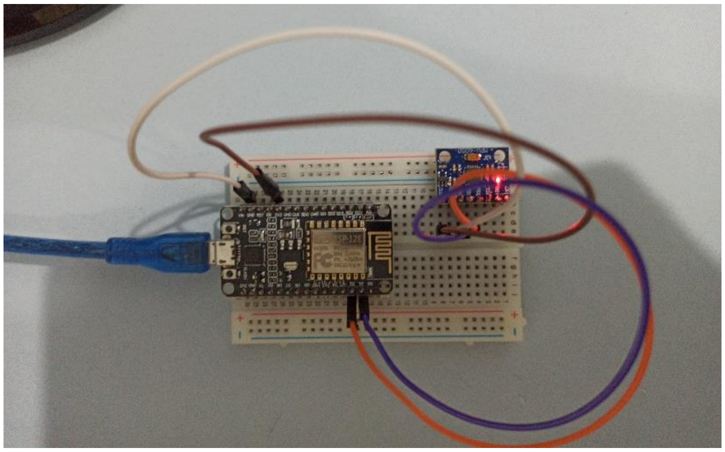

Figure 2 Prototype

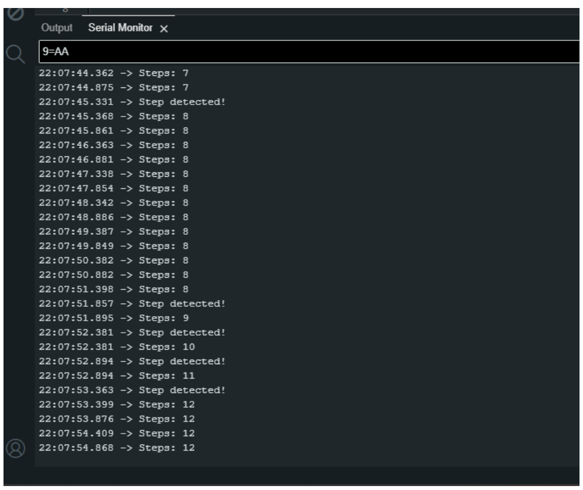

Figure 3 Serial Monitor

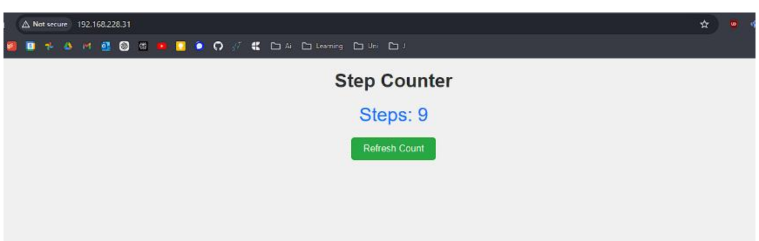

Figure 4 Web Dashboard

Possible Enhancements

OLED Display Integration

Integrating an OLED display into the step counter can significantly enhance user experience by providing immediate visual feedback of the step count directly on the device. This feature allows users to monitor their activity without needing to access a web browser, making it more convenient for real-time use during exercises or daily activities. The display can also show additional information, such as elapsed time or calorie estimates, further improving its utility as a fitness too.

Mobile Optimization

Optimizing the web interface for mobile devices can improve accessibility and usability for users on the go. A mobile-responsive design would ensure that the step count is easily readable on smaller screens, with a simplified layout for quick access to essential information. Enhancements could include touch-friendly controls, larger fonts, and streamlined navigation, making it easier for users to monitor their step count while engaging in physical activities.

Advanced Algorithms and accuracy

Incorporating machine learning algorithms for activity classification could enhance the sophistication of the step detection system. By analyzing data from the MPU6050, the system could differentiate between various activities, such as walking, running, and jogging. This capability would not only improve the accuracy of step counting but also provide users with more detailed insights into their physical activity patterns. Implementing such algorithms would involve training models on labeled datasets to recognize different movement patterns effectively.

Conclusions

This project successfully developed an IoT-based step counter using the ESP8266 microcontroller and the MPU6050 sensor. The system effectively monitors physical activity by accurately counting steps and providing real-time data via a web interface. Its design demonstrates significant potential applications in fitness tracking and rehabilitation, enabling users to monitor their progress and adapt their exercise routines accordingly.

Throughout the implementation, challenges such as sensor calibration and accurate step detection were encountered. These were addressed through careful adjustments to the step detection algorithm and thorough testing in various conditions. The iterative testing process ensured the device's reliability and robustness, ultimately resulting in a functional and user-friendly product.

Looking ahead, further enhancements, such as integrating machine learning for activity classification and optimizing the user interface for mobile devices, could significantly improve the device’s capabilities and user experience. Overall, this project showcases the promising intersection of IoT technology and health monitoring, paving the way for more advanced applications in the future.

References

(Siyang, Nilpanapan, & Kerdcharoen, 2018)
(Aditya, Ilham, Atabiq, & Jannah, 2023)
(Jayalath, Abhayasinghe, & Murray, 2023)
(Jayalath, Abhayasinghe, & Murray, Accurate Pedometer for Smartphones, 2014)
(Yu, 2023)
(Poliki & Potnuri, 2022)