International Journal for Modern Trends in Science and Technology
Volume 11, Issue 07, pages 231-235.
ISSN: 2455-3778 online
Available online at: http://www.ijmtst.com/vol11issue07.html
DOI: https://doi.org/10.5281/zenodo.16131213

IoT-Based Smart Car Parking System with RFID Authentication, Face Recognition, and Real-Time Cloud Monitoring

Dr. S. Mallikharjuna Rao, Momu Leela Krishna Chirukuri, Shahina Shaik, Hima Bindu Yathakula

Department of Electronics and Communication Engineering, Andhra Loyola Institute of Engineering and Technology, Vijayawada, India.

To Cite this Article
Dr. S. Mallikharjuna Rao, Momu Leela Krishna Chirukuri, Shahina Shaik & Hima Bindu Yathakula (2025). IoT-Based Smart Car Parking System with RFID Authentication, Face Recognition, and Real-Time Cloud Monitoring. International Journal for Modern Trends in Science and Technology, 11(07), 231-235. https://doi.org/10.5281/zenodo.16131213

Article Info
Received: 14 May 2025; Accepted: 06 July 2025.; Published: 17 July 2025.

KEYWORDS

ABSTRACT

With the rapid expansion of urban populations and vehicle ownership, traditional parking systems struggle to accommodate increasing demand, leading to congestion, fuel wastage, and environmental pollution. This research proposes an Intelligent Face Recognition IoT Based Car Parking System with Emergency Entry &Exit Using DL&Python to enhance parking efficiency and vehicle security. The system integrates multiple parking stations into a unified IoT network, dynamically allocating parking slots based on real-time availability. A face recognition mechanism is incorporated to authenticate drivers at entry and exit points, ensuring vehicle security and preventing unauthorized access. Image processing and deep learning techniques optimize facial recognition accuracy while IoT- enabled sensors manage parking slot occupancy and provide real-time updates. The proposed system reduces parking search time, alleviates traffic congestion, and enhances resource utilization, leading to lower fuel consumption and reduced emissions. Comparative analysis with existing models demonstrates superior performance in parking slot detection accuracy, driver authentication efficiency, and overall system responsiveness. To ensure seamless secure parking experience.

1. INTRODUCTION

The rapid urbanization and increasing vehicle ownership have led to a critical shortage of parking spaces in metropolitan areas, causing traffic congestion, excessive fuel consumption, and environmental pollution. As cities evolve into smart cities, integrating Internet of Things (IoT)- based solutions has become essential to address urban challenges, including parking

management. Traditional parking systems, which rely on manual or semi-automated processes, often fail to efficiently allocate parking spaces, leading to delays and frustration among drivers. In response to these challenges, intelligent parking solutions have gained significant attention. Recent advancements in IoT, artificial intelligence (AI), and image processing have enabled the development of smart parking systems that improve efficiency and security. A key concern in urban parking facilities is vehicle security, as unauthorized access and vehicle theft remain prevalent issues. To tackle these problems, face recognition technology has emerged as a reliable biometric authentication method for ensuring that only authorized individuals can access and retrieve their vehicles.

This research presents an Intelligent Face Recognition-Based Multi-Location Linked IoT-Based Car Parking System (IFRb MLL- IoT-CPS), designed to seamlessly link multiple parking stations under a centralized IoT-based framework. The system dynamically assigns parking slots based on real- time availability and authenticates drivers using face recognition technology. By capturing the driver's image upon entry and exit, the system ensures that vehicles can only be retrieved by verified owners, significantly enhancing vehicle security and preventing theft

1. Multi-Location Linked Smart Parking: An IoT-based system that integrates multiple parking areas into a single network, reducing search time and optimizing space utilization.
2. Face Recognition for Enhanced Security: A biometric-based authentication system that ensures vehicles are retrieved only by authorized drivers.
3. Real-Time Slot Allocation and Optimization: IoT sensors continuously monitor parking slot availability, providing real-time updates to drivers.
4. Traffic and Environmental Benefits: Reduction in congestion, fuel consumption, and carbon emissions by minimizing the time spent searching for parking.
5. Improved User Experience: A user-friendly interface that displays parking slot availability and facilitates seamless entry and exit.

The remainder of this paper discusses the literature review on existing smart parking solutions, the proposed methodology for integrating face recognition into IoT-based parking systems.

2. EXPERIMENTAL METHODOLOGY

This experiment focuses on the implementation of an IoT-based smart parking system integrated with face recognition, RFID authentication, and sensor-based monitoring. The methodology is divided into hardware setup, software integration, and testing phases.

2.1 Hardware Setup:

The experimental setup consists of the following components, as seen in the image:

2.2 Raspberry Pi (Central Processing Unit) The Raspberry Pi acts as the primary controller, processing data from sensors, RFID modules, and face recognition systems. It communicates with other hardware components via GPIO pins and controls the servo motor for gate operations.

2.3 Infrared (IR) Sensors

- our IR sensors are placed in designated parking slots to detect vehicle presence.
- Each sensor sends signals to the Raspberry Pi, updating the parking slot availability.

2.4 RFID Module & Card

- The RFID moduleis used foruser authentication.
- When a vehicle approaches, the driver scans an RFID card to validate access.
- The system allows entry only if the card is recognized.

2.5 Servo Motor (Barrier Control):

- A servo motor controls the gate mechanism.
- Upon successful authentication, the motor rotates to opener close the barrier.

2.6 LCD Display:

- Displays real-time parking slot availability and authentication status.
- Guides the driver on slot allocation based on sensor data.

2.7 Switch & Power Connections:

- A power switch controls the entire circuit.
- Proper wiring connects all sensors and modules to the Raspberry Pi.

2.8 Software Integration:

- Programming Language & Libraries.
- The system is coded in Python, with libraries such as OpenCV for face recognition, RPi. GPIO for sensor control, and MFRC522 for RFID communication

2.9 Face Recognition Module:

- A camera module (not visible in the image) is integrated to capture and recognize the driver's face.

• If the face is verified, the system grants access to the parking area.

2.10IoT-Based Data Processing:

• The system transmits real-time parking data to a cloud-based platform or a web dashboard.

• Users can check parking availability remotely.

2.11 Testing and Validation:

Phase 1: Sensor Calibration

IR sensors are tested for accuracy in detecting vehicles. The system verifies sensor response under different lighting conditions.

Phase 2: Authentication Testing

RFID cards are tested for recognition speed and failure rates. Face recognition accuracy is evaluated with multiple users.

Phase 3: System Performance Evaluation

The response time of gate operation is measured. The effectiveness of real-time parking updates on the LCD display is analyzed. The system's ability to reduce parking search time is recorded.

Fig 1 PARKING SLOT ALLOCATION

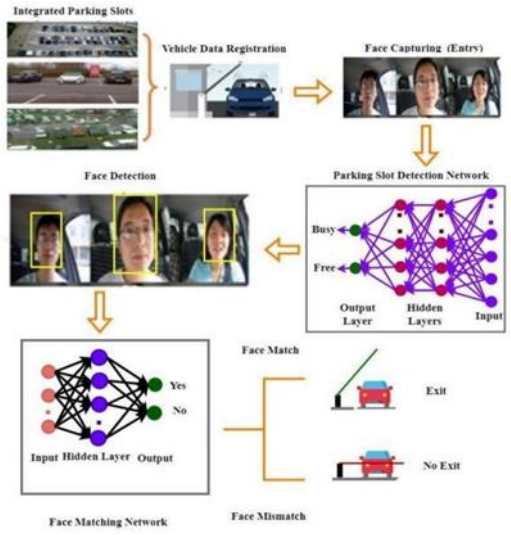


Fig 2 Model Framework

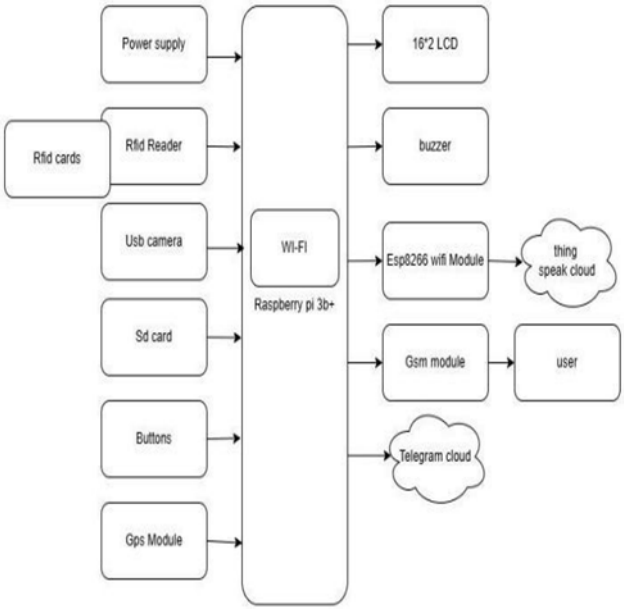


Fig : Flow Chart

3. EXISTING SYSTEM

In traditional systems, vehicle is manually select the slots, which is prone to traffic jam and sometimes leads to accidents. Their Family members do not have proper intimation during this period, leading to anxiety and concerns about their safety. While some systems use basic GPS tracking to provide. Vehicle location, they lack personalized updates about individual car details. Furthermore, such systems typically do not integrate photographic evidence or robust cloud-based storage. Most existing solutions are limited to SMS notifications for location tracking, offering little in terms of live interaction or transparency. Additionally, manual processes and minimal automation make these systems inefficient and unreliable in ensuring safety during transit.

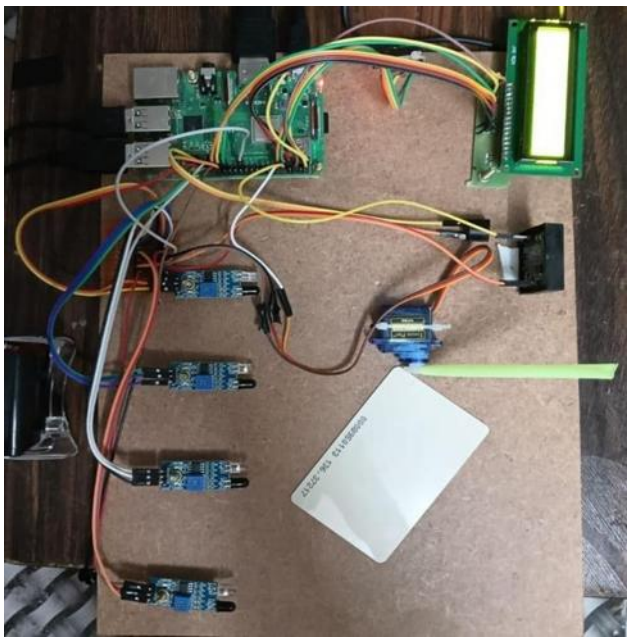
4. PROPOSED SYSTEM

The proposed system leverages IoT technologies to address the limitations of traditional methods and enhance the safety and monitoring Each vehicle is issued an RFID card, which is scanned during Entrying and exiting, recording data automatically and storing the data in a secure cloud. A GSM module ensures real-time notifications, including vehicle-specific alerts and the GPS location. The USB camera adds another layer of security by capturing images of humans as they board or leave slots for parking near to them with live visual confirmation. The system's cloud- based architecture allows authorities to access vehicles details, Candidate

details and images at any time, ensuring seamless data management. By integrating automation, location tracking, photo verification, and cloud storage, the proposed solution delivers a reliable and transparent platform that significantly improves the safety and efficiency of a candidate and vehicle.

5. RESULTS & GRAPHS

6. HARDWARE CONNECTION



7. CONCLUSION

The proposed IFRbMLL-IoT-CPS effectively integrates IoT with face recognition to provide an efficient and secure parking management solution. Future work can explore the integration of AI-driven predictive analytics to further optimize parking space utilization. The integration of IoT with intelligent face recognition for multi-location linked car parking systems has revolutionized urban parking management, enhancing security, efficiency, and convenience. This research proposed an advanced parking system that minimizes parking delays, optimizes resource utilization, and strengthens vehicle security through automated facial recognition. By leveraging real-time data processing and sensor-based monitoring, the system effectively reduces traffic congestion, fuel consumption, and pollution while ensuring a seamless user experience. The proposed model outperforms traditional systems by dynamically allocating parking slots and verifying driver identities, thereby mitigating vehicle theft risks. Future enhancements could incorporate AI-driven predictive analytics and cloud-based data sharing for further optimization. This research serves as a significant step toward developing smart city infrastructure with enhanced automation, security, and sustainability.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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