

AI Powered Car Parking System

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ABSTRACT

Traditional parking systems have problems. They waste space cause traffic jams and rely on people to watch. They also don't give you real-time information about parking spots. Current parking systems use people or simple sensors to manage parking. These systems are often wrong take a lot of time. Are hard to use in big cities. To solve these problems we created an AI-Based Smart Parking Management System. It uses technology and automated systems. It uses learning and computer vision to work. The system uses a model to detect cars from live camera feeds. It checks if a parking spot is taken or not in time. It also tracks cars to see how they move and park. We built a web app using Flask to show parking information. The app shows if a spot is available if a spot is taken, booking details, alerts and parking stats. The system also has features. It suggests the available spot. It detects if someone parks in the spot. It predicts how busy the parking will be. It also looks at parking data. The prediction engine looks at how people park and when. It tries to guess how many spots will be available in the future. This helps manage parking. Our system makes parking easier. It reduces the work for parking staff. It helps people find parking spots faster. It makes parking more convenient. The system can be used in places, like malls, schools, offices and cities. It's easy to use, not too expensive. Can grow with the needs of the place.

Keywords: Smart Parking System, YOLO, Vehicle Detection, Vehicle Tracking, Flask, Deep Learning, Parking Prediction, Smart Slot Recommendation, Wrong Parking Detection, Real-Time Dashboard

1. INTRODUCTION

With the rapid development of urbanization and the increasing number of vehicles, parking management has become a big concern in smart cities and modern transportation systems. Drivers spend much of their time looking for available parking spaces, which leads to higher fuel use, traffic buildup and frustration. Traditional parking systems depend largely on manual supervision or simple monitoring techniques, which are not only inefficient but also cannot provide real-time parking information.

Recent developments in Artificial Intelligence, Deep Learning and Computer Vision have enabled the development of smart parking management systems that can automate parking operations. AI-driven parking systems employ surveillance cameras and intelligent algorithms to detect vehicles, monitor parking occupancy, track vehicle movement, and deliver real-time parking information.

The proposed AI-Based Smart Parking Management System uses YOLO-based vehicle detection and tracking techniques for real-time monitoring of parking slots. The system analyzes live video streams from surveillance cameras and automatically detects occupied and vacant parking spaces. A web-based application is developed using Flask which provides real-time dashboard visualization, parking analytics, slot booking, occupancy logs, and alert notifications.

The system also includes advanced functionalities such as smart slot recommendation, wrong parking detection, and parking availability prediction using historical occupancy data. Vehicle tracking algorithms

help monitor parking activity continuously and improve overall system reliability.

Compared to traditional parking systems, the proposed system offers improved accuracy, automation, scalability, and user convenience. The project contributes toward the development of intelligent smart-city parking infrastructure capable of reducing traffic congestion and improving parking efficiency.

2. LITERATURE REVIEW

1. YOLO NAS-Powered Intelligent Vehicle Tracking and Monitoring System for Enhanced Parking Management in Urban Environments
Ariharan M., Sujitha Juliet, J. Anitha (ICACCS 2024)

This paper presents an AI-based vehicle tracking system using YOLO-NAS and DeepSORT algorithms for real-time parking management. The proposed system can accurately detect and track vehicles in surveillance video streams, which makes it suitable for surveillance in large parking environments. The study highlights the efficiency of modern YOLO frameworks in enhancing detection accuracy and processing speed. This paper is related to the proposed project as it discusses the use of AI-based vehicle detection and tracking for intelligent parking management.

2. IoT-Enabled Smart Parking System Using Artificial Intelligence and Optical Character Recognition
Mohammad Rafi Rashidi, Chris Cherian, Vipul Singh Negi, Suchismita Chinara (2024)

This research presents an IoT-based parking management system with AI-based Optical Character Recognition (OCR) for license plate identification and secure parking access. The system offers parking monitoring, slot reservation and automatic vehicle verification. The paper reveals how AI technologies can improve automation and convenience for users of modern parking systems.

3. AI-Powered Parking Management Systems: A Review of Applications and Challenges

Islam M. Ibrahim, Mohamed Khaled, Marwan Ashraf, Mario George, Iyad Abuhadrous (ASTJ, 2024)

The application of computer vision and artificial intelligence to contemporary parking systems is covered in this review study. The authors describe how real-time video analysis and deep learning models can enhance parking occupancy detection and lessen reliance on conventional sensor-based systems. Problems with illumination, environmental changes, and model correctness are also covered in the article.

4. Smart Parking Systems Technologies, Tools and Challenges for Implementing in a Smart City Environment: A Survey Based on IoT & ML Perspective

Aparna Raj, Sujala D. Shetty (International Journal of Machine Learning & Cybernetics, 2024)

This survey paper introduces different technologies of smart parking systems such as IoT devices, machine learning models, cloud platforms, and intelligent monitoring systems. Authors describe the benefits of smart

parking solutions for real time occupancy detection, parking automation, parking analytics and smart-city integration. The paper also tackles a number of issues such as scalability, sensor reliability, data inconsistency and system maintenance. The study is relevant to the proposed project as it provides useful insights into intelligent parking management and real-time monitoring systems.

5. AI-Powered Parking Systems: Enhancing Urban Mobility Through IoT and Automation

Zaheer Mustafa, Greyson Alwin (2025)

The paper considers AI-enabled parking management systems supporting real-time occupancy monitoring, predictive analytics and automated parking management. The authors explain how Artificial Intelligence and automation can enhance parking efficiency, alleviate traffic congestion and optimise the use of parking resources. The paper also proposes prediction models based on parking trend analysis to predict future parking availability. The implemented system also has parking prediction, occupancy monitoring, analytics and intelligent parking management features which makes this research relevant to the proposed project.

6. FindMySpot: AI & AR Based Parking System

G. Padmapriya, Alok Prasad, Vrutika Panikar (SSRN, 2024)

In this work, we present the implementation of the SORT (Simple Online and Realtime Tracking) algorithm for real-time vehicle tracking applications. The algorithm assigns a unique ID for each detected vehicle and continuously tracks the vehicle movements across multiple video frames. The paper emphasises the role of tracking algorithms in intelligent transportation systems and parking management systems, to increase the accuracy of monitoring and reducing duplicate detections. The parking system implemented in this study is relevant to the proposed project, because it uses SORT tracking to monitor vehicle movement, parking occupancy and parking behaviour in real time .

3. PROPOSED SYSTEM

I. System Overview

The proposed AI Based Smart Parking Management System, provides an intelligent and automated solution for real time parking monitoring using Artificial Intelligence, Deep Learning and Computer Vision techniques. The system continuously monitors parking areas with surveillance cameras and automatically detects vehicles. The object detection model used is based on YOLO to detect vehicles from the live video streams. The detected vehicles are further processed by SORT tracking algorithm to track the vehicle movement continuously. The status of parking slot occupancy is updated dynamically and displayed on a web dashboard based on Flask. The system provides several advanced features such as smart slot recommendation, parking prediction, occupancy analytics, wrong parking detection and alert generation. A database stores historical parking data for future monitoring and analysis. The proposed system may reduce the manual supervision, improve the parking utilisation, reduce the time to find a parking space and support the smart parking management in urban environments.

II. Video Acquisition and Preprocessing

The system is continuously fed with live video streams from the surveillance cameras installed inside the parking area. The captured frames are processed in real time to improve the accuracy of the vehicle detection under different environmental conditions. Before detection of vehicles several pre-processing operations such as resizing of frames, adjustment of brightness, reduction of noise, enhancement of contrast and extraction of Region of Interest are carried out. These preprocessing techniques enhance the quality of the image and enable the system to

achieve accurate occupancy detection. Then the processed frames are passed to the YOLO based vehicle detection module for further analysis.

III. Vehicle Detection and Tracking

The proposed system uses a YOLO based deep learning model for real time vehicle detection. The model detects vehicles from surveillance video streams and produces bounding boxes around detected vehicles. The system uses the SORT tracking algorithm to track the vehicles movement continuously. The tracking module identifies the vehicles and gives a unique ID to the vehicles and tracks it frame by frame. This helps in efficiently monitoring parking activity, vehicle movement and duration of occupancy. The parking occupancy monitoring accuracy and system reliability can be improved by combining YOLO detection and SORT tracking.

IV. Parking Slot Mapping and Occupation Detection

The parking space is divided into pre defined parking slots by deploying polygon based coordinate mapping techniques. Each detected vehicle is compared with parking slot regions to identify whether a slot is occupied or vacant. If a detected vehicle overlaps a parking slot region, the slot is marked as occupied. Otherwise the slot is empty. The occupancy information is updated continuously and shown on the dashboard in real-time. The method improves the accuracy of parking monitoring and reduces the need for manual supervision.

V. Smart Slot Recommendation Module

The proposed system has a smart slot recommendation feature that helps users find the nearest available parking slot. It calculates the distances to slots from the parking entrance and suggests the closest vacant parking spot. This feature cuts down parking search time, improves traffic flow within the parking area, and makes it easier for users.

VI. Prediction and Analytics Module

The system stores historical parking occupancy data in a database for analysis and prediction. The prediction engine looks at parking usage trends and occupancy statistics to estimate future parking availability and peak parking hours. Parking analytics, such as occupancy percentage and slot utilization, are shown on the dashboard through graphical visuals. These insights help administrators improve parking management efficiency.

VII. Wrong Parking Detection and Alert System

The proposed system includes a smart wrong parking detection module that identifies vehicles parked outside authorized parking areas. The system continuously monitors vehicle positions and checks parking boundaries using polygon-based mapping techniques. If a vehicle is parked incorrectly or detected in a non-parking zone, the system automatically generates alerts and stores violation information in the database. Users can view alert notifications through the dashboard. This feature improves parking discipline and security.

VIII. Web Dashboard and Database Management

A Flask-based web application is created to offer real-time parking management and monitoring. The dashboard shows occupied slots, vacant slots, parking analytics, booking details, alerts, and parking history. The system allows for user authentication, parking slot booking, occupancy logging, and storing historical data with database integration. Administrators can track parking activities and handle alerts using the dashboard interface.

4. SOFTWARE REQUIREMENTS / TOOLS

Programming Language: Python 3.8 or above

Frameworks & Libraries:

OpenCV – image preprocessing and video capture

Ultralytics YOLO – vehicle detection
 SORT Tracking Algorithm – vehicle tracking
 Flask / Django – backend and API services
 NumPy, Pandas – data handling
 cvzone – visualization support
 SQLite – database management
 JSON – configuration and data storage
 Frontend / Dashboard: HTML, CSS, JavaScript, Bootstrap / React
 Hardware / IoT Components:
 HD Surveillance Camera
 Computer System with GPU support
 Internet/Wi-Fi Connectivity

5. ALGORITHMS

The proposed Smart Parking Management System uses smart algorithms to watch parking in real time track vehicles see if a spot is taken and make predictions.

It mainly uses the YOLO algorithm to find vehicles from video. YOLO is very good at finding things in time and it is fast and accurate. It looks at each frame of the video. Finds vehicles by drawing a box around them and giving a score.

Since YOLO can find vehicles at the same time without slowing down it is very good for smart parking. After finding vehicles the system uses the algorithm to track them. This algorithm gives each vehicle an ID and helps keep track of when they enter, exit and how long they stay. This makes the system better at knowing if a spot is taken or not. The system also uses an algorithm to see if a vehicle is in a parking spot. If a vehicle is in a spot the spot is marked as taken. The system can also tell drivers where the closest empty spot's. This helps drivers find a spot quickly and reduces traffic in the parking area. The system looks at data to predict when the parking area will be busy. It also has an algorithm to find vehicles that are parked in the place and sends a warning. All these algorithms work together to make a parking system that is accurate and easy to use.

The Smart Parking Management System is very good at making parking easier and reducing traffic. It helps people find a parking spot quickly and makes the parking area more efficient. The system is also very good at reducing congestion and making the parking experience better for users. The Smart Parking Management System is a useful tool for managing parking areas. The system uses algorithms to make sure that parking is easy and efficient. It is a good system, for people who manage parking areas and for people who need to park their vehicles. The Smart Parking Management System is a way to improve parking.

6. RESULTS AND DISCUSSION

Real-time parking occupancy monitoring, vehicle detection, parking analytics, and intelligent parking management were all successfully built and evaluated by the suggested AI-Based Smart Parking Management System. For automatic parking monitoring, the system incorporates YOLO-based vehicle identification, SORT tracking, smart slot recommendation, incorrect parking detection, and Flask-based dashboard visualisation.

Parking occupancy detection, vehicle tracking, live parking analysis, dashboard monitoring, and booking management are the main topics of the experimental investigation. The outcomes show how well the suggested technique works to precisely identify occupied and empty parking spaces in real time.

6.1 Parking Occupancy Detection in Real Time

The output of the suggested system's real-time parking occupancy monitoring is displayed in Figure 6.1.1. Bounding boxes were created around parked cars by the YOLO-based vehicle detection algorithm, which effectively identified cars from the parking surveillance footage.

Polygon-based parking slot mapping techniques were used by the system to continuously monitor parking slot occupancy. Vacant parking spaces were shown separately, and occupied parking spaces were marked. In real time, the system also showed the total number of parking spots, occupied slots, open slots, and non-parking cars. Cars were successfully given unique IDs by the SORT tracking algorithm, which also continually tracked the movement of the cars throughout video frames. The technology successfully detected cars that were parked incorrectly and automatically produced notices for parking infractions.



Figure 6.1.1 Real-Time Parking Occupancy Detection Output

The results demonstrate that the proposed system can accurately monitor parking occupancy and parking violations in real time with high efficiency.

6.2 Parking Analysis Interface in Real Time

The Flask-developed Live Parking Analysis module is shown in Figure 6.1.2. Through the interface, customers can upload parking surveillance footage and use the YOLOv11-based recognition model to analyse parking occupancy in real time. AVI, MOV, MP4, and other video formats are supported by the system. Using the dashboard interface, users may start parking analysis and choose various parking spots. Real-time processing of the uploaded video results in the dynamic generation of parking occupancy data.

The Live Parking Analysis module offers an intuitive interface for intelligent parking monitoring and enhances automation.

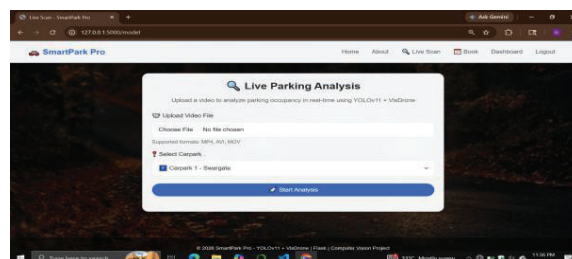


Figure 6.1.2 Live Parking Analysis Dashboard

6.3 Results of the Smart Parking Dashboard

The SmartPark Pro dashboard, designed for parking management and monitoring, is depicted in Figure 6.1.3. Real-time parking statistics, such

as total parking spaces, occupied spaces, parking availability, booking details, and reservation information, are shown on the dashboard. Additionally, the dashboard shows each parking area's occupancy percentage and parking site status. Parking space reservations and effective reservation history monitoring are made possible by the booking management module.

Both users and administrators can engage with the dashboard's user-friendly design.

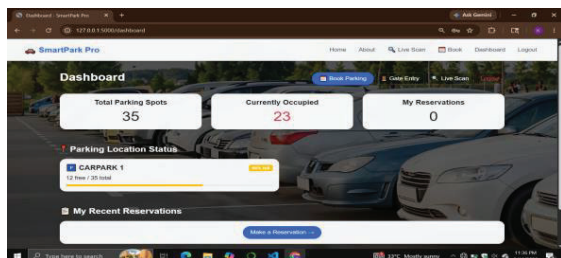


Figure 6.1.3 Smart Parking Management Dashboard

6.4 The Home Interface of SmartPark Pro

The SmartPark Pro system's homepage interface, created with Flask-based web technologies, is depicted in Figure 6.1.4. For smart parking services like real-time parking recognition, live parking availability monitoring, and rapid parking booking, the homepage offers an interactive and user-friendly environment. Major system features, such as YOLO-based vehicle detection, real-time parking space availability, and parking reservation services, are displayed on the interface. Through the web interface, users can register or log in to the system, obtain parking information, and browse through various parking management modules.

The webpage was created to facilitate real-time smart parking operations while offering a straightforward and effective user experience.

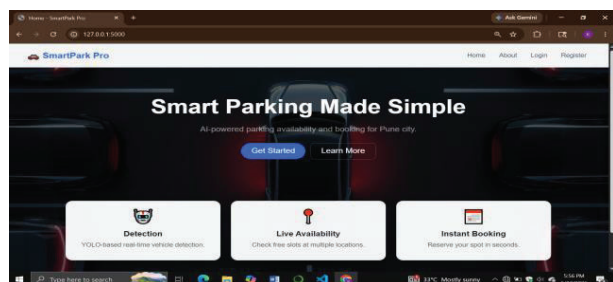


Figure 6.1.4 SmartPark Pro Homepage Interface

The created interface enhances user accessibility, parking management effectiveness, and general user engagement with the suggested smart parking system.

6.5 Important Findings

1. Multiple vehicles were successfully and accurately recognised at the same time by the YOLO-based vehicle detection algorithm.
2. By continually following vehicle movement across frames, the SORT tracking algorithm increased the dependability of vehicle monitoring.
3. Parking spaces that were occupied and vacant were correctly detected by the polygon-based occupancy detection approach.
4. Parking infractions were effectively detected using the incorrect parking detection module, which also automatically produced alerts.
5. Reservation management, parking occupancy visualisation, and real-time parking analytics were all offered by the Flask-based dashboard.
6. The suggested technique enhanced the effective use of parking spaces while lowering the need for manual parking supervision.
7. All things considered, the suggested AI-Based Smart Parking Management System showed excellent real-time performance, automation, scalability, and accuracy for intelligent parking management applications.

7. CONCLUSION

The proposed AI-Based Smart Parking Management System offers an intelligent and automated solution for real-time parking monitoring through Artificial Intelligence, Deep Learning, and Computer Vision techniques. The system employs YOLO-based vehicle detection and SORT tracking algorithms to detect vehicles, monitor parking occupancy, and efficiently track vehicle movement in real time.

The implemented system includes several key features, such as smart slot recommendation, parking prediction, wrong parking detection, alert generation, occupancy analytics, booking management, and real-time dashboard monitoring. The smart slot recommendation feature helps users quickly find nearby vacant parking spaces. The prediction module uses historical parking data to estimate future parking availability and identify peak parking hours.

The wrong parking detection module constantly checks parking boundaries and automatically sends alerts when vehicles are parked outside authorized areas. The Flask-based web application and database integration create an interactive dashboard for monitoring parking occupancy, parking history, booking details, and alert notifications.

Compared to traditional parking systems, the proposed system reduces manual work, improves parking space use, minimizes time spent searching for parking, and increases user convenience. The system is scalable, reliable, cost-effective, and suitable for deployment in malls, campuses, residential complexes, office buildings, hospitals, and smart-city environments. Overall, the project shows how AI and Computer Vision technologies can be effectively used to create smart and efficient parking management solutions.

8. REFERENCES

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