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Automated Vehicle Parking with Security System

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Abstract - As urban populations continue to rise, the demand for parking spaces has become increasingly critical. Traditional parking systems often fail to meet this demand, leading to congestion, wasted time, and increased frustration for drivers. The integration of technology in parking systems can significantly enhance their efficiency, safety, and user experience. The Smart Car Parking System with Security aims to address these challenges by leveraging advanced sensors, automated mechanisms, and biometric authentication.

***Key Words*:** automated vehicle parking, security, biometric sensor, multi storey parking

1. INTRODUCTION

With the rapid growth of urban areas and increasing vehicle ownership, managing parking spaces efficiently has become a significant challenge. Traditional parking systems often lead to time-consuming searches for vacant spots, traffic congestion, and security issues such as theft or unauthorized access. These inefficiencies highlight the need for a smarter and more secure solution to vehicle parking.

The Automated Vehicle Parking with Security System project addresses these challenges by integrating automation and security into a single platform. The system is designed to automatically detect available parking spaces and guide vehicles to them with minimal human intervention. It incorporates sensors, microcontrollers, and automated control mechanisms to handle the parking process.

Moreover, to enhance the security aspect, features such as RFID authentication or license plate recognition are implemented to allow access only to authorized users. Surveillance systems and intrusion detection alarms further contribute to the protection of vehicles within the facility.

This project demonstrates the practical application of embedded systems, IoT components, and security technologies in creating a modern, efficient, and safe vehicle parking environment. It is a step toward the development of smart city infrastructure that prioritizes both convenience and safety.

2. LITERATURE REVIEW

1. Smith and Lee, (2021) – "Automated Parking Systems: Technologies and Trends."

This study reviews the evolution of automated parking technologies, focusing on sensor-based vehicle detection and slot allocation systems. The authors highlight the efficiency gains in reducing search time for parking spots but note challenges in integrating security features beyond traditional access cards.

2. Kumar and Singh, (2020) - " Biometric Security Systems in Parking Management." Journal of Security Engineering.

This paper explores the implementation of biometric authentication methods such as fingerprint and facial recognition in parking systems. The authors discuss how biometrics enhance security by providing unique user identification, reducing unauthorized access, and overcoming limitations of RFID and card-based systems.

3. Zhao and Chen, (2019) - " Sensor-Based Vehicle Detection Techniques."

Sensors and Actuators. Zhao and Chen analyze various sensor technologies—including ultrasonic, infrared, and magnetic sensors—for vehicle detection in parking management. The paper compares their accuracy, cost, and ease of integration, concluding that ultrasonic sensors offer a good balance for most automated parking systems.

4. Patel and Sharma, (2022) – "Design and Implementation of Automated Vehicle Parking System using Microcontrollers."

This conference paper presents a microcontroller-based parking system that uses ultrasonic sensors for slot detection and control logic for vehicle entry/exit. It emphasizes low-cost hardware design while achieving reasonable automation and user interface simplicity.

3. PROBLEM DEFINITION

In today's fast-growing urban environments, the management of vehicle parking has become a major concern due to limited parking spaces, poor traffic management, and increasing security threats. Traditional parking systems are often manual, inefficient, and time-consuming, leading to traffic congestion, fuel wastage, and driver frustration. Additionally, the lack of proper security in parking areas increases the risk of vehicle theft, unauthorized access, and vandalism.

The core problem lies in the absence of an intelligent system that can automate the parking process while simultaneously ensuring the safety and security of the vehicles. Manual intervention also increases the chances of human error, mismanagement of space, and delayed response during emergencies or security breaches.

Therefore, there is a need for a smart parking system that not only automates the process of identifying and assigning vacant parking slots but also integrates robust security features to protect the vehicles and ensure only authorized access. This project aims to solve this problem by developing a fully automated and secure vehicle parking system using embedded technology and smart sensors.

4. METHODOLOGY

The Smart Vehicle Parking System faces several challenges. In the mechanism, achieving smooth and precise movement can be difficult due to potential misalignment or issues handling heavy loads. Fingerprint authentication may become unreliable if the sensor struggles to recognize dirty or wet fingers, affecting user experience. Additionally, live space updates may face delays or inaccuracies, leading to a mismatch between displayed and actual availability, which can confuse users and disrupt the system's efficiency.

A complete system architecture was conceptualized, integrating mechanical design CAD model we are design, electronics, and control systems. Detailed CAD models of Cartesian system mechanisms and components were created using design tools to like Catia v5. Suitable motors, sensors, and microcontrollers were selected, and the required control circuit was developed to operate Cartesian system and other sensors which are used in project.

The mechanism was programmed to operate the step by step operations of the Cartesian system, ensuring the operation perform in smooth and accurate timing.

SYSTEM FLOW

When vehicle Parking:

User Registration ➜ Real-Time Updates ➜ User Authentication ➜ Parking Slot Allocation ➜ Vehicle Park

When vehicle Retrieval:

User Registration ➜ Real-Time Updates ➜ User Authentication ➜ Find Slot Allocation ➜ Vehicle Retrieval

1 User Registration: Take the user's fingerprint during registration and assign a unique Fingerprint ID to them. This ID is linked to a pre-assigned parking slot in the system's database, ensuring every user has a designated slot. The registration process includes storing the fingerprint data securely for future authentication.

2 Real-Time Updates: Throughout the operation, the system continuously monitors the status of all slots, dynamically updating them as "vacant" or "occupied." This ensures accurate real-time information, which is displayed on the OLED screen for user convenience.

3 User Authentication: When the user interacts with the system, their fingerprint is scanned and matched against the stored Fingerprint IDs. This ensures secure and accurate identification of the user before any operation begins.

4 Parking Slot Allocation: If the user intends to park a vehicle, the system retrieves the parking slot associated with their Fingerprint ID. It checks whether the assigned slot is vacant and ready for use, then notifies the user and prepares for vehicle parking.

5 Vehicle Parking: The mechanism starts by activating the motors to transport the vehicle to the assigned slot. The Cartesian mechanism precisely handles the movement and placement of the vehicle, ensuring it is parked securely. The system updates the slot status to "occupied" after the process.

6 Vehicle Retrieval: For vehicle retrieval, the user scans their fingerprint again, which is matched to the stored ID to identify the associated slot. The system activates the mechanism to retrieve the vehicle from its slot and transport it to the retrieval point, updating the slot status to "vacant" once the operation is complete.

5. RESULTS AND DISCUSSION

The results show that the Automated Vehicle Parking with Security System significantly enhances parking efficiency and security, making it a practical solution for busy facilities. By reducing parking time and improving access control, the system streamlines operations, while biometric security adds a robust layer of protection, though its effectiveness relies on proper maintenance and user cooperation. Despite some technical challenges, the benefits of automation such as reduced labor costs, minimized human error, and improved data management far outweigh the limitations. Future advancements could focus on increasing biometric sensor accuracy, incorporating additional security features like facial recognition, and utilizing AI-based slot prediction to further boost efficiency and functionality.

6. CONCLUSIONS

The Automated Vehicle Parking with Security System represents a significant advancement in efficiently managing parking spaces while enhancing security. By integrating accurate vehicle detection and biometric authentication for user verification, the system automates the entire parking process, from entry and slot allocation to exit, minimizing human intervention. This automation provides benefits such as faster parking times, optimized space utilization, and reduced unauthorized access. The robust biometric security ensures that only registered users can access the parking facility, significantly decreasing the risk of theft or misuse. During development and testing, the system demonstrated reliable performance across various scenarios, maintaining accuracy in vehicle detection and user authentication. While some limitations, such as technical dependencies and maintenance requirements, were observed, these can be effectively addressed with regular upkeep and future technological improvements.

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