WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Intellipark: An AI Driven IoT Solution for Vehicle Parking

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DOI : https://doi.org/10.55248/gengpi.6.0425.14115

ABSTRACT-

Urban areas face increasing challenges in managing vehicle parking due to rising vehicle density and limited parking infrastructure. This paper presents INTELLIPARK, an AI-driven IoT-based intelligent vehicle parking system designed to optimize parking space utilization and enhance user convenience. The proposed solution leverages IoT sensors to detect real-time parking slot availability and integrates artificial intelligence techniques to forecast slot occupancy based on historical and real-time data. A mobile/web interface provides users with parking guidance, reservation capabilities, and dynamic slot updates. Furthermore, the system employs automatic number plate recognition (ANPR) for seamless vehicle entry and exit, improving both security and operational efficiency. Experimental results demonstrate the system's effectiveness in reducing parking search time and traffic congestion, making INTELLIPARK a scalable and efficient solution for smart city deployment.

Keywords-Smart Parking System, IoT-based Parking, ANPR, Real-time Data Processing, Wi-Fi Connectivity, Automated Entry-Exit, Database Management, Email Notifications, Traffic Optimization, Smart Cities, Sustainable Transportation ,Remote Slot Booking.

I. INTRODUCTION

The exponential growth in urban populations and the rising number of vehicles have significantly strained existing parking infrastructure in cities. Drivers often spend a considerable amount of time searching for available parking, leading to increased traffic congestion, fuel consumption, and air pollution. Traditional parking systems lack real-time monitoring and intelligent space management, resulting in poor user experience and inefficient space utilization. These challenges highlight the urgent need for a smart, automated parking solution.

Recent advancements in the Internet of Things (IoT) and Artificial Intelligence (AI) have opened new possibilities for transforming conventional parking systems into intelligent, connected platforms. IoT enables seamless communication between sensors, devices, and servers, providing real-time data on parking space availability. AI, on the other hand, can analyze historical and real-time data to predict slot availability, optimize space allocation, and assist in dynamic decision-making. Together, these technologies can greatly enhance the efficiency, reliability, and user-friendliness of parking systems.

INTELLIPARK is proposed as a comprehensive AI-driven IoT solution that addresses the core problems associated with traditional vehicle parking. The system employs IoT sensors to detect and update parking slot status in real time, while AI models are used to forecast demand and occupancy patterns. A user-centric application interface allows drivers to check availability, reserve slots, and receive navigation assistance to their designated spot. The system also integrates automatic number plate recognition (ANPR) to enable contactless and secure entry and exit of vehicles.

By automating and optimizing the entire parking process, INTELLIPARK not only improves the user experience but also contributes to broader urban mobility goals. It helps reduce traffic congestion, saves fuel, and supports the shift toward smart city development. The modular and scalable design ensures adaptability to various environments such as shopping malls, office complexes, airports, and public parking areas, making it a practical and forward-looking solution for modern urban settings.

II. LITERATURE SURVEY

Several research efforts have been directed toward the development of intelligent vehicle parking systems using emerging technologies such as IoT, AI, and cloud computing. Traditional parking management approaches often rely on manual monitoring or token-based entry systems, which are inefficient and lack real-time updates. To overcome these limitations, IoT-based parking systems have been introduced, where sensors embedded in parking slots

detect vehicle presence and transmit status to a central server. Studies such as those by Sharma et al. (2020) and Gupta et al. (2021) demonstrate the use of ultrasonic or infrared sensors to monitor slot occupancy and provide users with real-time availability through mobile applications.

Further advancements include the integration of AI for demand prediction and efficient allocation of resources. For instance, Patil and Deshmukh (2019) applied machine learning techniques to analyze parking trends and optimize slot recommendations, significantly reducing search time. Moreover, computer vision-based systems employing Automatic Number Plate Recognition (ANPR) have been explored to automate vehicle identification and access control, as reported by Kumar et al. (2022). These systems enhance both security and user convenience by eliminating the need for physical tickets or access cards.

Despite the progress, many existing systems suffer from limited scalability, high maintenance costs, and lack of integration with broader smart city infrastructure. Some rely heavily on cloud servers, leading to latency issues in real-time applications. Others lack predictive intelligence, which is crucial for effective traffic flow and parking management. These gaps in current literature and systems highlight the need for a more holistic and integrated approach.

The proposed INTELLIPARK system addresses these limitations by combining real-time IoT sensing, AI-based prediction models, and ANPR for automation, all within a user-friendly and scalable platform. By building upon and improving the methodologies found in prior works, INTELLIPARK aims to offer a more robust, efficient, and future-ready solution for smart vehicle parking.

III. RELATED WORK

Hardware Components:

- ESP32-CAM:Captures images of vehicle number plates for ANPR processing.
- IR Sensors: Detects the presence of vehicles at entry, exit, and parking slots.
- Ultrasonic Sensors: Measures slot occupancy in real-time.
- ESP8266 Wi-Fi Module: Enables cloud communication and real-time updates.
- Microcontroller (Arduino/ESP8266): Processes sensor inputs and controls system operations.
- Servo Motors: Automatically open and close the entry and exit gates.

Software and Web Development:

- OpenCV & Tesseract OCR: For number plate recognition using AI-based ANPR processing.
- Python(Flask/Django): Backend server for processing user requests and managing data.
- JavaScript, HTML, CSS: For frontend web development and interactive UI.
- MySQL: Cloud database for storing vehicle and slot information.
- IoT Cloud Platforms (ThingsSpeak, Blynk): For remote monitoring and data management.

IV. METHODOLOGY

A. BLOCK DIAGRAM

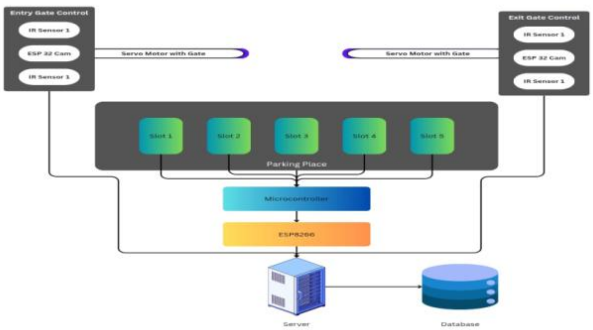


Fig. 1. Block Diagram of Overall System

An automated smart parking system that combines multiple parts for smooth vehicle entry, slot distribution, and exit control is depicted in the diagram. A microcontroller and ESP8266 module, an exit gate control, a parking space with slot monitoring, and an entry gate control make up the system. All of these components are linked to a central server and database for data management and real-time processing.When an IR sensor at the Entry Gate Control detects an incoming car, the system uses an ESP32-CAM to record the license plate. Automatic Number Plate Recognition (ANPR) is used to process the collected image in order to validate vehicles that have already been registered or permit new entry. A servo motor-controlled gate opens to provide entrance to the parking facility after authentication is finished.Several IoT-enabled parking spaces in the parking lot (Slots 1, 2, 3, 4, and 5) are outfitted with sensors that identify slot occupancy and send the information to a microcontroller. The microcontroller communicates the availability of parking spaces in real time to a server via an ESP8266 Wi-Fi module. A web-based portal allows users to view available slots, and as a car parks or leaves, the system dynamically updates the slot status.The entry gate and the exit gate control function similarly. Another infrared sensor detects the presence of a car when it approaches the exit, and the ESP32-CAM records the license plate to determine how long the car has been parked. The user then uses an integrated online site to pay the bill that the system creates. The car can depart after the servo motor-controlled exit gate opens after a successful payment.

B. SYSTEM WORKFLOW

Many challenges are addressed by the proposed Smart Parking Management System (SPMS), which combines web-based pre-booking, IoT-based real-time slot monitoring, and Automatic Number Plate Recognition (ANPR). In order to minimize the need for manual intervention and maximize parking efficiency, the whole parking process—from vehicle entry and slot allocation to invoicing and exit—will be automated.With the SPMS's dynamic billing feature, users only pay for the time they actually spend parking, in contrast to conventional fixed-rate parking systems. Based on entry and exit timestamps, the system determines the total amount of parking time and creates a bill appropriately. The web-based interface allows users to view their costs, and integrated online payment channels allow them to make payments. The exit gate opens automatically after payment is verified, eliminating the need for parking attendants to operate manually. In order to ensure effective space usage and a flawless parking experience, the flowchart depicts an organized parking slot booking system that offers two main booking modes: pre-slot booking and on-time slot booking. The procedure starts when a user selects one of the two parking slot allocation modes, depending on availability and choice.In the Pre Slot Booking mode, customers can utilize a mobile app or web page to reserve a parking spot in advance.

They can choose their desired time slot using this reservation system, which takes into account current availability. The system confirms and updates the database when a space is reserved.

The pre-registered information is verified by the ANPR (Automatic Number Plate Recognition) system or by hand entry as the car pulls up to the parking lot.The On-Time Slot Booking feature enables users who do not have a reserved time slot to locate a parking spot when they arrive. Using IoT-based sensors, the system determines the availability of a slot in real time when a car arrives at the parking entrance. The system records the car in the database and dynamically assigns a slot if one is available. The next step is verification, when the car is verified by the ANPR system or a special ID before entrance is allowed. This method gives drivers freedom while maximizing the use of parking spaces.The procedure is finished after the car is parked till the exit phase is started. The system determines the entire amount of time spent parking at the exit, creates a bill if required, and updates the database to identify the space as empty so that the following car can use it. By combining automation, Internet of Things sensors, and ANPR technology, operations run smoothly, causing less traffic and removing the need for manual intervention. The system guarantees optimal use of available spots, improves parking management, and increases customer convenience by offering both pre-booking and on-time booking choices.

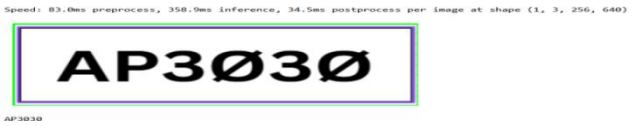
All information is kept in a centralized database that is controlled by the server, including payment records, parking spot occupancy, and vehicle entry and exit logs. This makes it possible to use parking spaces effectively, monitor in real time, and automate a smooth user experience. By lowering human intervention, reducing traffic, and improving security within the parking area, the technology guarantees seamless operations.

V. RESULTS AND DISCUSSIONS

The developed website is a component of an automated parking management system that is intended to effectively monitor and control parking spaces. A refresh button for updating the parking data is located at the top, along with the system's IP address (192.168.252.117) and a status indicator ("Not Found") that could indicate problems with connectivity or database access. The status of six parking spaces is displayed in the middle part. Slots 1 through 5 are marked as "Booked" in red, meaning they are filled, while spot 6 is marked as "Available" in green, with a space for a vehicle number to be entered to reserve the spot. The part at the bottom offers comprehensive details regarding parked cars, such as their numbers, parking status, "In Time," and "Out Time."For rapid and simple identification of available and occupied spaces, the homepage uses color-coded slot statuses and an eye-catching gradient background. All things considered, this intuitive interface makes parking management easier by providing real-time updates and effective space distribution

Fig. 5. Overview of Developed Webpage

Fig . 6. NPR using OCR Technology



id	vno	status	in_time	out_time
0	DL7070	1	11:55:25	00:00:00

id	vno	status	in_time	out_time
0	AP4040	1	21:30:31	00:00:00

id	vno	status	in_time	out_time
0	MH6060	1	21:45:27	00:00:00

Fig . 7. Confirmation e-mail send to User

To offer an effective parking management system, the Smart Parking System project successfully combines a database, web-based interface, and automated email notifications. The database maintains a well-structured structure for real-time changes by managing user information, parking slot availability, and transaction records. To improve customer convenience, the automated email system creates billing summaries and validates slot reservations. Users may book, check availability, and get immediate confirmations thanks to the website's user-friendly interface.

VI. CONCLUSION

This Internet of Things (IoT)-based smart parking system transforms conventional parking solutions by integrating state-of-the-art technology including Automatic Number Plate Recognition (ANPR), real-time data processing, and cloud connectivity. By utilizing elements like WEB CAM for car recognition, IR sensors for occupancy detection, and Wi-Fi modules for smooth communication, the system guarantees accurate and automatic parking management. This method greatly increases productivity, lowers operating expenses, and minimizes human error in contrast to traditional systems that depend on manual ticketing and human monitoring.Future improvements might include AI-powered analytics for predictive parking management, mobile app integration for easy access, and blockchain-based payment systems for increased security. All things considered, this project sets the groundwork for a highly automated, intelligent, and effective parking solution that supports contemporary urban development objectives and opens the door to smarter, more sustainable cities.

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