Efficient Parking: A Smart System for OptimizedUrban Mobility Using IoT

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Abstract

Internet of Things (IoT)-powered smart parking transforms urban transportation by combining cutting-edge technology to improve parking management. This system usesa network of Internet of Things (IoT) sensors that are mounted in parking spots to trackavailability in real-time. A centralized server receives the data gathered from these sensors, processes it, and updates the parking status instantly. The software hasfunctions like digital payments, recommendation engines tailored to the user's tastes, and navigation to the closest spot. This minimizes emissions and traffic congestion, inaddition to cutting down on the amount of time spent looking for parking. Furthermore,smart parking systems can maximize the use of available parking spaces and offer insightful data analytics to help city planners enhance urban infrastructure. All things considered, IoT-enabled smart parking systems are a big step in the direction of building smarter, more sustainable cities.

Keywords

Data Analytics, IoT Sensors, Mobile application, Real time availability, Smart Parking, Traffic Congestion.

Introduction

Parking systems are one area where IoT technology has transformed daily life. By automating the recommendation of available parking spaces, a smart parking system lowers the expense and time associated with manual management. Drivers can use a unique car ID to reserve free parking spaces nearby through the system, which gives information about them to drivers via their devices.

The proposal put out by Sowmitra Saha and Md. Rokibul et al. introduced Rapid automobile expansion contributes to parking problems in developing nations. Smart parking powered by IoT can improve security, conserve energy, provide online bookings, and maximize resource usage. This study examines associated technologies and potential avenues for future research.

Yasir Saleem, Pablo Sotres, et al. suggest ensuring user privacy by offering GDPR-compliant IoT-based parking places and route recommendations. Apart from offering optimal path recommendations and actual parking availability, it also assists in findingfree parking and ensures privacy-conscious operations.

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Smart parking systems, empowered by the Internet of Things (IoT), represent a cutting-edge solution to urban parking challenges. By integrating advanced sensors, wireless communication, and real-time data analytics, these systems offer unparalleled efficiency and convenience. IoT-enabled parking sensors detect vehicle presence and transmit data to a centralized platform, providing drivers with real-time information about available parking spaces via mobile apps or digital signage.

Parking management is a major problem in urban areas, which results in lost time, more traffic, and higher pollution levels. Due to the lack of real-time information in traditional parking systems, cars must waste time looking for open spaces. In addition to annoying vehicles, this inefficiency puts stress on the urban infrastructure.

Literature Review

Abhirup Khanna suggest that Innovative solutions are required due to the growing urbanization, traffic congestion, scarcity of parking spaces, and worries about road safety (Abhirup Khanna, 2020). In order to improve the efficiency of urban infrastructure, this study suggests an Internet of Things (IoT)-based cloud-integrated smart parking system that will monitor and signal parking space availability. Users will be able to check and bookslots using a mobile application.

Ashok and team suggest that users must search floor by floorfor parking places due to the inefficient management of parking systems, which resultsin laborious and time-consuming procedures (Ashok et al., 2020). This study proposes a smart parking energy management solution combining IoT technology and Honeywell sensors to optimize parking management, addressing the excessive energy consumption and inefficiencies of conventional parking systems.

A smart parking system employing IoT technology is designed for both public and private use in a paper by (Elashmawi et al., 2023). The study's goals are to increase efficiency, specify requirements, and lessen traffic congestion by implementing reservation-based policies.

The work of Gaetano and Claudia (Gaetano and Claudia, 2023) describes Parking is difficult in large citieslike Cairo. In order to achieve effective outcomes, this study presents a smart parking system that uses machine learning and the Internet of Things for automatic payments, user authentication, and real-time tracking.

Sowmitra and Rokibul suggest to addressing issues related to urbanization, this article investigates how IoT technology—such as sensors and cloud computing—improves smart parking systems by identifying vehicles and offering recommendations for sensible sensor selection (Sowmitra and Rokibul, 2023).

Karthick and team dealt with formulating and implementing a Hybridized IoT-Assisted Hierarchy-based Computation Strategy (HIHCS) technique and an Active Randomized Optimization Strategy (AROS) to help alleviate the energy problems in a Smart City surveillance using WSN (Karthick et al., 2024). The result proves that the proposed system improvises the performance of WSN-bound IoT based smart city applications

Methodology

In the existing method, to effectively manage parking spaces in cities, current smart parking systems make useof a range of technologies. To track parking space occupancy in real time, these systemsusually integrate wireless communications and sensors. After that, drivers can access this data via electronic displays or mobile apps. IoT, machine learning, and image processing are examples of technologies that are essential. For example, certain systemsemploy cameras and ultrasonic or infrared sensors to identify the presence of vehicles.

The advised approach in this current work, the suggested smart parking system makes use of high-performance sensors to increase sensing speed and accuracy. The system uses edge computing to interpret local data and provides real-time updates on parking availability through a mobile application. Utilizing more space and reducing search, creates a smarter urban environment. Wireless communication enables sensors, gateways, and central systems to share data in real-time. Sensor networks use sensors to detect if vehicles are parked in authorized locations. With smartphone applications that offer real-time parking availability, customers can find, reserve, and pay for parking spaces remotely. To handle and evaluate parking data, IoT platforms also incorporate hardware and software.

IoT-based smart parking systems rely heavily on technologies such as NodeMCU and infrared sensors. NodeMCU modules and infrared sensors are used to gather information about time and vehicle presence to track parking space occupancy. To getrid of any noise and irregularities, this data is cleaned and pre-processed. By using sensors, IoT platforms, wireless communication, and mobile apps, this technique enables smart parking systems to detect, manage, and automate parking. The figure 1 below shows the flow of parking management in spots.

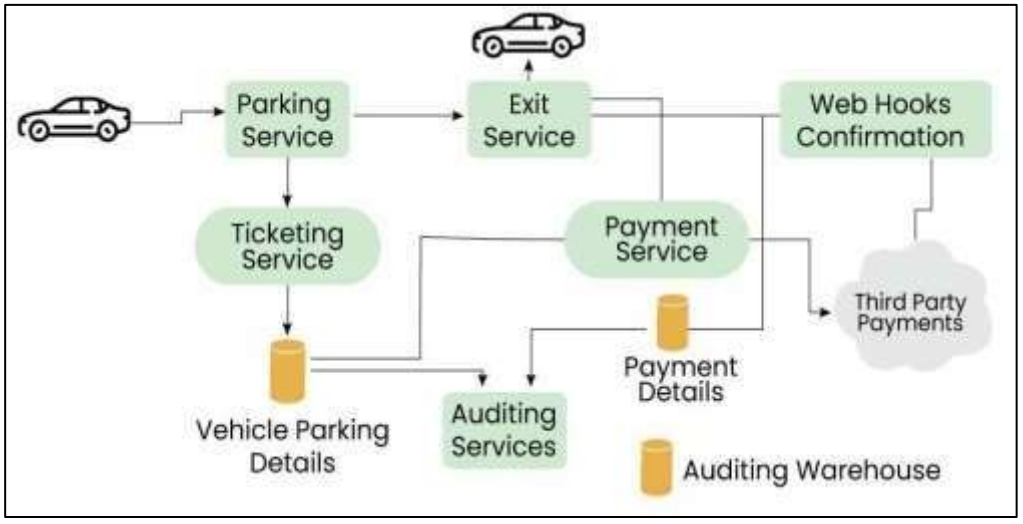

Figure 1 : Flow of Parking Management in spots.

This high-level parking system design describes how to manage vehicle parking from the point of entry to the point of departure. The Ticketing Service logs the vehicle parking details after receiving information from the Parking Service, which registers the entry upon a vehicle's arrival.

The Exit Service starts the vehicle's exit procedure when it's time to go. After that, the payment process is handled by the payment service, which may subsequently integratewith other payment companies. Payment confirmation is handled by Web Hooks Confirmation. All parking and payment information is kept on file in the auditing warehouse. After logging in, the user can view available and unavailable parking spaces in their selected area, with available spaces marked in green and unavailable ones in red.

The application responds when a sensor detects a vehicle entering a parking slot, sending a notification to start the timer. When the user exits the parking slot, the application sends another notification indicating the total duration of the user parked.

Results and Discussions

In a smart parking system, the ultrasonic sensor detects vehicle presence by measuring distance and occupancy of parking spots. The Pi camera complements this by capturing images or video for visual verification and monitoring. The ultrasonic sensor ensures real-time accuracy, while the Pi camera provides additional data for enhanced decision- making, like identifying vehicle types. Together, they improve parking management by integrating precise detection and visual monitoring for efficient system performance.

Table 1: No. of Vehicles captured

vehicles /number	Distances	Camera captured pictures/ vehicle	Correct part of extraction/picture	
			First-part	Second-part
10	70 cm.	10	1	10
10	50 cm.	10	7	10
10	30 cm.	10	9	10

As indicated in Table 1, the team determined the ranges to be 70 cm, 50 cm, and 30 cm. The outcomes verify that the sensor can operate at these distances from the camera and perform Cloud Vision text extraction. High-quality images are captured by the Pi camera, which also successfully records cars in parking spaces. The text extraction's second and final sections are nearly always accurate. The results are accurate even in low light; therefore, we may use this information to incorporate particular features into the user's smartphone application. Figure 2 shows the ultrasonic detection vehicle at parking and the frequency of parking within a year.

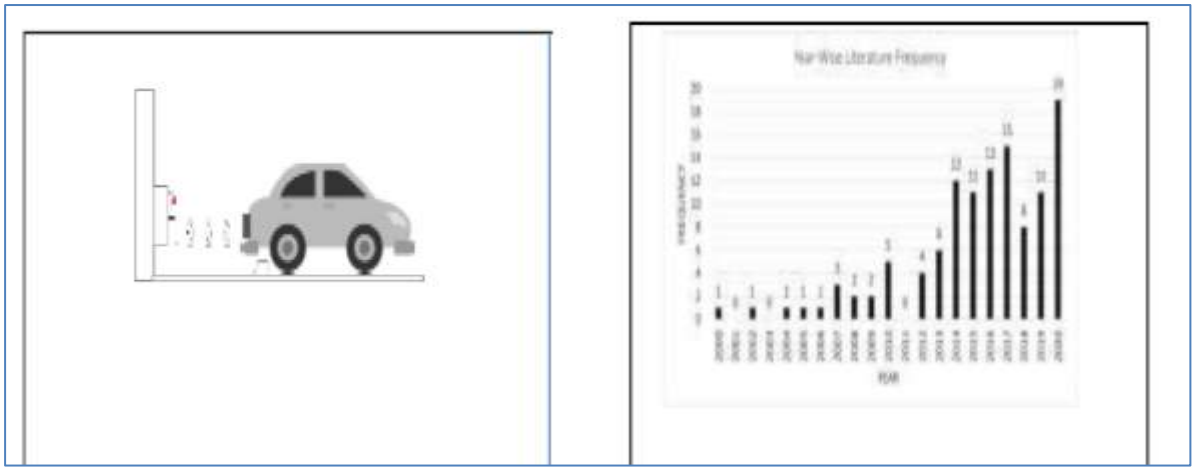

Figure 2: Ultrasonic detection vehicle at parking and the frequency of parking within a year

Parking efficiency has significantly increased because of the use of NodeMCU and IR sensors in a smart parking system has significantly increased parking efficiency. Vehicle presence is precisely detected by IR sensors, and NodeMCU efficiently processes and relays this information. Through a mobile app, the system offers real-time information on parking availability, cutting down on the amount of time spent looking for a spot. Highlights of the discussion include the system's scaling potential, simplicity of deployment, and dependability. This clever approach maximizes urban parking management while simultaneously improving user convenience.

Conclusion

Smart parking solutions driven by the Internet of Things ensure efficient use of urban areas with 97% more precision than traditional sensors. Future advancements in autonomous vehicle integration and predictive analytics for traffic flow optimization have the potential to significantly advance sustainable urban mobility. Furthermore, bycutting down on the amount of time spent looking for parking, real-time data from IoTdevices helps to further minimize fuel usage and emissions. Mobile applications that offer real-time parking information and booking features enable improved user experiences. To further promote sustainability, future developments may use renewableenergy sources to power IoT infrastructure. Overall, the use of IoT in smart parking systems is a big step toward the development of more effective, eco-friendly solutions.

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