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Vertical rotation parking using Radio Frequency Identification (RFID) based on Microcontroller

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ABSTRACT

The vertical parking system is an innovative solution to optimize limited parking space, especially in urban areas. This research developed a prototype of a vertical rotation system based on Arduino Mega, which utilizes a DC motor as the rotational foundation of a gear chain mechanism to move the parking slot vertically. This system is also equipped with an ultrasonic sensor to detect the car's position, RFID as a user identification card, and a keypad to manually open the parking slot and car portal. For power stability, two step-down modules are used: one to supply the DC motor and another for the Arduino Mega, to avoid voltage surges and ensure the system runs optimally. The Arduino Mega acts as a control center that integrates all components and the system's working logic. Test results show that the system is able to quickly identify users, stop the slot rotation with high accuracy using an ultrasonic sensor, and maintain system stability through precise voltage regulation. This system offers an automated, efficient, and safe approach to vertical parking for users.

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1. INTRODUCTION

Technological advances in the transportation sector demand innovation in more efficient and modern parking systems [1],[2]. The increasing number of vehicles has led to limited parking space, especially in dense urban areas and public places such as shopping centers, offices, airports and entertainment venues [3]-[5]. Conventional parking systems often result in congestion and suboptimal land use. Conventional parking systems are unable to overcome these problems, so a more effective solution is needed.

One solution that can be implemented is a vertical parking system, which is able to increase the efficiency of land use by arranging vehicles in tiers [6]. In addition, the use of RFID (Radio Frequency Identification) in the parking system can facilitate the process of identifying vehicles quickly and accurately without requiring direct contact, so that it can speed up the parking process and reduce waiting time and increase security [7]-[9]. The use of microcontrollers in the parking system also allows the system to work automatically without significant manual intervention, making this system more reliable and efficient [10]. Vertical rotation parking is designed to maximize land use by arranging vehicles in a tiered manner. This system works with a rotating mechanism that automatically adjusts the position of vehicles according to the available slots [11]. With a more complex design, this system can accommodate more vehicles than conventional parking. The use of a microcontroller in this system allows for more precise control of mechanical movements and RFID (Radio Frequency Identification) readings [12],[13]. The microcontroller will process data from RFID to identify vehicles and determine available parking slots. In addition, the system can be equipped with additional sensors to increase security and prevent operational errors [14].

Thus, the implementation of this system can improve efficiency and security in parking management. The development of a vertical rotation parking system based on RFID and a microcontroller is expected to be an innovative solution to modern parking problems [15]. This technology not only optimizes land use but also reduces the time required for parking. In addition, this automated system can reduce dependence on human labor, making it more practical and economical. Therefore, this study aims to design and build a vertical rotation parking control system that uses technology to facilitate the process of parking and retrieval of vehicles. This system will reduce waiting time and minimize the risk of losing vehicles.

2. METHOD

The block diagram shown in Figure 1 illustrates a microcontroller-based automated parking system consisting of a number of integrated input and output components. The RFID component serves as a vehicle identification tool, enabling the system to recognize incoming or outgoing vehicles by reading the RFID card carried by the user. To complement the authentication system, a keypad is also provided, allowing users to manually enter data, such as additional access codes. The electrical voltage to drive the DC motor is controlled by a step-down regulator component, which lowers the voltage from the main power source to match the motor's operational needs and allows the system to precisely stop movement, especially when the vehicle approaches a designated parking position. The microcontroller acts as the system's control center; it receives data from sensors such as RFID, keypads, and ultrasonic sensors, then processes it to control actuators and other output devices. System information, including parking slot availability, is displayed on an LCD to facilitate user interaction. Vehicle movement in the rotational parking system is controlled by a DC motor that drives a chain or gear, while a servo motor is used to automatically open and close the parking gate based on card readings and slot availability. Visual indicators such as LEDs signal the user about the system's status, whether access is permitted or denied, while a buzzer serves as an audible indicator to alert users in the event of an operational error. To ensure accurate vehicle stopping, the system is also equipped with an ultrasonic sensor that measures the vehicle's distance from the parking endpoint. With the integration of all these components, the automated parking system can function efficiently and precisely, reducing the need for manual intervention. Figure 1 show the diagram block of proposes vertical parking. This parking system is designed as a prototype consisting of eight parking spaces arranged in a vertical rotation using steel.

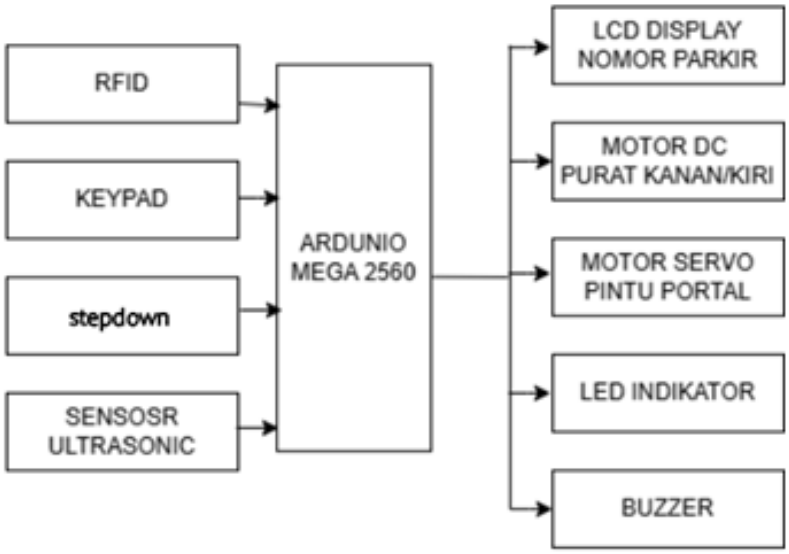
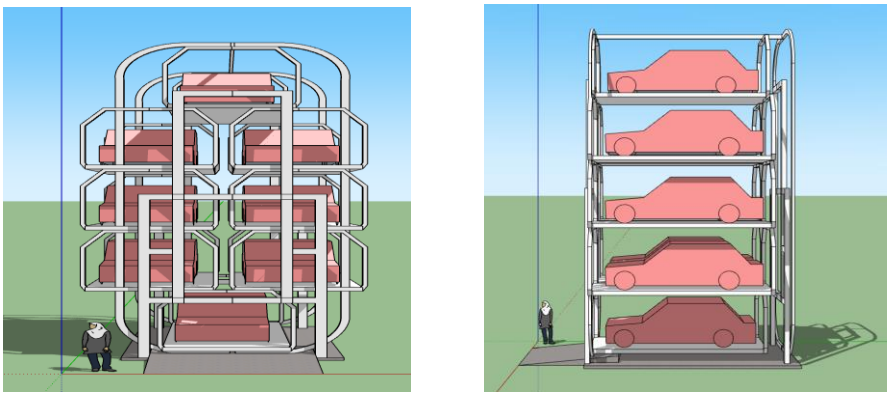


Figure 1. Diagram block of proposes vertical parking

The mechanical form is shown in Figure 2. Vertical parking system is equipped with two on/off buttons that function to flow voltage to the entire system, including a microcontroller, ultrasonic sensor , LCD, DC motor, servo motor, driver module, RFID, and I2C module, with one adapter or power supply as the main power source. The Arduino Mega microcontroller is used as the brain of the control system that initializes the input and output ports to regulate the work of all components in the automatic parking system.



(a) (b)

Figure 2. Mechanical design (a) front view (b) side view

The input in this system consists of RFID TAG with 8 cards, each of which has a unique ID as entry access, a number keypad for selecting the parking card ID number, and an ultrasonic sensor that detects the presence of the vehicle. As an output, a DC motor is used as the main mechanical drive with a gear chain to move the parking space up and down, as well as a servo motor that functions as an additional feature driver. For information display, this system is equipped with an LCD connected to the Arduino Mega, which displays the number of the selected parking space, making it easier for users to identify available parking slots.

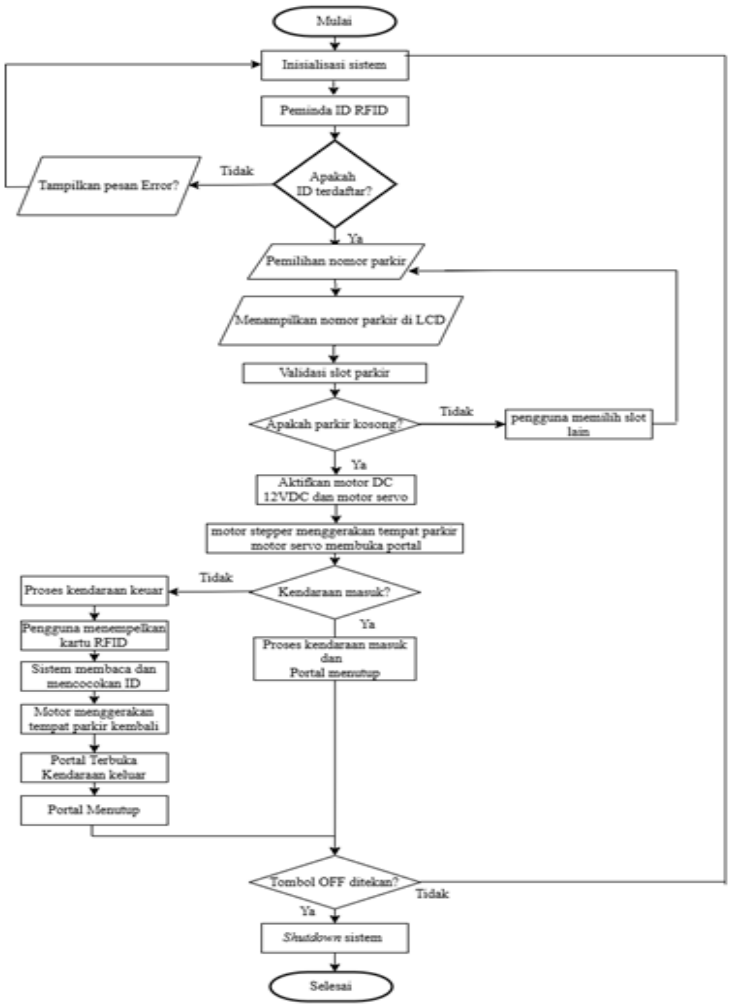


Figure 3. System flowchart

3. RESULTS AND DISCUSSION

The purpose of testing and measuring the equipment is to ensure that all components are functioning properly and as intended. RFID testing is performed to accurately read and recognize RFID tags. Tags can be read within a maximum distance of 3 cm. The following is how to read an RFID tag, as seen in Figure 4.

Figure 4. RFID tag reading

The reading of incoming cars can be seen on the LCD display after RFID tagging is applied. Figure 5 shows the LCD display when a car enters through the portal and parks in its designated parking slot.

Figure 5. LCD display

Keypad testing aims to ensure that each programmed button functions properly and can be recognized by the Arduino. This is essential for ensuring the reliability of systems that use keypad input. Figure 6 shows that pressing (*) on the keypad opens the car's entry portal. This indicates the keypad is functioning properly. If any buttons are unresponsive or produce incorrect characters, double-check the connections and ensure there are no loose cables or incorrect pins.

Figure 6. Keypad testing

4. CONCLUSION

The experiment concluded that the design and construction of the vertical rotation parking system performed as expected. All sensors could read the vehicle's condition. The motor and ultrasonic sensors could accurately position the car's slot.

REFERENCES

[1] U. Gazder, A. Shehabi, K. Fardan, H. Alkhabbaz and Z. Ibrahim, "Smart parking solution for congested areas: Application of vertical rotary systems," *2nd Smart Cities Symposium (SCS 2019)*, Bahrain, Bahrain, 2019, pp. 1-5, doi: 10.1049/cp.2019.0220.

[2] M. Rezky and M. Yuhendri, "Argometer Becak Motor Berbasis Android," *JTEV (Jurnal Tek. Elektro dan Vokasional)*, vol. 6, no. 1, p. 158, 2020, doi: 10.24036/jtev.v6i1.107925.

[3] S. Ma, H. Jiang, M. Han, J. Xie and C. Li, "Research on Automatic Parking Systems Based on Parking Scene Recognition," in *IEEE Access*, vol. 5, pp. 21901-21917, 2017, doi: 10.1109/ACCESS.2017.2760201.

[4] T. O. Olasupo, C. E. Otero, L. D. Otero, K. O. Olasupo and I. Kostanic, "Path Loss Models for Low-Power, Low-Data Rate Sensor Nodes for Smart Car Parking Systems," in *IEEE Transactions on Intelligent Transportation Systems*, vol. 19, no. 6, pp. 1774-1783, June 2018, doi: 10.1109/TITS.2017.2741467.

[5] P. Liu, Z. Chen, M. Liu, C. Piao, K. Wan and H. Huang, "Vertical Parking Trajectory Planning With the Combination of Numerical Optimization Method and Gradient Lifting Decision Tree," in *IEEE Transactions on Consumer Electronics*, vol. 70, no. 1, pp. 1845-1856, Feb. 2024, doi: 10.1109/TCE.2023.3321109.

[6] A. T. Mobashsher, A. J. Pretorius and A. M. Abbosh, "Low-Profile Vertical Polarized Slotted Antenna for On-Road RFID-Enabled Intelligent Parking," in *IEEE Transactions on Antennas and Propagation*, vol. 68, no. 1, pp. 527-532, Jan. 2020, doi: 10.1109/TAP.2019.2939590.

[7] R. Panahi and I. Gholampour, "Accurate detection and recognition of dirty vehicle plate numbers for high-speed applications," *IEEE Trans. Intell. Transp. Syst.*, vol. 18, no. 4, pp. 767–779, Apr. 2017.

[8] L. Cai, H. Guan, Z. Y. Zhou, F. L. Xu, X. Jia and J. Zhan, "Parking Planning Under Limited Parking Corridor Space," in *IEEE Transactions on Intelligent Transportation Systems*, vol. 24, no. 2, pp. 1962-1981, Feb. 2023, doi: 10.1109/TITS.2022.3219651.

[9] B. Wang, C. Shao, J. Li, D. Zhao, and M. Meng, "Investigating the interaction between the parking choice and holiday travel behavior," *Adv. Mech. Eng.*, vol. 7, no., pp. 1–11, Jun. 2015.

[10] M. Roca-Riu, E. Fernández, and M. Estrada, "Parking slot assignment for urban distribution: Models and formulations," *Omega*, vol. 57, pp. 157–175, Dec. 2015.

[11] A. Chand, M. Kawanishi, and T. Narikiyo, "Application of sigmoidal Gompertz curves in reverse parallel parking for autonomous vehicles," *Int. J. Adv. Robot. Syst.*, vol. 12, no. 9, p. 127, Jan. 2015.

[12] C. Xuezhi, "Automatic Vertical Parking Path Planning Based on Clothoid Curve and Stanley Algorithm," *2022 IEEE 5th International Conference on Information Systems and Computer Aided Education (ICISCAE)*, Dalian, China, 2022, pp. 761-766, doi: 10.1109/ICISCAE55891.2022.9927631.

[13] Z. Tian, P. Zhang, K. Feng, Y. Tang and Y. Lu, "Research on Vertical Parking Path Planning of Semi-trailer Train Based on Improved Hybrid A* Algorithm," *2022 2nd International Conference on Computer Science, Electronic Information Engineering and Intelligent Control Technology (CEI)*, Nanjing, China, 2022, pp. 776-780, doi: 10.1109/CEI57409.2022.9950219.

[14] P. Choorat, C. Sirikornkarn and T. Pramoun, "License Plate Detection and Integral Intensity Projection for Automatic Finding the Vacant of Car Parking Space," *2019 34th International Technical Conference on Circuits/Systems, Computers and Communications (ITC-CSCC)*, JeJu, Korea (South), 2019, pp. 1-4, doi: 10.1109/ITC-CSCC.2019.8793297.

[15] A. Kızıl, A. C. Kutlucan, C. Doğan, S. Koçak and V. Sezer, "Design and Implementation of Autonomous Parallel and Vertical Parking Mobile Vehicle," *2018 6th International Conference on Control Engineering & Information Technology (CEIT)*, Istanbul, Turkey, 2018, pp. 1-8, doi: 10.1109/CEIT.2018.8751778.