An-Najah National University

Faculty of Engineering information technology

Department of computer Engineering

Graduation Project 2

Vertical Car Parking

Accomplished By

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Presented in partial fulfillment of the requirement for Bachelor degree in Computer Engineering

Acknowledgment :

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Disclaimer Statement:

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Contents

Chapter 1

Abstract:

"Vertical Car Parking" offers an innovative solution to vertical parking, using a rotating platform system to move and park cars vertically inside the parking tower.

The project aims to provide an effective parking solution and save time searching for an empty space, utilizing space to park the largest possible number of cars in a small space, while ensuring safe access control through RFID cards, allowing drivers to park their cars and retrieve them easily.

Chapter 2

Introduction

2.1 Problem:

As the number of people owning cars continues to rise and available land and empty spaces for parking become scarce, finding a vacant parking spot while ensuring security has become increasingly challenging. This dilemma often leads to wasted time and frustration in searching for parking spaces. Additionally, the option of purchasing large expanses of land to accommodate numerous cars has proven to be impractical for many due to financial constraints and limited availability of suitable locations.

In response to this growing issue, the concept of vertical parking structures has emerged as a viable solution. Vertical parking facilities involve stacking cars in a vertical arrangement, allowing for the efficient utilization of limited space. This innovative approach not only maximizes parking capacity but also addresses the scarcity of horizontal space for conventional parking lots. By adopting a vertical parking system, multiple cars can be parked in the same footprint that would traditionally accommodate only one vehicle.

2.1 Objective:

The objective is to address the challenges arising from the surge in the number of cars and the limited availability of parking spaces. The goal is to optimize the use of constrained space by introducing vertical parking structures, offering a viable alternative to conventional parking approaches. These structures involve stacking cars vertically, aiming to maximize parking capacity. The implementation of vertical parking structures is intended to alleviate congestion, provide practical and convenient parking solutions, and promote efficient land use in urban environments.

2.2 Scope of the Work:

The scope of this project encompasses the design, development, and implementation of a Vertical Car Parking system. The key components and functionalities include the Parking Access System, Parking Exit System, Rotary Platform, Display Screen, Base Rotation, and Checking Card mechanism. These elements collectively form an integrated solution to efficiently manage parking within a limited space.

Parking Access System: Utilizes RFID card technology for secure access control.
Deducts parking fees electronically upon entry.

Parking Exit System: Incorporates an IR sensor to detect the presence of a vehicle for smooth exit operations.
Automatically opens the parking gate upon sensing a vehicle.

Rotary Platform: Employs a NEMA23 motor and driver for precise movement of elevators within the vertical parking tower.
Ensures efficient parking and retrieval, optimizing space usage.

Display Screen: Utilizes an LCD display to provide real-time information on the availability of parking spaces.
Indicates the number of full and empty elevators to assist drivers before entering.

Base Rotation: Implements a roundabout at the exit to rotate and direct the car towards the exit.
Enhances the flow of vehicles and facilitates a smooth exit process.

Checking Card: Verifies the RFID card for sufficient funds.
Generates a buzzer sound in case of insufficient funds.

KeyPad for the Admin: Enables the parking lot owner or administrator to access the system using a keypad.

Requires entry of a secret code for authorization, offering an alternative to RFID cards.

The project aims to create a comprehensive and automated vertical parking solution that not only maximizes parking capacity but also ensures convenience, safety, and effective utilization of space. The integration of modern technologies such as RFID cards, IR sensors, and LCD displays contributes to a seamless and user-friendly parking experience.

2.3 Significance:

The Vertical Car Parking system is significant due to:

Space Optimization:

- Efficiently uses limited space in urban areas.

Increased Parking Capacity:

- Accommodates more vehicles compared to traditional lots.

Time Efficiency:

- Streamlines parking and retrieval processes, saving time for drivers.

Convenience for Drivers:

- RFID card system simplifies entry, enhancing user convenience.

Financial Savings:

- Reduces land acquisition and maintenance costs.

Security and Access Control:

- Ensures secure access with RFID cards, enhancing overall safety.

Technological Advancements:

- Showcases commitment to modernizing urban infrastructure.

Environmental Impact:

- Preserves green areas, aligning with sustainable development goals.

Promotion of Efficient Land Use:

- Supports smart city principles and efficient land utilization.

User-Friendly Experience:

- Integrates user-friendly features for both drivers and administrators.

Chapter 3

Constraints and Earlier Coursework:

1. Constraints & Limitations:

- The challenges we faced in the implementation of infrared (IR) technology were attributed to the system's susceptibility to ambient light, creating difficulties in achieving optimal functionality.
- The light-dependent resistor (LDR) posed challenges in our project, particularly due to its susceptibility to variations in ambient light conditions, impacting the optimal functioning of infrared technology within the system.
- We also had difficulty finding a serrated belt that applies to the Sprockets, and also a suitable Coupler for the motor.

2. Earlier Coursework :

The development of the Vertical Car Parking system draws upon knowledge and skills gained through earlier coursework. Previous academic studies have provided foundational understanding in various areas relevant to the project. Key aspects of earlier coursework include:

Digital Systems and Microcontrollers:

Overview: Covered fundamental principles of digital systems and microcontroller programming, laying the groundwork for embedded systems design.

Embedded Systems Design:

Overview: Explored the design and implementation of embedded systems, emphasizing the integration of hardware and software components.

Control Systems and Motors:

Overview: Studied control systems and motor mechanisms, providing insights into the principles governing precise movements and positioning.

Sensor Technologies:

Overview: Examined different sensor technologies, including infrared (IR) sensors, and gained an understanding of their applications and limitations.

Programming with Arduino:

Overview: Acquired practical skills in programming microcontrollers, with a specific focus on the Arduino platform.

Understanding earlier coursework forms the basis for the successful development of the Vertical Car Parking system, ensuring that theoretical knowledge is translated into practical solutions. The interdisciplinary nature of the coursework contributes to a holistic approach in addressing project challenges and requirements.

Chapter 4

Literature Review:

The literature review for the Vertical Car Parking system involves an in-depth exploration of existing research, projects, and technologies related to vertical parking solutions. This comprehensive review provides valuable insights into contemporary trends, innovations, and challenges within the field. Key aspects covered in the literature review include:

Current Trends in Parking Solutions:

- *Analysis:* Examined recent developments and innovations in parking management systems, with a focus on vertical parking structures.
- *Significance:* Identifying current trends informs the project design, ensuring alignment with industry advancements.

RFID Access Control Systems:

- *Review:* Explored the utilization of RFID technology in access control systems for parking facilities.
- *Significance:* Understanding RFID systems enhances the security and efficiency of access control within the Vertical Car Parking system.

Motorized Parking Systems:

- *Analysis:* Investigated existing motorized parking systems, evaluating key components and mechanisms for efficient vertical parking.
- *Significance:* Learning from existing motorized systems informs the selection of components for precise and reliable elevator movements.

User Interfaces in Parking Solutions:

- *Review:* Explored user interface designs in parking systems, emphasizing the importance of clear communication and ease of use.
- *Significance:* Designing an intuitive and user-friendly interface contributes to a

positive user experience for drivers and administrators.

Integration of Sensors in Parking Facilities:

- *Analysis:* Examined the role of sensors, including IR sensors and LDR sensors, in enhancing the safety and functionality of parking structures.
- *Significance:* Implementing sensor technologies contributes to efficient and secure vehicle detection and monitoring.

Parking Space Optimization Strategies:

- *Review:* Explored strategies for optimizing parking space, especially in urban environments where space is limited.
- *Significance:* Maximizing space usage is a key objective of the Vertical Car Parking system, making insights from optimization studies crucial.

The literature review serves as a foundation for the Vertical Car Parking project, offering a comprehensive understanding of existing technologies and methodologies. This knowledge informs design decisions, helps address potential challenges, and provides a basis for innovation within the project. The synthesis of information from various sources contributes to the development of a robust and effective vertical parking solution.

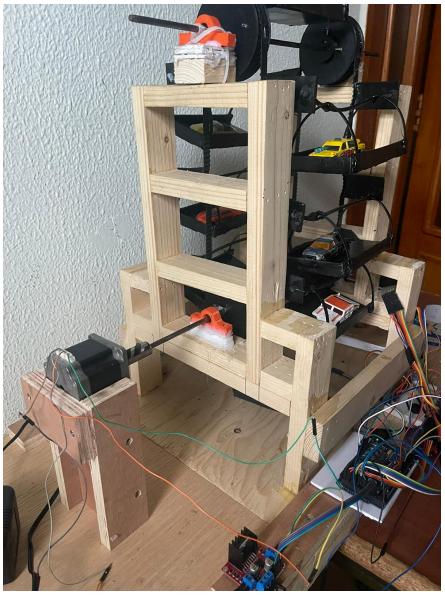
Chapter 5

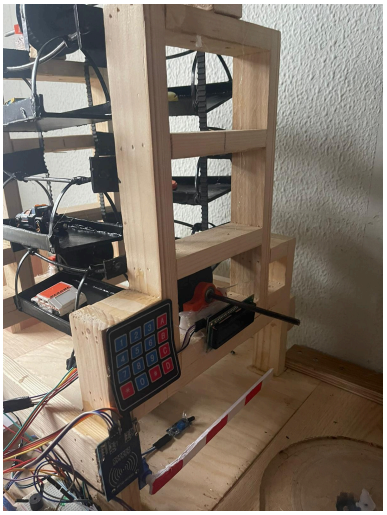
Methodology

5.1 System Architecture

The base :

The vertical parking structure consists of four toothed rollers two on each side, with two rollers vertically connected to each other through toothed skimming. The side rollers are connected to a 6mm iron rod. The bottom rail is driven by a NEMA23 motor, facilitated by the use of a coupler for connection.





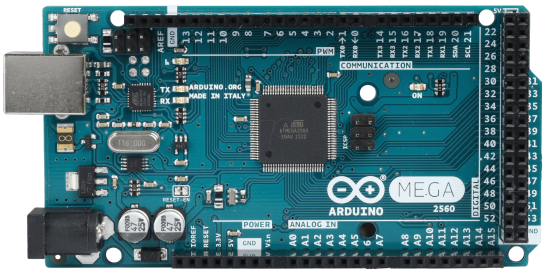
The Elevators:

The vertical parking structure consists of eight elevators, three elevators on each side, one elevator at the top and another on the floor. Each elevator unit consists of a floor and a shelf that supports the elevator, which are securely mounted on the toothed scraper. This arrangement facilitates clockwise and counterclockwise rotation of the lifts for efficient parking and retrieval.

5.2 Processing units and used devices

12. Arduino Mega :

One of the most important components of our project, the Arduino is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins, 16 analog inputs, 4 UARTs, It contains everything needed to support the microcontroller.



13. Towerpro Servos SG90 :

We used 2 Towerpro Servos SG90 one used it to control the opening and closing of the gate, and second servo we used it to move the roundabout for the car to exit safely and smoothly.

14. Power Supply:

We used the power supply for the motor with 12 volts

15. L298n Motor Driver:

is a popular dual H-bridge motor driver integrated circuit (IC) used to control DC motors(we use it with Stepper Motor NEMA23)

16. Stepper Motor Nema23:

We used it to move the system in a rotational motion

17. IR Sensor :

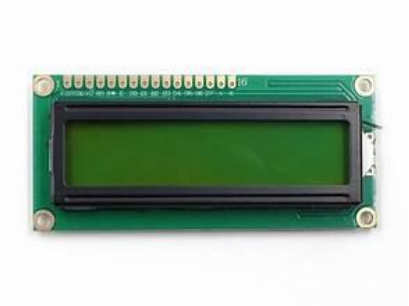
We used it to sense movement, so that during the exit process, when there is a body in front of it, it keeps the gate open until the vehicle exits safely. When entering, the gate opens, and when the body is in front of it, it closes the gate.

18. KeyPad :

The admin uses it to enter the parking via a secret number.

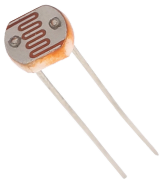
19. LCD 16*2:

It was used to print welcome and departure phrases, in addition to displaying the number of available and full elevators.



20. LDR Sensor:

It was used to sense the car above the roundabout.



21. RFID-RC522:

Every driver carries a card containing a certain balance of money. When entering,

the driver inserts the card in order to reserve his own elevator and pay a certain amount of money. When exiting, the driver uses the same card in order to return the elevator that was previously reserved.

22. Buzzer:

It is used to issue an alert sound when the inserted card is insufficient.

23. Breadboard:

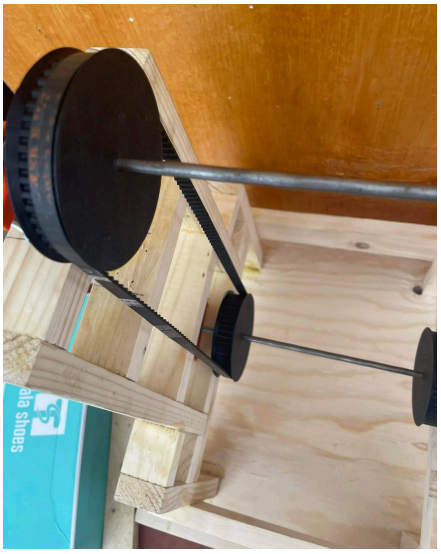
The Breadboard is used in the fields of electronics and programming to temporarily assemble and connect electronic components without the need for soldering.

24.Sprockets:

We designed the rollers by 3D printing to match the design.

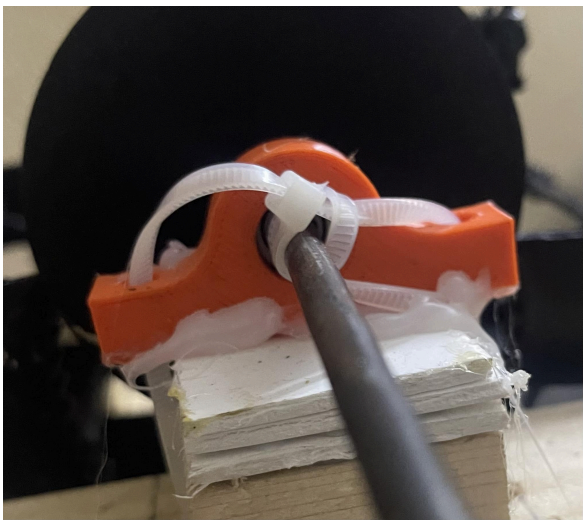
25.Belt serrated:

We used it to fit the reel sprockets



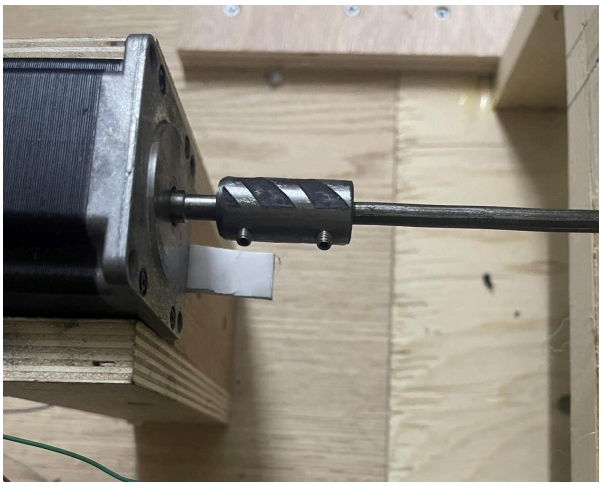
26.Hanger:

We designed the Hanger by 3D printing to match the design.



27.Coupler :

We utilized the Coupler to refer to the component that facilitates the connection between the motor shaft and the iron rod with attached sprockets.



5.3 How does the system work?

When the first vehicle arrives, the driver inserts the card. The system checks the card balance if it is sufficient or not. If it is not sufficient, an alert sound sounds and the system does not allow entry to that vehicle. If it is sufficient, a welcome message is displayed on the LCD and the gate opens. There is the first elevator waiting. You enter the vehicle and the driver parks it inside the elevator. Meanwhile, the gate is closed for safety and security. When the driver wants to exit, the IR sensor sees him and then opens the gate again in order to get him out. Then the number of full elevators and the number of empty ones is displayed on the LCD. When the second vehicle arrives, the same steps are performed, except that the difference is that when the system reads a different card, it lowers the nearest empty elevator in order for the next vehicle to enter, and so on. When the driver returns. In order to take his vehicle, he enters his card again, but this time without withdrawing the balance, and the phrase “Welcome Back” appears. Then the system recognizes the elevator that carries this card number and then descends the elevator in the closest way (Shortest Path), by calculating the number of steps and Follow the path with the fewest steps in order to save time and energy. When the vehicle exits, the mobile rotor, when it senses that the vehicle is in the right place, turns 180 degrees for a comfortable and easy exit. When all the elevators are full, and another vehicle arrives, the system displays The LCD shows that the parking is full and the gate never opens again.

When the admin arrives at the parking , whether he wants to enter or performs maintenance in the parking lot , he can enter the parking lot without using the card and deduct an amount of money. He can enter his secret code on the keyPad and then the gate opens.

5.4 Semantics for the project:

In the context of the "Vertical Car Parking" project, semantics refer to the meaning and interpretation of various components and actions within the system. Understanding the semantics is crucial for ensuring the proper functioning, communication, and interaction between different elements. The following points elaborate on the semantics of key project aspects:

RFID Card Access:

Semantic Interpretation: The RFID card serves as a secure digital key granting access to the parking facility.

Significance: Ensures authorized entry and contributes to a streamlined user experience.

NEMA23 Stepper Motor:

Semantic Interpretation: The NEMA23 motor is the driving force behind elevator movement, facilitating efficient vertical parking.

Significance: Enables precise control, optimizing space usage and retrieval processes.

IR Sensor for Exit:

Semantic Interpretation: The IR sensor detects the presence of a vehicle during exit, triggering the gate to open.

Significance: Enhances safety and ensures smooth exit operations.

TowerPro Servos SG90:

Semantic Interpretation: TowerPro Servos control gate opening and closing, as well as the rotation of the roundabout for safe exit.

Significance: Contributes to the overall reliability and user-friendly operation of the entry and exit processes.

LCD Display:

Semantic Interpretation: The LCD display provides real-time information on the availability of parking spaces.

Significance: Enhances user communication, allowing drivers to make informed decisions before entering the parking facility.

Checking Card Mechanism:

Semantic Interpretation: Verifying the RFID card for sufficient funds and triggering a buzzer if funds are insufficient.

Significance: Ensures financial transactions are valid, preventing unauthorized entry in the case of insufficient funds.

KeyPad for Admin:

Semantic Interpretation: The keypad provides an alternative entry method for the parking lot owner or administrator.

Significance: Offers an additional layer of security and access control for administrative purposes.

Breadboard Usage:

Semantic Interpretation: The breadboard serves as a temporary platform for assembling and connecting electronic components during prototyping.

Significance: Facilitates flexibility in testing and modifying the system without permanent connections.

Chapter 6

6.1 Results & Discussion

3. Results :

The implementation of the Vertical Car Parking system has demonstrated several key functionalities, contributing to its effectiveness and usability. Some noteworthy results include:

Successful RFID Access Control:

The RFID card access system effectively controls entry, ensuring secure and authorized parking for users.

Efficient Elevator Movement:

The NEMA23 stepper motor-driven elevators showcase efficient and precise movement within the vertical parking tower.

Real-time Information Display:

The LCD display provides real-time information on the availability of parking spaces, enhancing user experience.

Smooth Gate Operation:

The TowerPro Servos SG90 contribute to smooth gate operations, ensuring a secure and reliable entry and exit process.

4. Discussion :

The successful integration of various components, such as the Arduino Mega, L298N Motor Driver, and RFID-RC522, highlights the system's robustness. Challenges faced during implementation, such as sensor accuracy and system responsiveness, were addressed through careful calibration and programming adjustments.

The utilization of modern technologies, including IR sensors, LDR sensors, and RFID cards, enhances the overall functionality and security of the Vertical Car Parking system. Additionally, the inclusion of a keypad for administrative access adds an extra layer of control.

Chapter 7

7. Conclusion & Future Work

1. Conclusion:

In conclusion, the Vertical Car Parking system has proven to be an innovative and effective solution for optimizing parking space in urban environments. The successful implementation of key features, including RFID access control, elevator movement, and real-time information display, establishes the system as a viable parking management solution.

The collaboration between Leen Zaher Sharaf and Lana Atabeh, under the supervision of Dr. Abdallah Hasan Rashed, has resulted in the successful development of a functional prototype. The project aligns with the objectives of providing a convenient, secure, and space-efficient parking solution.

2. Future Work:

Enhanced Security Features:

additional security measures, such as integrating advanced encryption protocols for RFID cards, to further enhance access control.

Smart Parking Analytics:

Implement data analytics to gather insights into parking patterns, peak hours, and user preferences, contributing to smarter parking management.

Mobile Application Integration:

Develop a mobile application to provide users with real-time parking availability, reservation options, and payment functionalities for a seamless experience.

Environmental Sustainability:

Investigate the integration of eco-friendly technologies, such as solar power for the system's energy needs, aligning with sustainable practices.

Scaling for Larger Deployments:

Consider scalability for larger parking lots, evaluating the system's performance and making necessary adjustments to accommodate increased demand.

By addressing these areas in future work, the Vertical Car Parking system can evolve to meet evolving user needs and contribute to advancements in urban parking management.

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