RFID-Based Automated Parking Management System

T E A M 4 8 - P a r k c a r s

EE		ME	CE	ISE
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INTRODUCTION

The project aims to develop an RFID Automated Parking Management System to streamline parking operations and enhance user experience through innovative automation. Utilizing RFID technology with a reading range of up to 3 meters, the system enables seamless vehicle identification, automates entry and exit processes, and integrates advanced monitoring features. The system is designed to improve parking efficiency by providing real-time vehicle tracking and management. Additionally, it includes a smart notification system that alerts users to vacate the parking spot after 105 minutes and imposes a fine if the vehicle exceeds 120 minutes, ensuring optimal utilization of parking spaces. By integrating real-time alerts, user notifications, and penalty mechanisms, this system addresses the challenges of parking space congestion and inefficient management, reliable.

OPTIMIZING PARKING AREA

Objective function

Maximize $Z = \sum_{i=1}^{m} \sum_{j=1}^{n} (xij + yij)$

Decision Variables

x = Binary variable indicating whether a standard parking slot is assigned at position (1 if yes, 0 otherwise).

y = Binary variable indicating whether a compact parking slot is assigned at position (1 if yes, 0 otherwise).

Parameters

•m: Number of rows.

•n: Number of columns.

Constraints

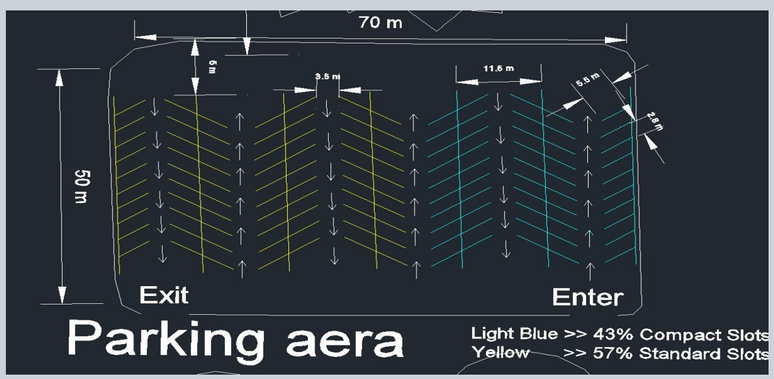
x(i,j) +y (i,j) ≤ 1 Each position can only be assigned either a standard or compact slot.

n·slot_length $\leq$ 70m Standard slots (5m x 2.5m) and compact slots (4.5m x 2.2m).

m·(slot_diagonal+lane_width) $\leq$ 50m

lane_width $\geq$ 3m Allocate a minimum lane width of 3m between rows.

PROTOTYPE DESIGN



- Dimensions of inclined parking spaces (45 degrees) are 2.8 meters wide and 5.5 meters long.
- Parking lines are white and 10 cm wide.
- The minimum width of any one-way traffic lane is 3.5 meters and for two-way traffic lanes is 7 meters .

PROTOTYPE DEVELOPMENT: EE

3 Voltage sources

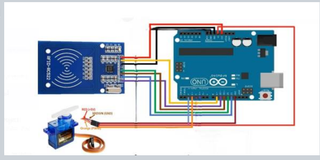
- USB A from the PC to the Arduino
- 5 V_{DC} (2 servo Motor)
- 3.3V_{DC} (RFID RC522+ESP8622)

2 Sensors

- For : RFID RC522. This sensor will be used to read the cheeps.

Circuitry

As illustrated in the adjacent circuit, the RFID sensors are connected to the Arduino, which will read the chips. Upon successful detection, the gate will open. Additionally, if the vehicle remains in the parking space for more than 30 seconds, an email notification will be sent.



Calculations and Motor Specs

$$\text{Gear Ratio} = \frac{\text{Diameter of Second Gear}}{\text{Diameter of First Gear}} = \frac{0.02\,\text{m}}{0.01\,\text{m}} = 2$$

$$T_{\text{output}} = T_{\text{motor}} \times \text{Gear Ratio} = 0.1765\,\text{Nm} \times 2 = 0.353\,\text{Nm}$$

$$T_{\text{exerted}} = 0.981\,\text{N} \times 0.3\,\text{m} = 0.2943\,\text{Nm}$$

$$T_{\text{output}} = 0.1765\,\text{Nm} \times 2 = 0.353\,\text{Nm}$$

Exerted Torque = 0.2943 Nm

Motor Output Torque = 0.353 Nm

$$T_{\text{motor}} > T_{\text{exerted}} \quad (0.353\,\text{Nm} > 0.2943\,\text{Nm})$$

PROTOTYPE DEVELOPMENT: ME

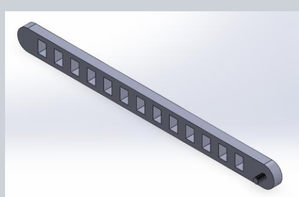
We did a stress-analysis to check if the servo motor has a torque that can outstand the stress exerted by the arm's weight and found that we needed to use a torque upgrade using a 1:2 gear ratio.

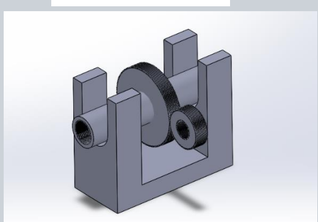
$$\tau = F \times r$$

The SolidWorks design presents the design of the small gear, large gear, the stand, and the space to install the gate arm

$$\tau_{\text{output}} = \tau_{\text{motor}} \times \text{Gear Ratio}$$

$$T_{\text{motor}} > T_{\text{exerted}}$$

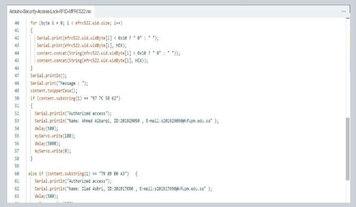




SOFTWARE INTEGRATION

-As we can see in the adjacent picture of the code, we first read the cheep in order to link each cheep to a person.

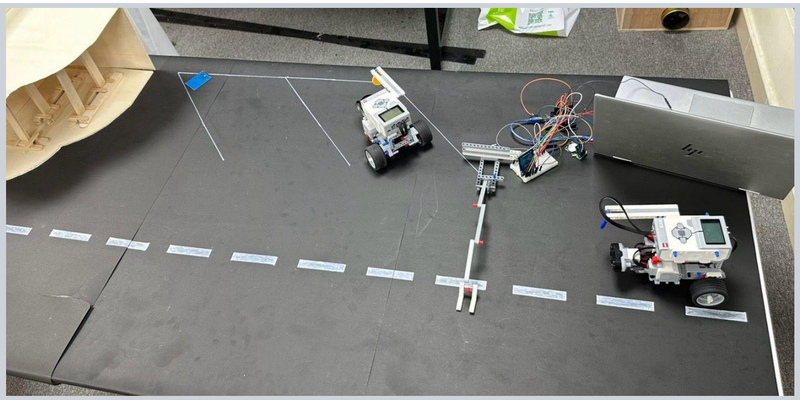
-As we can see in the adjacent picture of the code, after defining the cheeps, we linked them to the servo motor. If the cheep is recognized, it will open the gate.



TESTING

We tested the system using two EV3 cars equipped with RFID tags. The first car approached the gate, its tag was recognized, the drop gate opened, and it parked for less than 30 seconds without a fine. The second car exceeded the allowed parking time, triggering the system to issue a fine. The project components, including the drop gate and RFID reader, functioned seamlessly, validating the system's accuracy and compliance with performance specifications.

RESULTS



In conclusion, our prototype (as shown in the above figure) successfully achieved all project objectives. The system effectively utilized RFID technology to identify vehicles and operated the drop gate. Testing demonstrated the accurate issuance of fines for violations and smooth parking operations for compliant vehicles. This project highlights the potential for automated systems to enhance parking management while improving efficiency and enforcement.