Project Overview

The MazeMaster project, developed by students Mohammad Salman and Mohammad Najjar at An-Najah National University, focuses on designing and implementing a maze-solving robot. The robot uses the left wall-following algorithm to autonomously navigate through mazes, with additional features like remote control via a web interface and environmental temperature monitoring. The project combines hardware components (e.g., ultrasonic sensors, DC motors, microcontrollers) and software algorithms to create a functional and interactive robot.

Key Objectives

1. **Autonomous Navigation:** Implement the left wall-following algorithm to enable the robot to solve mazes.

2. **Remote Control:** Develop a web interface for starting, stopping, and monitoring the robot remotely.

3. **Environmental Monitoring:** Integrate a temperature sensor (DHT11) to display ambient temperature on the web interface.

4. **Versatility:** Demonstrate the robot's potential for applications like search and rescue, industrial automation, and exploration.

Methodology

1. Hardware Components:

- Ultrasonic Sensors: Detect walls and obstacles.
- DC Motors: Provide movement, controlled by an L298N motor driver.
- Microcontrollers: Arduino Mega for motor control and ESP32 for Wi-Fi communication.
- Sensors: GY-521 (orientation), TCS3200 (color detection for the goal), DHT11 (temperature), and optical encoders (wheel rotation).
- Power Source: Lithium battery for portability.

2. **Software and Algorithms:**

- Left Wall-Following Algorithm: The robot follows the left wall until it reaches the goal (black carpet).
- PID Control: Ensures straight movement by synchronizing motor speeds using optical encoders.
- Web Interface: Allows remote control and displays real-time temperature data.

3. **Testing and Calibration:**

- The robot was tested in controlled maze environments to fine-tune its navigation and sensor accuracy.
- Challenges included motor speed inconsistencies and ultrasonic sensor interference, which were partially mitigated through corrective maneuvers and recalibration.

Results and Analysis

1. **Ultrasonic Sensors:**

- Accurately detected obstacles within a range of 0–200 cm (±1 cm error).
- Minor inaccuracies occurred due to environmental noise and surface reflectivity.

2. **GY-521 Sensor:**

- Measured the robot's orientation (yaw angle) with an error of ±2–15 degrees.
- Drift and mechanical vibrations introduced noise, requiring periodic recalibration.

3. **Performance:**

- The robot successfully navigated mazes using the left wall-following algorithm.
- Motor speed variability and sensor inaccuracies occasionally caused deviations, but the robot demonstrated resilience by recovering and continuing its path.

Discussion

- **Achievements:**

- The robot effectively integrated multiple sensors and control systems to achieve autonomous navigation.
- The web interface provided seamless remote control and environmental monitoring.

- Challenges:

- Motor speed inconsistencies and ultrasonic sensor inaccuracies impacted performance.
- External factors like noise and surface reflectivity affected sensor readings.

- Future Improvements:

- Replace DC motors with stepper motors for better speed control.
- Upgrade ultrasonic sensors to infrared sensors for improved accuracy.
- Add a camera for enhanced navigation and feature expansion.

Conclusion

The MazeMaster project successfully demonstrated the integration of autonomous navigation, remote control, and environmental monitoring in a maze-solving robot. While the robot achieved its primary objectives, challenges like motor variability and sensor limitations highlighted areas for improvement. Future work could focus on hardware upgrades and advanced algorithms to enhance performance and expand the robot's applications.