An-Najah National University

Faculty of Engineering and Information Technology

Computer Engineering Department

Graduation Project 2

Underground Parking System

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Disclaimer

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Abstract

The system utilizes a crane mechanism to transport cars from a designated surface area to individual cells arranged in an N x M matrix configuration underground. The primary objective of this project is to provide a convenient and efficient parking solution for urban areas with limited surface parking space. The system includes an Admin web page that allows. The system automatically assigns an available cell for the car to park, optimizing space utilization and ensuring a parking space upon arrival. There will be sensors that are used to detect if there is a car that needs to park, and there sensors in each parking space (cell) to ensure that the car is parked successfully. The user will get a RFID card to park his car, also he will use this card to retrieve the car to the pickup point. The system will get the user car and park it in the closest empty cell, using this method, users can secure a parking space in advance without the need for specific criteria for selection.

1 INTRODUCTION

1.1 Statement of the problem

Due to the growing number of vehicles, urban areas are increasingly challenged by a lack of surface parking. Traditional parking options are unable to keep up with the demands of densely populated cities, which lead to traffic blocks, lost time. The ineffectiveness of the current parking systems also annoys users who are trying to find parking spaces. exact same steps for a certain test, enhancing the reliability and the efficacy of the process.

1.2 Objective

Our project aims to address the problem of limited parking in urban cities. To make parking simpler and more efficient, we designed an underground parking system with the use of a smart crane. Our top priorities are:

- Better Parking Space Use: By making the best possible use of the underground space, we hope to maximize the amount of space that is available.

- Quick Parking: As soon as you arrive, a system we're building will immediately locate a parking space for your car and park it. This eliminates the need to drive around looking for a parking spot.

- Easy Car Pickup: You can easily get your car back when you need it by using an RFID.

- Smart Parking Plans: We're using smart plans to decide where cars should park, making sure we use the space in the best way possible.

- Safety first: Safety is ensured through the use of sensors to verify successful parking.

1.3 Organization of the report

The first chapter is the introduction, where the definition of the problem and the objectives of the project

The second chapter is the Constraints, and Earlier coursework. This chapter shows the project's constraints and it shows how earlier coursework has been used in doing the project well.

After that, we have the Literature Review chapter.

The next chapter is the Methodology. This chapter explains the hardware components used in the project, the structure of the system, the mechanism, and the admin web page.

Then we have the Results and Discussion chapter which contains the final results of the project, and discussion of them.

The final chapter is the Conclusion of the project, what we learnt, and future work that can be done to the project.

2 CONSTRINTS, STANDARDS and EARLIER COURSEWORK

2.1 Constraints

Constraints Faced During Project Execution

Throughout the execution of our project, we encountered a significant constraint that had a bearing on the development process.

- Time Limitations: Given the scope of the project and the limited resources at our disposal, effectively managing our time became a crucial aspect of our approach. We needed to allocate our time judiciously across various project phases, encompassing research, design, implementation, and testing.

- Knowledge Gap and Research Challenges: As computer engineering students, we recognized a knowledge gap in certain mechanical areas that were integral to the project's success. This necessitated extensive research efforts to bridge our limited mechanical expertise and gain a comprehensive understanding of the relevant components.

2.2 Earlier coursework:

- Microcontrollers and PIC:

  In these courses we learnt how to deal with most of the hardware components especially in the labs.

- Critical Thinking and Scientific Research:

  In this course we got experience in making good reports and how to make an efficient researches.

- Networks and Wireless:

  This courses gave us the knowledge and the experience to make connection between several nodes and how to control the system using WiFi.

Overall, these courses provided us with the necessary knowledge and skills to successfully develop and implement our project.

3 LITERATURE REVIEW

To address urban parking challenges, our project focuses on utilizing underground spaces for parking solutions. Our research centers on implementing an automated crane mechanism within the underground parking system, optimizing space utilization and streamlining parking processes. By addressing challenges through microcontroller programming and mechanical principles, we successfully integrated smart control algorithms and sensors to ensure safe and accurate parking procedures. This project highlights the practical application of our knowledge in microcontroller technology and mechanics to enhance urban parking efficiency.

4 METHODOLOGY

4.1 Hardware components

Arduino mega:

It was used to control the system, receive commands and move other components accordingly.

Figure 4. 1: Arduino MEGA 2560

Esp8266:

It responsible for communication between firebase and the Arduino board it gets data from the firebase and send it to Arduino board via Serial.

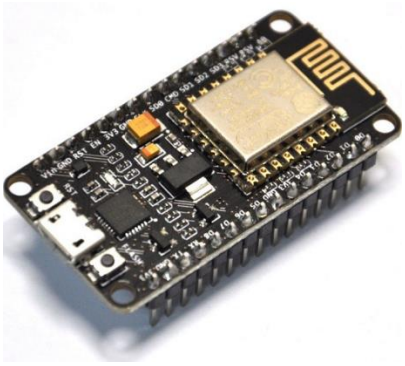

Figure 4. 2: ESP8266

Stepper motor:

There is two stepper motors in the system, one of them used to move the crane left and right in the x-axis and the other is used to move it upper and lower in y-axis.

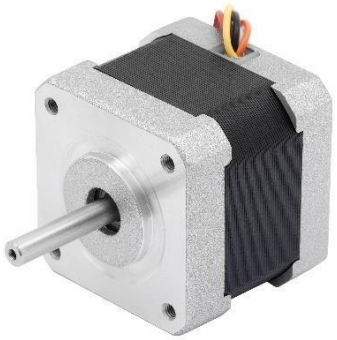

Figure 4. 3: Stepper motor

A4988 driver:

For each stepper motor we used an A4988 driver.

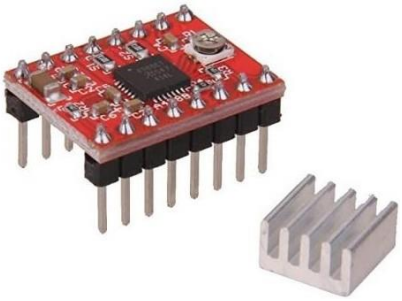

Figure 4. 4: A4988 Driver

CDROM with DC Motor:

This is used to implement the crane arm part, moving it inside and outside using the DC motor.

Figure 4. 5: CDROM

L298N H-Bridge:

It was used to control the DC motor in the CDROM.

Figure 4. 6: H-Bridge

Limit Switch:

Two limit switches was used to add reference for the system as an origin point in the axes.

Figure 4. 7: Limit Switch

DS1307-RTC:

It was used to get the time for user actions.

Figure 4. 8: DS1307-RTC

LCD:

It was used to show the user the state of car, time he came, duration that his car kept in the parking and the cost on him.

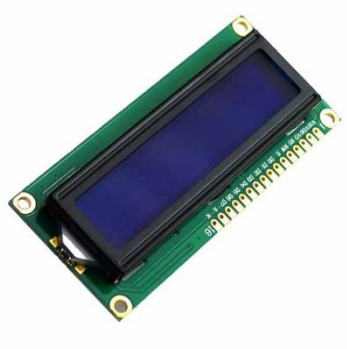

Figure 4. 9: LCD

I2C LCD Interface:

This is used to make an interface for the LCD to implement it easier with 2 pins only.

Figure 4. 10: I2C LCD Interface

RFID:

This is used give every user an id for his car to park and retrieve it.

Figure 4. 11: RFID

IR Sensor:

We have nine IR sensors in the system, each of them is used to know if there is a car in the parking space or not.

Figure 4. 12: IR Sensor

Multiplexer:

This is used to make the system more scalable that we implement nine sensors in one Arduino pin.

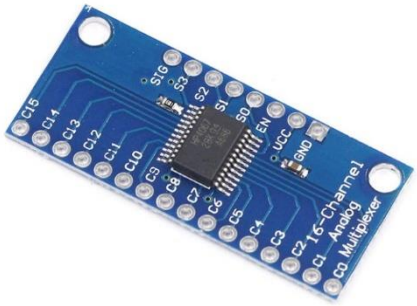

Figure 4. 13: Multiplexer

4.2 Structure

We've designed a way for our system to move in three dimensions, just like how we move in the real world (up, down, left, right, forward and backward), this movement help us to go from one parking space to another and retrieve cars. We take the idea of movement from the CNC machine.

The x-axis for moving left and right, z-axis for moving up and down we use screws and stepper motors to make this movement, also in y-axis we use a CDROM with its dc motor to take car and put it in the cell.

The main three components are:

1- X-axis:

2- Z and y axes:

3- The parking areas structure:

4.3 Sensors and Multiplexer (MUX) for Hardware Verification

Multiplexer (MUX): we added nine IR sensors to make sure that our system works smoothly, especially when parking cars. To make the best use of these sensors and not overload our control system, we use a multiplexer (MUX). It's like a switchboard that help us to connect and use several sensors effectively.

IR Sensors for Checking Parking: Inside each parking space, we placed an Infrared (IR) sensor. These sensors are like tiny eyes that check if there's a car parked in that space or not.

Real-time Hardware Checks: These IR sensors continuously send data to our control system, which is like the brain of our setup. This brain compares the real-world data from the sensors with what it expects to see based on its calculations.

Detecting Changes: We set up a system to catch any differences between what the sensors say and what the control system thinks should happen, Even if there's a tiny difference, we pay close attention.

Alerting the Admin: If our system notices anything unusual, like a car not parking right, it immediately notify to the person in charge. This quick response helps keep the parking process running smoothly.

4.4 Admin Web Page Interface

We created an admin web page to make it easier for the admin to deal with the system, he can easily know how many cars in the parking, move the crane arm to any parking space, park new car, return a car from the parking to the street and return the crane arm to the origin point.

In this figure we can see the admin web page contents as shown:

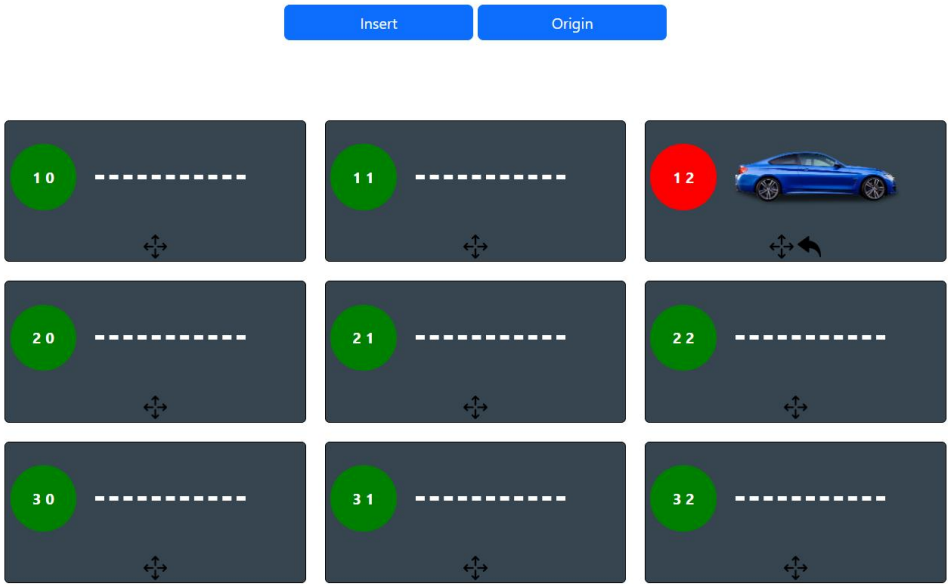

Figure 4. 14: Admin Web Page

As it is shown here there is two buttons in the top:

Figure 4. 15: Top buttons

The first button is “Insert”, it is used to give the admin the control to park a new car that is already in the above-ground parking space.
The second button is “Origin”, the admin can use it to move the crane arm to the origin point, which is the above-ground parking space.

Now we will see in the next figure how we implement the parking space when it is empty as shown:

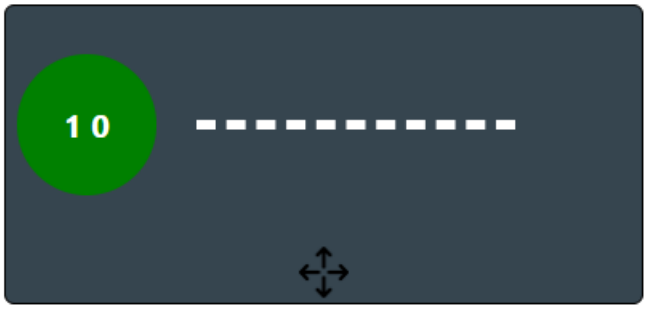

Figure 4. 16: Empty Parking Space

First we notice the green circle which indicates that is an empty parking space and the number inside it refers to the index of the cell.
We also notice the button “move” with the sticker which is let the admin to move the crane arm to the parking space that is the button inside it.

Now in this figure we will see the parking space when it is full as shown:

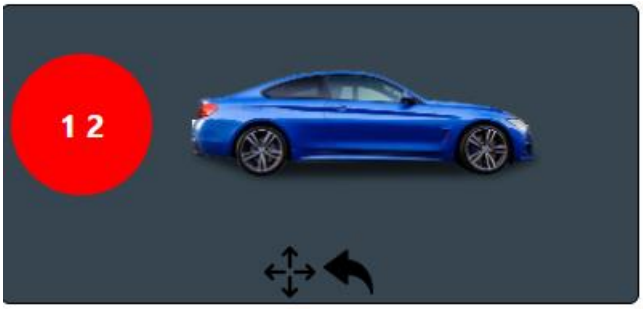

Figure 4. 17: Full Parking Space

As the opposite to the previous figure, the circle shows with red color which indicates it has a car inside it, also a car is shown in the cell to make it notice more.
As in the empty cell, there is a “move” button to move the crane arm only, but here there is a button which is exists only in the full cell that is responsible for returning the car to the above-ground parking space.

This page gives the administrator the flexibility to control the whole system in simple web page with good and easy design.

4.5 Mechanism of action

The Mechanism of Action: How Our Underground Parking System Works

Parking Your Car:

When a user arrives and wants to park his car, he drives to parking space on the road above the underground system.

Using the RFID Card:

The user uses his RFID card to activate our system. The crane system receives the signal from the RFID card and starts moving, it takes the car and put it in the closest empty parking space.

Car Retrieval:

When a user wants to leave and needs his car, he is simply use his RFID card once more.

Our system identifies the user's car in its assigned parking cell.

The crane system goes to that specific cell, picks up the car, and moves it back to the above-ground parking space.

Payment and Information:

While retrieving the car, an LCD display shows the user the duration his car has been parked underground. The system calculates the parking fee based on the time and displays the amount owed.

5 Results and discussion

Our underground parking system has exceeded expectations. It offers a straightforward solution for users, allowing them to effortlessly park and retrieve their cars using special cards. The robot arm within the system smoothly transfers cars between the street and the underground area, optimizing the utilization of space. This user-friendly approach, coupled with a clear display screen indicating parking duration and fees, has garnered positive feedback.

One notable feature of our system is the integration of sensors for hardware verification. These sensors play a crucial role in ensuring that cars are successfully parked. They add an extra layer of reliability to the process.

This project directly addresses the parking challenges commonly experienced in urban areas, showcasing its potential to alleviate congestion and parking woes. Looking ahead, we're committed to making it even better. We're exploring ways to enhance security and payment options to make the system even more accessible and beneficial for urban communities. The success of our underground parking system during our college journey underscores its practical value.

6 Conclusion

The underground parking system, is a promising solution for city parking challenges. It's easy to use with special cards, and people find it convenient. We've made it even more reliable by using sensors. We're committed to making it even better by adding more security and payment options. This project shows our dedication to solving real problems with smart technology, and we're excited about its potential for cities.

6.1 What we have learnt:

1. Using Arduino to control our system.
2. Make actions using Esp8266 (WIFI).
3. How to build a full design hardware and software.

6.2 Future work:

1. Add reservation feature to let the user reserve his parking space before he comes.
2. Add payment process.
3. Make a mobile application for the user.