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Self - Balancing Robot Using PWA and BLE

T. Lakshmi Prasanna, G. HemaAsritha, B. Sanjana, J. Geethika, K. Raga Ranjitha, Ch. Sandhya

Department of Comuter Sciecne Engineering, Narayana Engineering College, Nellore, Andhra Pradesh, India

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ABSTRACT

The project aims to develop a self-balancing robot that can be controlled and monitored using an ESP32 microcontroller and a Bluetooth Low Energy (BLE) connection. The robot uses an MPU5060 gyro sensor to maintain balance while moving. The control and monitoring of the robot are achieved through a Bluetooth Web API-based Progressive Web App (PWA) built with ReactJS. The system is designed to be user-friendly and accessible. The PWA provides an intuitive interface for controlling the robot's movement, including forward, backward, left, and right movements, as well as stopping and starting the robot. The PWA also displays real-time sensor data from the MPU5060 gyro sensor, such as tilt angle, acceleration, and velocity, which allows users to monitor the robot's movement and performance. The ESP32 microcontroller provides the necessary processing power to control the robot's movement and communicate with the PWA through BLE. The MPU5060 gyro sensor is used to detect the robot's orientation and maintain balance while moving. The system is powered by a rechargeable battery, making it portable and convenient for use in various environments.

KEYWORDS: Progressive Web Apps, Bluetooth Low Energy

INTRODUCTION

A self-balancing robot is a type of robot that uses sensors and algorithms to balance itself on two wheels. In recent years, there has been a growing interest in building self-balancing robots as they can be used for a variety of applications, such as delivery robots, security robots, and educational robots.

In this project, we will be building a self-balancing robot using progressive web apps (PWA) and Bluetooth Low Energy (BLE) technology. PWAs are web applications that can be accessed through a web browser and provide a native app-like experience to users. They can be installed on a mobile device and can work offline.

BLE is a wireless communication technology that enables low-power, short-range communication between devices. In this project, we will be using BLE to establish a connection between the self-balancing robot and a mobile device, allowing the user to control the robot using any device.

The project will use an Arduino microcontroller, motors, and sensors to build a physical robot. We will also be developing a PWA that will allow the user to control the tolerance of the robot's movement and monitor its status. The PWA will be designed to work on both desktop and mobile devices, providing a seamless user experience.

2. LITERATURE SURVEY

1. "Development of a Self-Balancing Robot with Bluetooth Control Based on Arduino" by Wang Xinyang, Chen Yufei, and Zhang Hao. This paper discusses the design and development of a self-balancing robot using an Arduino microcontroller and Bluetooth control.
2. "Design and Control of a Self-Balancing Two-Wheeled Robot Based on Fuzzy Logic" by Ahmad Zaky, Fitri Yakub, and Adnan Shahid Khan. This paper presents a design for a self-balancing robot using fuzzy logic control.
3. "Design and Implementation of a Self-Balancing Robot Controlled by Bluetooth and Smartphone" by Saravanan Subramanian and Varun A. Deshpande. This paper presents a design for a self-balancing robot that is controlled by a smartphone using Bluetooth.
4. "Bluetooth Low Energy for Internet of Things Applications" by Mohammad Aazam and Azeem Ahmad. This paper provides an overview of Bluetooth Low Energy (BLE) technology and its applications in the Internet of Things (IoT). It includes details on the architecture, protocols, and security features of BLE, as well as its advantages and limitations.
5. "Progressive Web Apps: The Future of Mobile Web" by Nikunj Aggarwal and Aviral Agarwal. This paper provides an overview of Progressive Web Apps (PWA) and their potential as the future of mobile web applications. It includes details on the architecture, features, and benefits of PWA, as well as its limitations and challenges.

As the field of robotics and automation continues to grow, self-balancing robots have become a popular area of research and development. Various techniques and algorithms have been used to develop self-balancing robots, including PID control, Kalman filtering, and machine learning.

Arduino is a popular platform for building small-scale robots due to its ease of use and low cost. In a similar vein, Bluetooth technology has become a widely adopted wireless communication standard that enables seamless data transmission between devices.

One of the most critical components in a self-balancing robot is the sensor used to detect its tilt angle. The MLX sensor is a popular choice due to its high accuracy, low noise, and fast response time. It uses a combination of accelerometer and gyroscope data to determine the tilt angle, making it ideal for use in a self-balancing robot.

In addition to the MLX sensor, an IR sensor can be used to detect obstacles and allow the robot to move in a backward direction. The IR sensor emits an infrared signal that bounces back when it hits an obstacle, allowing the robot to detect its presence.

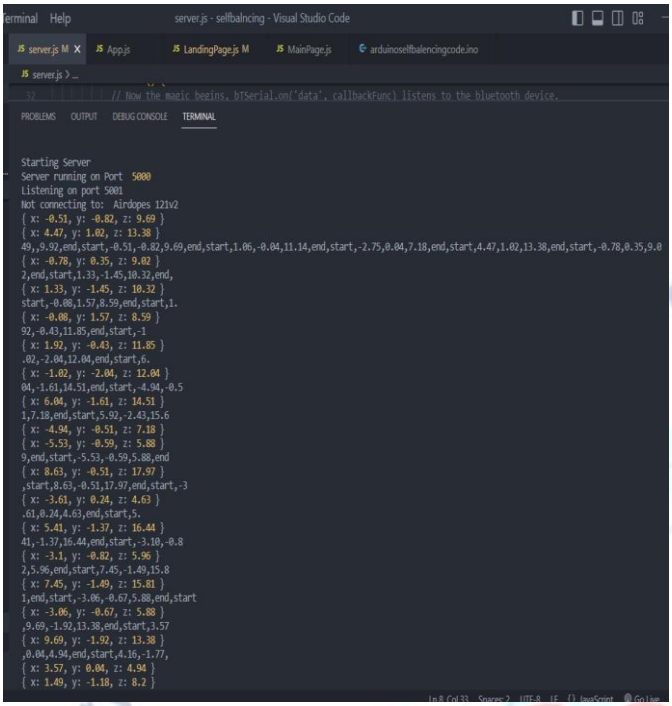
To display the sensor data graphically in a React app, a WebSocket connection can be established between the Node.js server and the app. This allows real-time data transmission between the robot and the app, enabling the app to display the sensor data in a graphical format.

There is a significant amount of literature available on self-balancing robots, Arduino programming, Bluetooth communication, and sensor integration. This project can benefit from drawing upon these existing resources to ensure a robust and well-designed system.

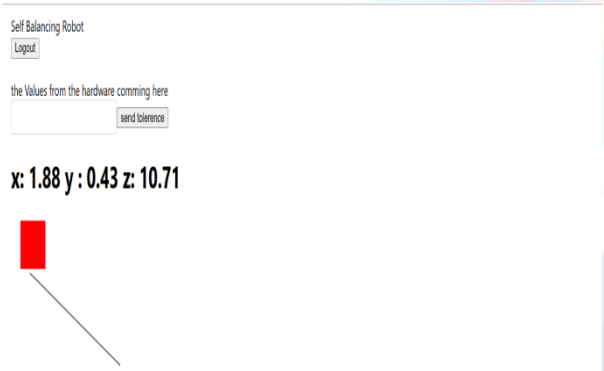
WORKING OF PROJECT

1. The microcontroller reads data from the accelerometer and gyroscope sensors to determine the angle of the robot and maintain its balance.
2. The microcontroller also communicates with the PWA over Bluetooth Low Energy to receive control signals from the user.
3. The PWA can be accessed from any device that supports a web browser and Bluetooth Low Energy, such as a smartphone or tablet.
4. The PWA provides a user interface to control the robot's movement, adjust its balance, and view sensor data such as the robot's angle and motor speed.
5. The PWA sends control signals to the microcontroller over Bluetooth Low Energy to control the motors and adjust the balance of the robot.
6. The microcontroller adjusts the speed and direction of the motors based on the control signals and sensor data, to move the robot in the desired direction while maintaining its balance.

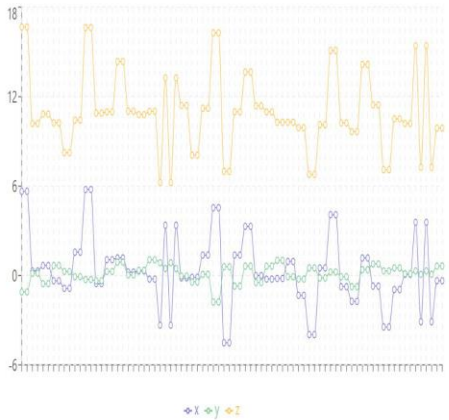
RESULTS AND OUTPUTS



Bluetooth readings refer to data that is transmitted wirelessly over Bluetooth connections between devices. This can include a wide variety of information, such as sensor data, audio streams, and control signals.



In the above figure the line graph represents the x-axis, y-axis and z-axis of the robot where x-axis is horizontal angle, y-axis is vertical angle and z-axis is the height angle.



the PWA graph is designed to provide a high-quality, app-like experience to users, while still being accessible through a web browser. By leveraging web technologies and APIs, PWAs offer a flexible and powerful alternative to traditional native apps, and are becoming increasingly popular with developers and users alike. In the above figure the graph shows the movements in the form of graph ranges.

FUTURE SCOPE

The Self-Balancing Robot Using Progressive Web Apps and Bluetooth Low Energy has a lot of potential for future development and applications. Here are some of the possible future scopes for this system:

1. Advanced control algorithms: Developers can experiment with advanced control algorithms, such as Model Predictive Control (MPC) or Reinforcement Learning (RL), to enhance the self-balancing capabilities of the robot. These algorithms could enable the robot to handle more complex terrain and environments.
2. Gesture-based control: The smart phone app could be modified to use gesture-based controls, allowing the user to control the robot by tilting or shaking their phone.
3. Autonomous navigation: The addition of a camera or lidar sensor could enable the robot to navigate autonomously, avoiding obstacles and following a set path.
4. Multi-robot coordination: Multiple self-balancing robots could be connected to the same smart phone app, allowing for coordinated movements and group tasks.

5. Augmented Reality (AR) integration: The smart phone app could be enhanced with AR features, allowing the user to see a virtual representation of the robot and its surroundings.
6. Educational applications: The self-balancing robot could be used as an educational tool to teach programming and robotics to students of all ages.
7. Industrial applications: The self-balancing technology could be applied in industrial settings, such as warehousing or manufacturing, to transport goods and materials in a safe and efficient manner.

Overall, the Self-Balancing Robot Using Progressive Web Apps and Bluetooth Low Energy has a lot of potential for future development and applications, and developers can continue to innovate and improve upon this technology to make it even more versatile and useful.

CONCLUSION

In conclusion, a self-balancing robot using Progressive Web Apps (PWA) and Bluetooth Low Energy (BLE) is a complex system that requires both hardware and software components to work together seamlessly. The IMU sensor, motor drivers, BLE module, and smart phone app all need to function correctly for the robot to balance and move as intended.

Developers building such a system should carefully design and implement each component, thoroughly test the system, and iterate until all components work together seamlessly. Unit testing can be used to verify that each software component behaves correctly, while integration testing can be used to verify that the hardware and software components work together as intended.

Overall, a self-balancing robot using Progressive Web Apps and Bluetooth Low Energy has the potential to be a fun and useful project, with applications ranging from entertainment to educational purposes. However, it requires a significant amount of technical skill and effort to build and test, and developers should be prepared to invest the necessary time and resources to ensure its success.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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