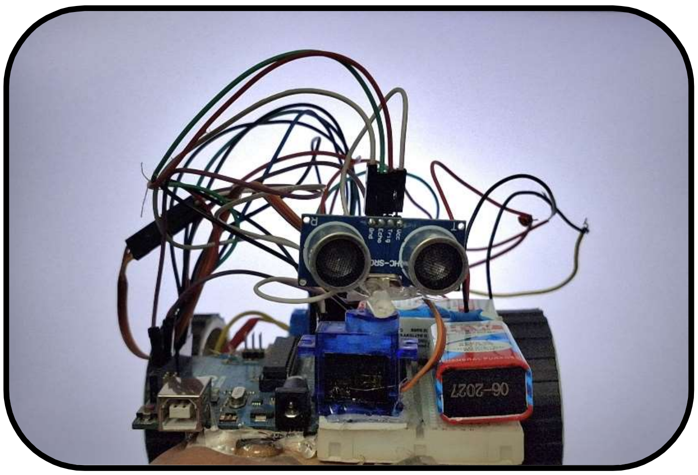
GE-107

Tinkering Lab – Report

Maze Solving Robot



Project ID - 27	
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Overview

The maze-solving robot is an autonomous system designed to navigate through mazes using a right-hand wall-following approach. Equipped with ultrasonic sensors, a servo motor, and motorized wheels, the robot can detect obstacles, measure distances, and make real-time decisions to determine its movement.

A control algorithm that processes sensor inputs to execute appropriate movements drives the robot's functionality. It moves forward when the path is clear, turns left when the right and front walls are blocked, and turns right to avoid obstacles. By leveraging these capabilities, the robot is designed to navigate complex mazes without external intervention.

Motivation & Real-Life Applications

The motivation behind this project stems from the growing need for autonomous systems capable of navigating complex environments without human intervention.

Maze-solving robots are a fundamental example of such systems, with real-life applications in rescue missions, automated logistics, exploration, and robotics education.

These robots demonstrate the principles of sensor-based navigation and decision-making, which are essential for developing more advanced autonomous technologies.

Objective and Goals

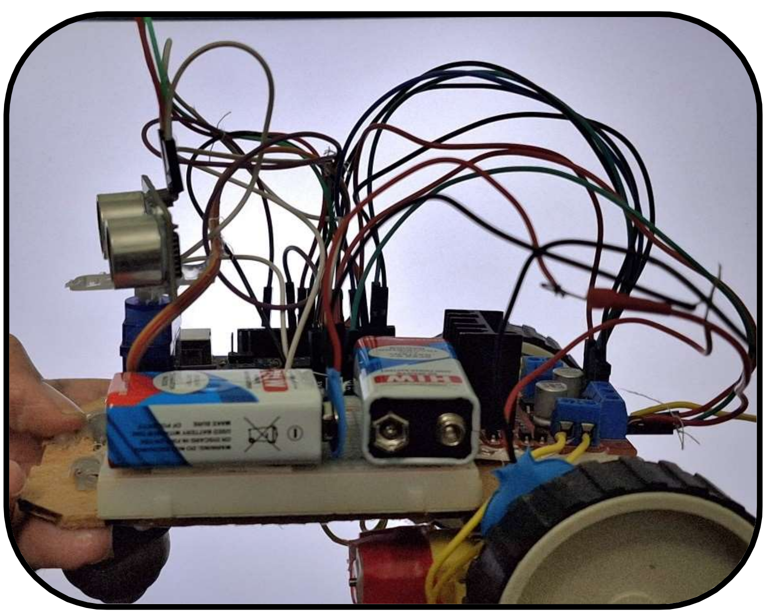
The primary objective of the maze-solving robot is to design and implement a system that can autonomously navigate through a maze while avoiding obstacles and following the right-hand wall. The goals include:

- Efficiently detect and respond to obstacles using ultrasonic sensors.
- Demonstrating stable and accurate wall-following behaviour.
- Ensuring real-time decision-making for smooth traversal of complex paths.

Problem Statement

Developing a maze-solving robot requires addressing several challenges:

- **Autonomous Navigation**
  The robot must navigate a maze without human intervention, requiring precise obstacle detection and responsive decision-making.
- **Obstacle Avoidance**
  Obstacles within the maze may vary in size and distance, necessitating accurate real-time sensing and threshold calibration to distinguish paths from walls.
- **Path Selection**
  The robot must follow a logical algorithm, such as the right-hand wall-following approach, to ensure systematic maze traversal while accounting for dead ends and loops.
- **Smooth Movement**
  Synchronizing motor speeds and controlling turns are crucial for maintaining stability, especially in tight spaces or sharp corners.
- **Sensor Accuracy**
  Ultrasonic sensors must deliver reliable measurements, and the servo motor must adjust sensor orientation precisely to scan different directions effectively.



System Model and Workflow

The robot is an integrated system of hardware and software components that work together to navigate a maze:

- **Ultrasonic Sensor**
  Measures distances to detect walls and obstacles ahead and to the right. It provides input data for decision-making.
- **Servo Motor**
  Rotates the ultrasonic sensor to scan at specific angles (e.g., front and right). This ensures accurate environmental sensing.
- **Microcontroller (Arduino)**
  Acts as the brain of the robot, processing sensor data and executing control logic to determine the robot's movements.
- **Motor Driver**
  Controls the DC motors that drive the wheels, enabling the robot to move forward, turn, or stop based on the commands from the microcontroller.
- **Chassis and Wheels**
  Provides the physical structure and mobility required for navigation.

The workflow that the robot uses is described below:

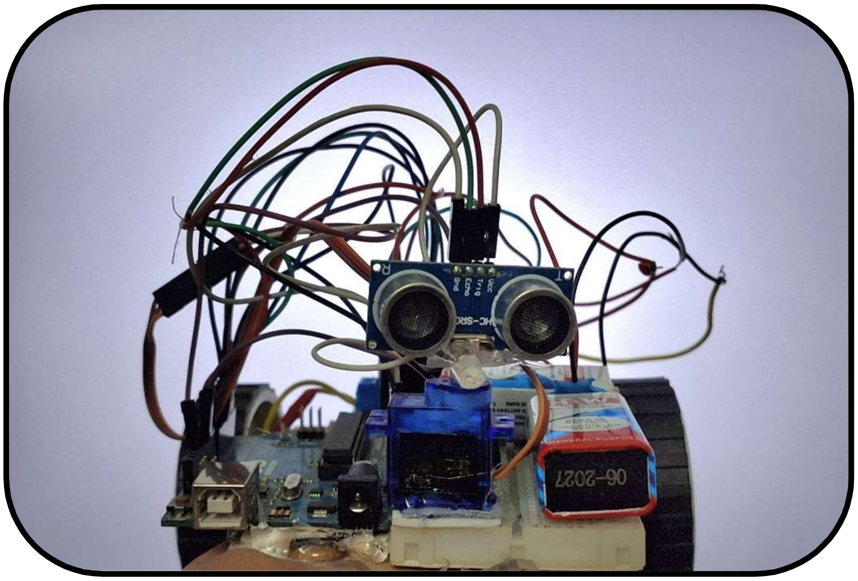
1. Sensor data is continuously collected and analysed by the microcontroller.
2. The control algorithm determines the robot's movement based on the maze's layout and obstacles.
3. Motor commands are issued to execute the chosen movement, adjusting the robot's position and direction accordingly.

Working Principle

1. **Initialization**
    - The robot initializes its sensors, servo motor, and motor drivers. The servo motor is set to its default position (facing forward).
2. **Sensing the Environment**
    - The ultrasonic sensor measures distances at various angles using the servo motor.
    - Data from the front and right is used to assess the presence of walls or obstacles.
3. **Decision-Making**
    - The robot applies the right-hand wall-following logic:
        - **Move Forward:** If no obstacle is detected in front and the right wall is present.
        - **Turn Right:** If the front is blocked but space is available on the right.
        - **Turn Left:** If the right wall and the front wall is present, indicating a need to adjust its course.
4. **Executing Movements**
    - Based on the decision, motor commands are issued:
        - **Forward Movement:** Both motors are powered equally.
        - **Right Turn:** One motor is stopped while the other continues.
        - **Left Turn:** Like the right turn, but in the opposite direction.
5. **Adjusting Position**
    - If the robot drifts too close or too far from the right wall, minor corrections are made to maintain an optimal distance.

6. **Continuous Operation**

   - The robot repeats the sensing, decision-making, and movement cycle until the maze is solved or a stopping condition is met.



Components Used

- **Ultrasonic Sensor –** This is used to detect walls and measure distances.
- **Servo Motor –** To rotate the ultrasonic sensor for directional sensing.
- **Motor Driver –** Controls the DC motors for movement.
- **Microcontroller (Arduino) –** Processes sensor data and executes navigation logic.
- **Chassis and Wheels –** Provides the robot's structure and mobility.
- **Miscellaneous –** Batteries, breadboard, connecting wires.

Result

The results we achieved were not entirely satisfactory, as the robot was unable to complete the entire maze autonomously. While it demonstrated the ability to navigate certain sections of the maze, it faced difficulties in handling more complex turns, dead ends, or adapting to unforeseen obstacles.

Despite these limitations, the project was a valuable learning experience, even if the performance fell short of full autonomy. These challenges have provided insights into areas that need improvement, such as refining algorithms, enhancing sensor accuracy, and optimizing decision-making processes. Although the robot didn't fully meet our expectations, it represents a meaningful foundation for future iterations and advancements.

Challenges Faced

- Despite numerous attempts and exploring multiple algorithms, we could not achieve the maze-solving robot's full potential.
- During the project, we encountered significant challenges with space management and struggled to integrate neatness into the robot's design, particularly with wire management.
- To improve accuracy, we focused on maintaining a reliable threshold distance. However, the robot often failed to accurately determine where to stop and resume its path, leading to inconsistencies in navigation.

Conclusion

The maze-solving robot effectively showcased autonomous navigation using a simple yet reliable wall-following algorithm. It highlights the potential of sensor-driven systems for real-world applications. Future improvements could include:

- Incorporating multiple sensors for enhanced accuracy.
- Optimizing pathfinding for faster maze traversal.
- Adapting the system for dynamic and unstructured environments.