An-Najah National University
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Graduation Project 2

RC Car

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I also want to extend my appreciation to our esteemed supervisors, Dr. Anas Toma, for their invaluable guidance and assistance in developing RC Car. I would also like to thank the Graduation Projects Committee for giving us the opportunity to work on this project and contribute to the creation of a tool that will benefit resturents and hotals. This experience has been a significant learning opportunity, and although we acknowledge that there may be room for improvement in the RC car, we remain optimistic that it will evolve into a valuable resource for the events industry, enhancing the happiness and satisfaction of its users.

I would also like to express my sincere gratitude to our families and friends for their unwavering love, encouragement, and patience during the long hours dedicated to this project.

Disclaimer

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Abstract

This project aims to develop an RC car to helps restaurants deliver orders to customers with greater accuracy and speed. The project is significant because it improves the ordering process for restaurants. By reducing the need for waiting the staff and enabling faster service, it improves efficiency and minimizes potential delays and errors that are common in traditional waiter-based ordering systems.We believe that the project should include room mapping, room auto-pilot for car movement without limitations, and an order handling system to continuous order management and customer delivery. In order to ensure smooth operation, it is necessary to ensure that the vehicle is fully functional during the development process. The next step is to map the room using the car. Once the mapping is completed, the vehicle will be equipped with a navigation system, allowing it to autonomously navigate the room using coordinates. Finally, a load system will be installed on the vehicle to effectively handle and fulfil customer orders.

Introduction

Developing an RC car for food delivery in restaurants and hotels is a complex task that involves addressing several critical factors before beginning construction. Key considerations include the vehicle's positioning, wheel configuration, and torque requirements. It is also important to select an appropriate motor drive circuit capable of supporting the car's components while maintaining mobility. Additionally, the vehicle must effectively integrate sensors to ensure accurate room mapping and navigation. These elements are crucial for creating a robust and efficient autonomous delivery solution that can enhance service speed and accuracy in modern dining establishments.

4.1 Problem

Robotics integration represents a major advancement in the complete automation of transportation systems. This development enhances efficiency and reliability, while simultaneously decreasing the necessity for a large workforce. As an example of this technological progress, my RC car has been specifically designed for food delivery within restaurants and hotels. Equipped with advanced features including ultrasonic sensors, color sensors, and an Arduino Mega controller, it provides a state-of-the-art solution for automating food delivery. By doing so, it greatly improves service speed and guarantees accurate delivery.

4.2 objectives

The objectives of the RC car project are to address the main challenges encountered by restaurants and hotels in their manual food delivery processes. Furthermore, our goal is to enhance the customer experience, increase operational efficiency and accuracy, and offer valuable insights to restaurant and hotel managers.

4.3 Scope of the Project

The scope of our RC car project is to develop a comprehensive robotic solution that addresses the challenges and goals outlined in the Problem Statement and Objectives sections. The project is designed to cater to the needs of restaurant and hotel managers, their staff, and customers. This includes ensuring seamless operation, and enhancing the overall food delivery process.

4.4 Importance

Our RC car project aims to optimize food delivery operations, automate tasks, and incorporate valuable features that boost the efficiency and success of restaurants and hotels. It offers the following benefits:

1. Automation of manual food delivery processes: Our RC car automates various aspects of food delivery, such as room mapping and order handling. This reduces the time and effort required for these processes and minimizes the need for human intervention. As a result, the system ensures smooth and timely delivery, enhancing overall operational efficiency.

2. Bluetooth control with manual drive: Our RC car includes Bluetooth functionality, allowing staff to manually control the car when necessary. This feature provides additional flexibility and ensures that the car can navigate complex environments or handle special delivery requests that require manual intervention.

3. Enhanced customer experience: Our RC car provides customers with a faster and more accurate food delivery service. By minimizing delays and errors commonly associated with traditional waiter-based systems, it guarantees a superior dining experience. This, in turn, encourages repeat business and customer satisfaction.

4. Improved efficiency and accuracy: By automating the food delivery process, our RC car enhances operational efficiency and accuracy, thus reducing the risk of errors and disruptions that could negatively impact service quality. Consequently, restaurants and hotels can consistently deliver a flawless experience to their clients.

4.5 Report Outline

The report is divided into seven phases. It starts with an introduction, which is followed by a thorough examination of constraints, standards, and codes. Next, we analyze previous coursework that is relevant to the project and highlight the main challenges we faced. The report also includes a chapter that carefully reviews the existing literature, as well as a chapter that outlines the methodology we used, including the various stages of project development and the tools and technologies we employed. Our results and discussion section gives a comprehensive overview of the obstacles we overcame and the achievements we made. Finally, the conclusion chapter presents recommendations and goals for future development.

Constraints, Standards and Earlier coursework

5.1 Constraints

1. Lack of Knowledge about ROS and Raspberry Pi:
   Due to our limited understanding of the Robot Operating System (ROS) and the complexities of integrating it with Raspberry Pi, we chose not to utilize LiDAR technology. Instead, we decided to use ultrasonic sensors for obstacle detection. While the ultrasonic sensors offer sufficient functionality, they do not provide the same level of accuracy and data richness as LiDAR.

2. Wheel Availability:
   One of the challenges we encountered was finding wheels that met the specific size and quality requirements for our RC car. This constraint affected the stability and maneuverability of the car, which necessitated making design adjustments to accommodate the available wheel options without compromising performance.

3. Bluetooth Device Sleep Mode:
   The Bluetooth device used for manual control of the RC car automatically enters sleep mode after a period of inactivity. This presented difficulties in maintaining a consistent connection for manual driving. To overcome this challenge, we utilized the serial connection of the laptop to directly send data to the Arduino Mega when the Bluetooth device enters sleep mode. This alternative approach ensured continuous communication and control, preventing any disruptions caused by the Bluetooth device's sleep cycle.

5.2 Standards

In this section of the report, we will analyze the engineering standards that were employed in the design process. This will provide you with a more comprehensive comprehension of the meticulous consideration given to each component. By integrating Arduino as the primary control unit and employing a diverse range of sensors and motors, our intention is to demonstrate our dedication to developing a resilient and intelligent robotic system.

Below are the engineering standards that are applicable to our project for designing a RC CAR:

1. Matrix Algorithm for Navigation:
   Our project utilizes an algorithm that treats the environment as a matrix, with specific node values representing different states:

   - 0: Not visited node
   - -1: Obstacle

- 2: Visited node
- 3: Goal location (e.g., delivery point)

2. Bluetooth HC-05 Communication Protocol:
We employ the Bluetooth HC-05 module for sending data and controlling the RC car:
   - Sending 'M' initiates manual control mode.
   - Sending 'U' activates auto-self-drive mode.
   - Sending '*' resets and stops the car.
3. Color Sensor Integration:
A color sensor is utilized to detect specific colors (e.g., red) in the environment, marking goal locations (3) within the matrix algorithm.
4. Pathfinding Algorithm - BFS (Breadth-First Search):
The RC car employs the BFS algorithm to navigate the matrix efficiently and locate the goal (3), ensuring optimal pathfinding and navigation.
5. Specific Movement Rules:
The algorithm follows predefined rules for movement, determining actions such as turning left, right, forward, or backward based on the current environment and matrix conditions.

5.3 Earlier coursework

We found it crucial to participate in various courses that greatly enhanced our knowledge and equipped us with the necessary skills to successfully finish this project. These courses included:

- mobile robot Movement
- Arduino Programming
- Breadth-First Search (BFS) Algorithm

Literature Review

Robotic delivery systems are gaining popularity in busy city areas, where speed and accuracy are crucial. These systems utilize sensors, navigation algorithms, and communication technologies to navigate complex environments and ensure timely delivery. By incorporating robots into restaurant and hotel operations, delivery times are reduced, errors are minimized, and the overall dining experience for customers is enhanced.

Alongside the increasing prevalence of delivery robots, there is a significant rise in consumer demand for convenience and personalized service in the hospitality industry.

Our Delivery RC Car project aims to provide a tailored solution for food delivery in restaurants and hotels. Equipped with Arduino-based control systems and ultrasonic sensors, our RC car can autonomously navigate dining environments by detecting obstacles. Bluetooth HC-05 technology enables seamless integration with existing restaurant operations, offering both manual and autonomous control modes to adapt to varying service demands.

While existing literature explores the benefits of robotic delivery systems in general terms, our project focuses specifically on the practical implementation and customization required for hospitality settings. By addressing challenges such as safely maneuvering around diners and effectively communicating with restaurant staff, our RC car aims to optimize delivery processes and elevate the dining experience for customers.

In summary, the integration of robotic delivery systems in restaurants and hotels represents a significant shift towards improving operational efficiency and customer satisfaction. Through innovative technologies and strategic implementation, projects like our Delivery RC Car aim to redefine the standards of food delivery in the hospitality industry, paving the way for future advancements in automated service solutions.

Methodology

7.1 Hardware parts :

7.1.1 Overview

In this section, we will discuss the hardware components that we have utilized:

- Arduino Mega
- Steper motor (NEMA 17)
- Four wheels
- Steper Motor Driver (TB6600)
- 3 Ultrasonic Sensor(HC-SR04)
- HC-05 Bluetooth Device
- Color Sensor (TCS3200)
- one switch
- Connecting wires
- 12V battery and 6V battery

7.1.2 Description

In this section, we will discuss the specific hardware components we utilized:

1. Arduino Mega
   The microcontroller has 16 analog inputs and 54 digital input/output pins, 15 of which can be used as PWM. It also features 4 UARTS and a Serial to USB connection.

Figure 7.1: Arduino mega 2560

2. Motors

   - Steper Motor Driver (TB6600)
     The TB6600 stepper motor driver is designed for bipolar stepper motors. It operates efficiently with voltages up to 42V and currents up to 4.5A. It supports microstepping up to 1/32 step for smooth motion control. It includes built-in protections against overcurrent and overtemperature for reliable performance. It is suitable for CNC machines, 3D printers, and robotics requiring precise and stable motor control.

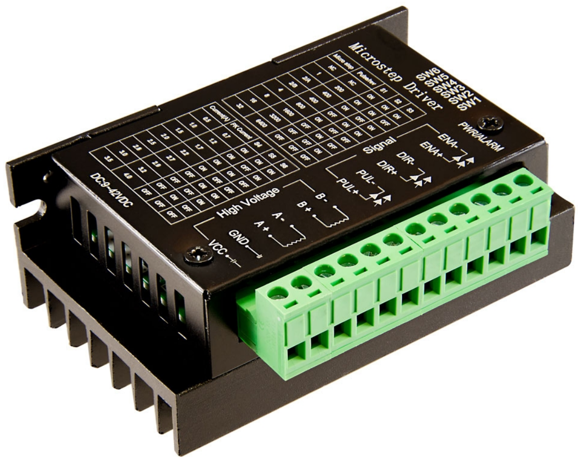


Figure 7.2: TB6600 Steper motor

- Steper motor
  The NEMA 17 stepper motor is known for its compact size and strong torque. It measures 42mm x 42mm and has a standard step angle of 1.8 degrees (equivalent to 200 steps per revolution). This motor is commonly used in applications such as 3D printers and CNC machines, where precise control and moderate torque are important.

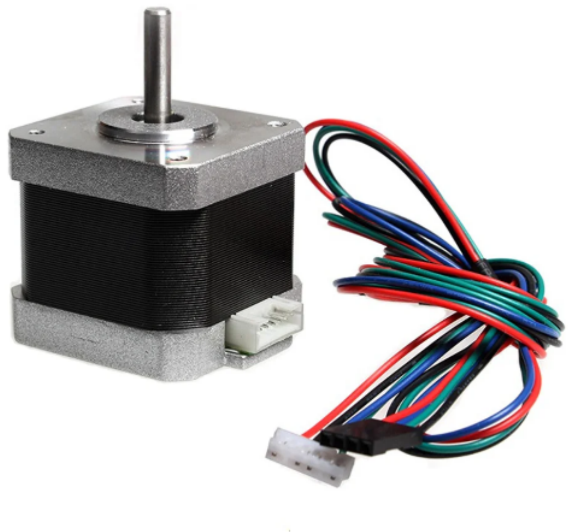


Figure 7.3: Steper motor (NEMA 17)

- Ultrasonic Sensor
  The HC-SR04 ultrasonic sensor is commonly used in robotics to measure distances. It emits ultrasonic pulses and accurately calculates distances ranging from 2cm to 400cm based on the time it takes for the echoes to return.

Figure 7.4: Ultrasonic Sensor(HC-SR04)

- Bluetooth
  The HC-05 Bluetooth module operates on Bluetooth 2.0. It is compact and widely used. It supports serial communication (SPP profile) and can function as a master or slave device. It has a range of up to 10 meters in open spaces.

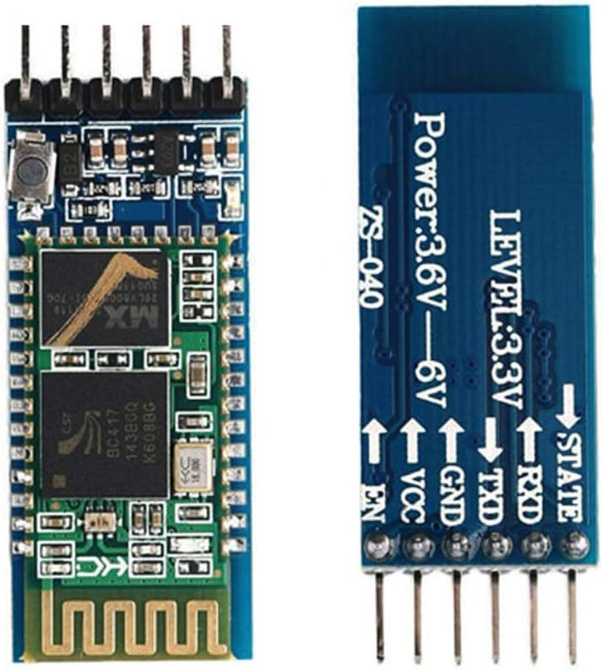


Figure 7.5: Bluetooth Device (HC-05)

- Color Sensor
  The TCS3200 color sensor is used in electronic applications for color detection. It detects light intensity across wavelengths using photodiodes and converts the data into frequency signals to identify colors. With an adjustable white LED for consistent lighting, the sensor can accurately distinguish various colors.

Figure 7.6: Color Sensor (TCS3200)

- wheels
  - Main wheels
    We used scooter wheels that fit the car model, and connect it with Steper motors.

Figure 7.7: Main wheels

  - Secondary wheels
    We used two caster wheels to help balance the car and make its movement easier.

Figure 7.8: Secondary wheels

- Switch's
  The switches used to provide power (5V) to the car.

Figure 7.9: Switch ON - OFF

- Batteries

  - 12V Battery
    We used a 12V battery with 8.5AH to power the motors.

Figure 7.10: 12V Battery

– 6V Battery
  We used a 6V battery to power the Arduino and other devices that require 5V.

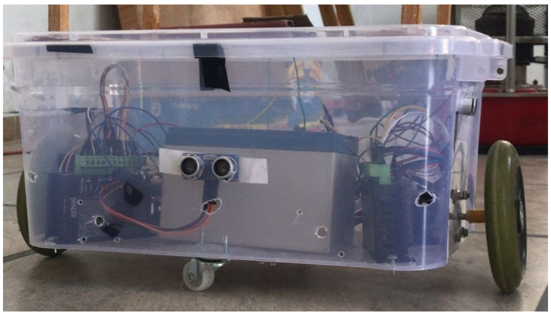
Figure 7.11: 6V Battery

7.1.3 Hardware Development

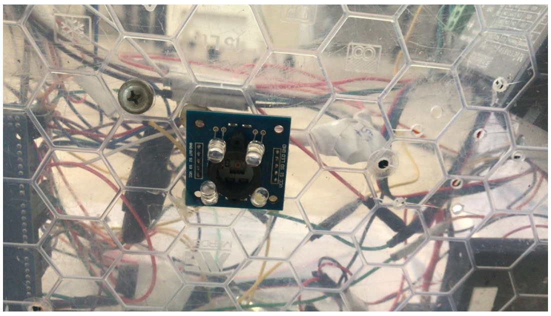
To build the car body, we began by creating the base for the car. Then, we connected it with the motors and ensured that it was well-balanced.Additionally, we attached the ultrasonic sensor, color sensor, and all other components to the car.

Figure 7.12: Body of the Car

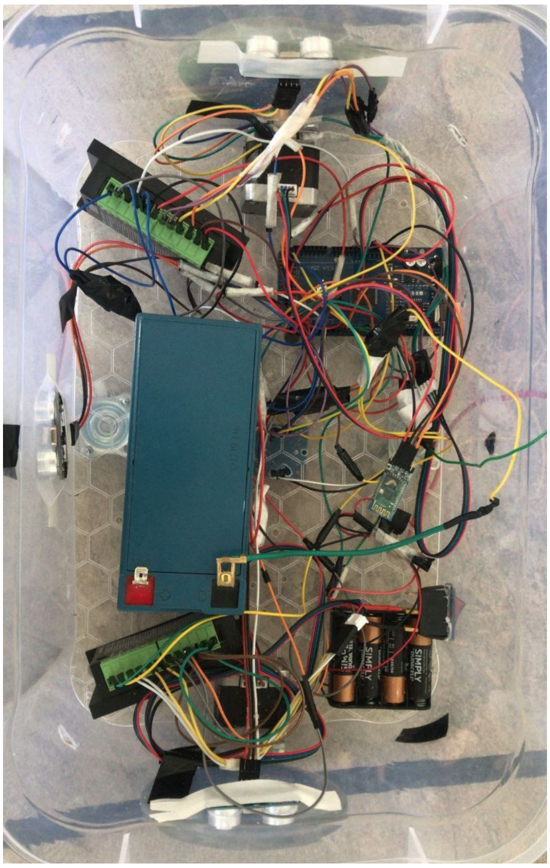
Finally, The final result for the Car as shown:



(a) The final result for Car



(b) The color sensor under the car



(c) The components of the car

7.2 Methods and techniques:

- This circuit for the RC car algorithm

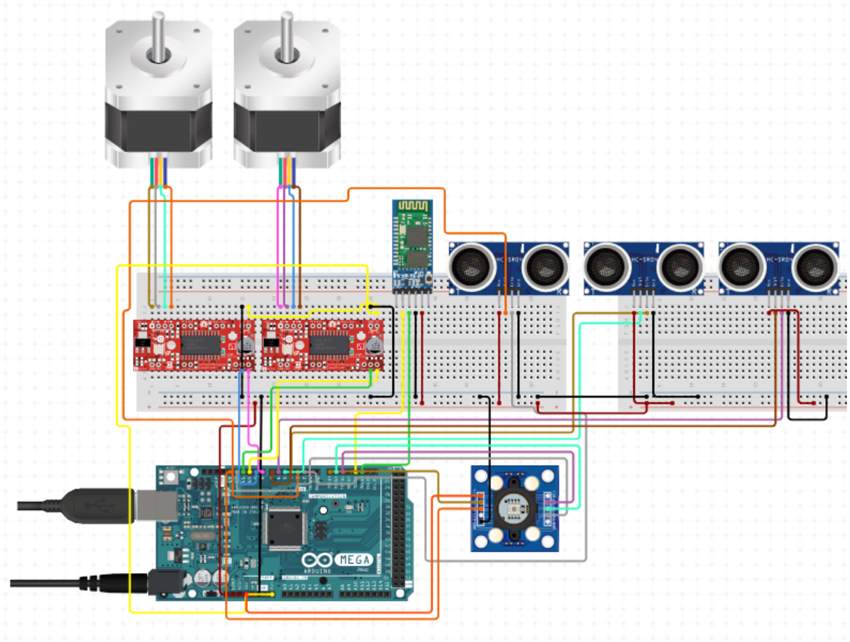


Figure 7.14: The Hardware components

- Overview: The algorithm we used is based on a matrix that matches the size of the room, as shown in Figure [7.15]. The starting point is located at (0,0) in the matrix. The car keeps moving until it reaches every node in the matrix, and then returns to the base node. The direction of the car is determined based on the matrix shown in Figure [7.15].

Start point (0,0)	Forward →		
RIGHT ↓			LEFT ↑
		← Backward	

Figure 7.15: Start Point and Car Direction in the matrix

The car gives the node in the matrix values while moving. In the beginning, all the matrix values are zeros. If the node is visited, give it a value of 2. If there is a wall, give it a value of -1.

The role of moving :

1. Case 1: Keep moving if there is no wall in front.

2	Car →	0	0
0	0	0	0
0	0	0	0
0	0	0	0

(a) Before move Forward

2	2	Car →	0
0	0	0	0
0	0	0	0
0	0	0	0

(b) After move Forward

2. Case 2: If there is a wall in front, move left.

	0		
	Car →	-1	
	0		

(a) Before move Left

	Car ↑		
	2	-1	
	0		

(b) After move Left

3. Case 3: If the car is at the edge.

↓ Car →	0	0	← Car ↓
0			0
0			0
↑ Car →	0	0	← Car ↑

Figure 7.18: Movement at the Edge

4. Case 4: If the wall is at the front, right, and left.

	-1		
	Car→	-1	
	-1		

(a) Before Turn

	-1		
← Car	2	-1	
	-1		

(b) After Turn

5. Case 5: Move right if the left visited.

	2		
	Car →	-1	
	0		

(a) Before move right

	2		
	2	-1	
	Car ↓		

(b) After move right

Now, if the color sensor detects the color red, the node value should be set to 3. Additionally, when the car finish move on all the matrix should return to the base using the BFS algorithm, which searches for the shortest path to the base.
And can the car back to the base by send to Bluetooth key '#'.

Here an example of the car movement with obstacle :

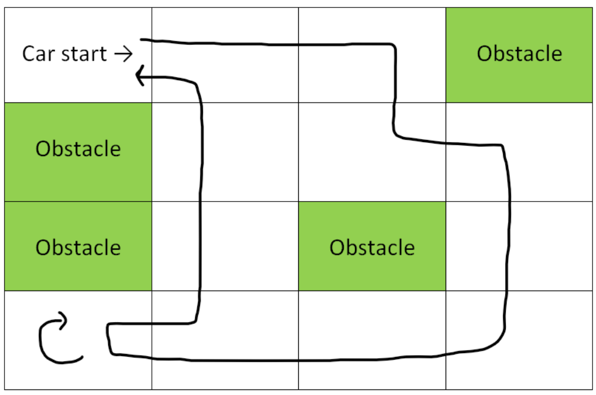


Figure 7.21: Example of car movement

Here an example of the car moving from base to the goal after find the shortest path.

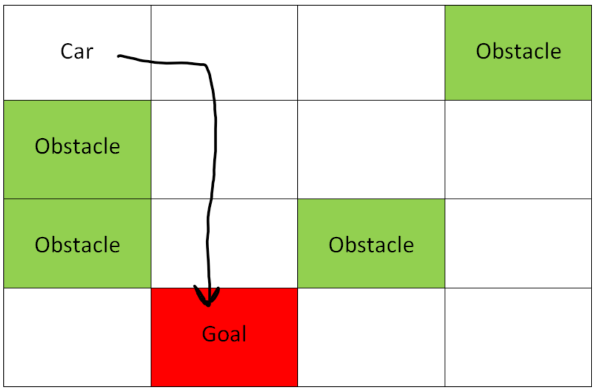
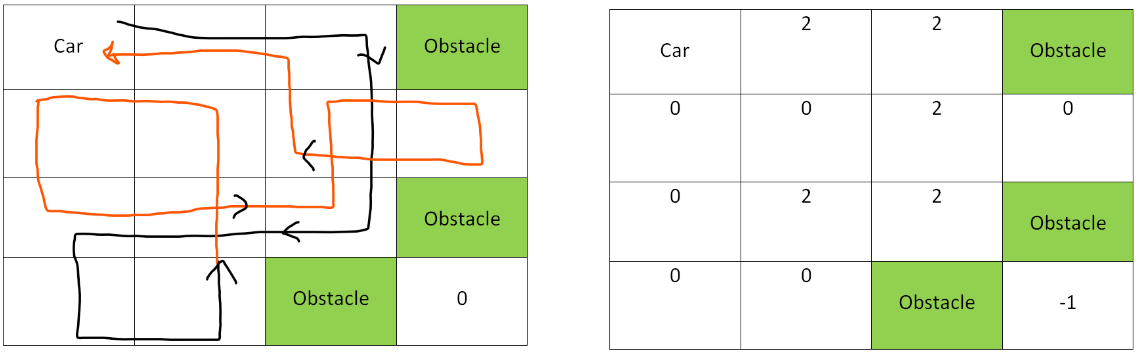


Figure 7.22: Example of car moving to goal

Special cases:

– If there is an unreachable node, assign it a value of -1.



(a) Before convert node to -1

(b) After convert node to -1

Result and Discussion

The delivery RC car project aims to revolutionize food delivery in restaurants and hotels by integrating hardware and software components. The car's success is evident in its ability to autonomously navigate dining spaces and deliver orders accurately and quickly.

Ultrasonic sensors detect obstacles, allowing the car to navigate safely in crowded areas. The Bluetooth HC-05 module enables seamless communication for manual and autonomous control modes, enhancing the car's operational flexibility.

The car's software algorithm includes a robust navigation system that uses a matrix-based approach to map rooms and determine the best routes to tables. This algorithm, similar to BFS (Breadth-First Search), enables the car to systematically locate and deliver orders while avoiding obstacles.

Challenges encountered throughout the project include sensor calibration and occasional connectivity issues, affecting the car's reliability in real-world scenarios. Despite these obstacles, the project has shown promising results in improving delivery efficiency and customer service in hospitality settings.

Looking ahead, future enhancements could involve integrating machine learning algorithms to optimize routes and interpret sensor data more effectively.

Conclusion and recommendations

The delivery RC car project was a valuable opportunity for our team to learn and develop new skills. We gained in-depth knowledge and expertise in various areas, including:

Hardware Construction: We gained expertise in the assembly and configuration of the various hardware components of the car, such as motors, sensors, and the Arduino Mega microcontroller. This practical experience played a vital role in our comprehension of the mechanics and electronics involved in autonomous vehicles.

Arduino Programming and Configuration: We have mastered the programming and configuration of the Arduino Mega through extensive experimentation and testing. This ensures optimal performance and seamless integration of various sensors and communication modules, such as the color sensor.

Sensor Integration: We have successfully integrated and calibrated ultrasonic sensors, which are essential for accurately detecting obstacles, measuring distances, and enabling reliable navigation in complex environments.

Vehicle Testing and Optimization: To achieve smooth and efficient vehicle movement, rigorous testing and refinement processes were conducted. This involved fine-tuning motor control, sensor responsiveness, and overall system reliability to meet operational requirements.

Future work

While the project to develop RC cars for food delivery has made significant progress in improving operations in restaurants and hotels, there are still several promising features that need to be explored and implemented for future enhancements:

1. Dynamic Path Adaptation:
   The goal is to develop algorithms that allow the car to adjust its delivery routes in real-time, taking into account various environmental factors like crowd density, obstacles, or changes in restaurant layouts, especially during peak hours.

2. Machine Learning for Path Prediction:
   By integrating machine learning algorithms, we can predict the optimal delivery paths by considering historical data, customer orders, and environmental conditions.

3. Enhanced Communication and Feedback Systems:
   Implementing a strong communication interface that enables smooth interaction between the car, restaurant staff, and customers. This interface could include features such as real-time order status updates, feedback collection, and customer interaction capabilities.

4. Advanced Sensor Technologies:
   Exploring advanced sensor technologies, such as lidar or advanced vision systems, to enhance obstacle detection, navigation precision, and operational safety in diverse and challenging environments.

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