SMART PARKIG SYSTEM USING IoT

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Abstract
As urban populations grow, the need for efficient and organized parking solutions becomes critical. Traditional parking systems, especially for outdoor environments, are inadequate in managing high traffic and space constraints. This paper presents an IoT-based smart outdoor parking system that addresses these issues through real-time slot detection using weighbridge load sensors, automated fare calculation, and integration with a companion mobile application. The system enhances user convenience, reduces traffic congestion, and offers automated billing and security.

Keywords
IoT, Smart Parking, Outdoor Parking System, Load Sensor, Real-Time Monitoring, Mobile App.

Introduction

The rapid growth of urban spaces has resulted in increased vehicle density, creating significant challenges in parking availability and management Conventional parking schemes are dependent on manual observation or static allocation, and often result in inefficiency, congestion, and user irritation. Using IoT technologies, these parking systems intelligently integrate sensor networks with decision-making capabilities. The system automatically detects open parking spots, handles billing seamlessly, and lets users reserve spaces in advance. This not only gives drivers more convenience and control but also helps prevent wasted parking spaces. Unlike most existing parking systems that can't scale well, don't offer refunds, and aren't responsive to changing traffic conditions, this system uses an IR sensor network paired with cloud computing to deliver accurate real-time updates and dynamically allocate parking slots. With a mobile app, users can easily manage their parking needs from their phones. To safeguard against unauthorized access and fraudulent transactions, the system uses encrypted communication and AI-driven security measures. A comparison with traditional systems emphasizes the efficiency and effectiveness of IoT- based smart parking systems. The study endeavors to deliver an accessible, secure, and smart infrastructure consistent with urban development objectives.

Literature Review

An IoT-Based Smart Outdoor Parking System by GokulKrishna S., Harsheetha J., Akshaya S., and Jeyabharathi D. presents a sensor-based solution for efficient outdoor parking management. Previous research has attempted numerous methods, such as IoT-based billing and monitoring, parking detection based on WSN, deep-learning vacancy detection, and GPS tracking. Although vision- based and GPS-reliant methods are plagued with issues like cost, complexity, and accuracy, the developed system will focus on sensor-based

detection to offer a stable and energy-sufficient parking automation system that improves security and ease of use in metropolitan areas[1].

P Sathyanathan and his platoon have introduced a smart parking system that uses IoT technology, logical detectors, and remote monitoring to ameliorate parking effectiveness. Recent advancements are now pushing the boundaries of these systems, incorporating IoT, drones, 5G, and deep learning to make them indeed smarter. Some systems calculate on drones equipped with detectors to spot open parking spaces, while others use image processing to determine whether a spot is vacant or engaged. Mobile apps allow druggies to bespeak parking spots and get real- time updates. By using pall- grounded systems and intelligent navigation, it becomes easier to manage business inflow and allocate parking spaces. While deep literacy performs well, it can be precious and delicate to gauge for utmost druggies[2].

Design and Development of IoT-Based Smart Parking System for Campus Area by Yoanes Bandung, M. Fahrel Naufal Aldiansyah, Muhammad Raflie Dwi Putra, and Muhammad Ilyas Irfan Syiraaj proposes a smart parking solution based on IoT suitable for campus settings, with machine learning, sensors, and mobile apps combined to make parking management more efficient.
Past research has tested solutions from AI-based surveillance-based parking systems, multi-agent RFID configurations, and ultrasonic detection systems, to deep-learning-based vehicle classification and prediction models. Although these solutions provide part of the solution, issues persist in optimizing real-time data fusion, parking space estimation, and vehicle identity verification for seamless automation. In contrast to earlier models based on single detection methods, the new system emphasizes holistic integration of IoT, machine learning, and mobile apps to improve real- time parking slot identification, space allocation, route guidance, payment automation, and vehicle orderliness to result in an efficient campus parking experience[3].

Smart Parking Using IoT by Hiba A. Abu-Alsaad and Rana Riad K. AL-Taie offers an IoT-enabled solution to smart parking based on cloud integration to improve real-time availability tracking and reservation management. Existing research has investigated numerous smart parking approaches, such as IoT-enabled mobile apps for slot reservations, sensor-based vacancy detection, deep-learning-enabled vehicle classification, and blockchain-enabled privacy protection schemes. Researchers have explored cloud-infused parking systems with proven advantages in scalability and interoperability, and others have proposed RFID and GPS-based space management models for effective space utilization. Although previous deployments have enhanced the efficiency of parking, they typically struggle with issues of cost, computational overhead, and real-time monitoring. In contrast to previous models, the system under proposal incorporates cloud technology to facilitate smooth communication, real-time monitoring of space, and effective booking functionality, providing a scalable and user-friendly solution to urban parking bottlenecks[4].

Smart Parking System with Pre & Post Reservation, Billing, and Traffic App by Gayatri N. Hainalkar and Mousami S. Vanjale presents an IoT-driven solution for urban parking management, incorporating reservation, cashless billing, and real-time traffic updates. Previous studies have explored intelligent parking systems employing RFID authentication, short-range communication technologies, static and dynamic resource allocation models, and cloud-based frameworks for real- time monitoring. Researchers have developed RFID-based access control systems, mobile- integrated parking assistance, and cloud-enhanced IoT models for urban mobility optimization.
Unlike prior models, the proposed system integrates pre- and post-trip booking, automatic billing, and real-time traffic data accessibility, providing a comprehensive and efficient parking management approach that enhances driver convenience and urban traffic regulation[5].

Numerous researchers have proposed IoT-based smart parking solutions to alleviate traffic congestion in urban areas. Waleed Zahir Al Qaidhi developed a system that utilizes cloud connectivity to provide real-time parking updates and alert notifications. Aashish Joshi, along with
K. M. V. S. and M. H. T., designed a platform featuring QR code-enabled slot reservations and integrated digital payments. Elakya R., Narsingoju R., and their team implemented an LED-based visual indication system to highlight slot availability. In another approach, Amol Pomaji and colleagues employed infrared sensors to detect vehicle presence. Anusha D. H., A. M. S., and M. M. D. H. combined Arduino, RFID

technology, and GSM modules to enable real-time tracking andsecure access. Dipali Balmiki's team introduced a web-based interface for parking slot booking and navigation, while Hannah M. Joseph and A. A. structured their system with distinct user and admin functionalities. M. R. M. Veeramanickam, L. A. Bewoor, and K. Moholkar proposed an Arduino- based model following a first-come-first-serve logic integrated with cloud support. Ashutosh Kumar Singh and co-authors focused on RFID-based identification to guide users to the nearest available slots. Meanwhile, IJEAT researchers utilized a combination of ultrasonic sensors and Pi cameraswith Firebase backend and PayPal payment integration. IJRASET contributors further advanced the field by applying evolutionary algorithms for intelligent scheduling of parking slots. While each of these systems addresses key aspects such as detection, access, or booking, the current study presents a unified and cost-effective model that integrates user interaction, space management, and cloud- based administration into a single scalable framework[6].

Ramesh M, Sriram N, Suganth K M, Shree Tharun Krushna K S, Anitha Rani A, and Kodeeswari K introduced a smart parking solution based on a modified YOLOv8 deep learning model designed to identify vehicles and determine parking slot occupancy in real time. The model was trained on a substantial dataset comprising 13,786 annotated images representing a wide range of parking conditions, including different angles and lighting scenarios. It achieved impressive results, with a training accuracy of 80% and a validation accuracy of 82%, demonstrating high precision and generalizability. The architecture integrates enhanced modules such as Cross-Stage Partial Fusion (C2f) and Spatial Pyramid Pooling-Fast (SPPF), improving its capability for multi-scale object detection. When compared to prior models like YOLOv5 and Mask-RCNN, their system showed superior accuracy and faster processing. Unlike conventional sensor-based solutions, this vision- driven model reduces hardware dependency, enabling greater scalability and cost-efficiency. Their adaptability and high performance make them well-suited for dynamic, real-time parking management in this present urban environment[7].

Abhirup Khanna and Rishi Anand created a system called IoT for Smart Parking that helps cities park more efficiently by adding sensors, cloud services and mobile apps. The system is set up so that each car parking space has an ultrasonic sensor to detect vehicles, with the data about occupancy transported wirelessly to a main Raspberry Pi unit using ESP8266 modules. With this data, the cloud server is updated in real time so that slot availability is monitored for everyone. Thanks to Apache Cordova and AngularJS, users can now view live information about slots and park their vehicles in advance from anywhere, getting confirmation once the reservation is complete. An alert is sent and penalties are applied if anyone tries to use the system without permission. Linking low-cost IoT devices to cloud services produces an inexpensive smart parking system that is both fast and user-friendly for use in cities[8].

Y. Tanvi, B. Lakshmi Sowmya, Prashanth B. N., and Shinu M. Rajagopal developed an IoT- powered smart parking system with the aim of enhancing traffic movement and reducing environmental footprint by reducing unnecessary car idling and congestion. Their system employs ultrasonic sensors to detect the presence of a vehicle in a parking space, with an Arduino Uno being responsible for data acquisition and control of a servo motor to open and close gates. An RGB LCD display is provided to give users real-time feedback on availability of the slots. With approaching vehicles, it dynamically checks availability and grants or rejects access to avoid unauthorized or excessive parking. Low energy consumption is prioritized through effective calibration and low- power hardware elements, which increases system reliability while minimizing costsEveryone enjoys a seamless experience with this system, where parking is managed automatically without the need for human monitoring. The creators present it as a practical and scalable solution for smart cities, one that not only improves parking management but also supports environmentally sustainable urban development. [9].

In order to improve urban parking management through real-time data collection and space optimization, Jan Silar, Jirí Ruzicka, Zuzana Belinova, Martin Langr, and Kristyna Hlubuckova started a large-scale smart parking pilot in Uherské Hradiště, Czech Republic. In order to detect nearby vehicles and send this information via the Sigfox IoT network, they installed magnetometric sensors on streets and at intersections. magnetometric detectors on thoroughfares and at corners. While megacity officers viewed the data via a central dashboard, druggies entered real- time updates via a mobile app. This made it possible to track and

dissect business and residency data in real time, which bettered pricing, enforcement, and transportation planning. The integration of spatial analytics and Civilians tools, which made parking exertion easier to fantasize and manage, was a crucial element of their design. Above all, the system showed that significant functional advancements could be achieved without the need for fresh structure, and it was honored as a precious donation to smart megacity development [10].

ParkSmart, a smart parking payment system created by Wong Jin Wah, Sathiapriya Ramiah, and Intan Farahana Kamsin, aims to fully digitize traditional ticket systems. Their system reduces business at entrances and does down with paper tickets by exercising License Plate Recognition LPR) technology to enable buses to enter and exit parking lots automatically. By using a mobile app, druggies can accessibly pay for parking without having to deal with workers or use ticket machines. The authors conducted a user survey to evaluate the system's potential and discovered that time-saving contactless parking solutions were highly desired. contactless parking results were largely asked . Despite not being considerably used at the time of the study, ParkSmart was a promising fit for smart parking because of the rising demand for new parking technology [11].

Anurag Gupta, Gyan Pratap Singh, Sanchita Ghosh, and Bharat Gupta erected a system that incontinently predicts how numerous parking spaces will be available at any moment with the help of LSTM networks. The system gathers and processes real- time parking lot residency data using jeer Pi boards, Pi cameras, ultrasonic detectors, and an Internet of effects platform. Using information from cameras deposited at the entrances and exits, a Haar Cascade Classifier is used to identify motorcars. An LSTM model examines once trends to read when parking spaces will probably open, and parking statistics are streamlined to Firebase every five twinkles. The model has demonstrated reliable performance in prognosticating parking vacuity, with a mean absolute error of 643 and an R2 of 082. druggies can plan their parking in advance and admit these prognostications through the companion mobile app, which lowers charges and the environmental impact. AI integration offers a scalable, provident, and environmentally responsible system of managing civic parking [12].

Parking in metropolises with numerous vehicles by linking live niche status with directions to those spacesAn infrared detector is used to descry the presence of vehicles, and its readings are reused by an Arduino ATmega2560 microcontroller. The data is also transmitted via an ESP32 Wi- Fi module to the Blynk cloud platform, allowing real- time updates to be viewed through a mobile operation.To help drivers navigate inner parking areas, LED pointers point to available spaces, while servo motors automatically control the opening and ending of entry and exit gates. The prototype was tested under realistic scripts to estimate its responsibility and functionality. These tests vindicated that the system performs well in practice. Thanks to its low cost, fast deployment, and user-friendly design, this result is well- suited for smart municipality operations that aim to ease business flux and optimize the use of communal parking spaces.[13].

Samyak Jain, Rajashree Jain, Shubhi Gupta, and Bhavana Narsingoju suggested a smart parking strategy that uses sensor technology and wireless communication to guarantee real-time operation, that uses detector technology and wireless communication to guarantee real- time operation. Three main modules make up their tripod- shaped system one for executive control, one for parking space operation, and one for stoner commerce. **These modules are each connected via the pall**. The prototype uses a servo motor, NodeMCU, Arduino UNO, and infrared detectors to automate gate control and descry vehicles. Through a mobile operation, druggies can view space status grounded on real- time niche vacuity data that is uploaded to the Blynk pall. also, an TV display gives motorists on- the- spot instructions. When tested using a configuration with two parking spaces, the prototype showed reliable and prompt operation. Despite being firstly intended This system can be gauged for use in smart megacity settings for domestic complexes and seminaries. Although the authors point out that adding payment integration and more sophisticated niche allocation could further increase its utility in larger civic settings, its affordability and simplicity are its main advantages.[14].

S. Rajalakshmi, A. B. Haripriya, B. Supriya, and A. Usha, In the system, microcontrollers, ultrasonic detectors and Wi- Fi modules are used to understand if a vehicle is there and to shoot its residency details to the main garçon. An app is offered for druggies to check available parking, so they can fluently find a

parking spot. Since energy effectiveness, constant niche discovery and remote control are its main features, the model is ideal for introducing into smart metropolises. While the main purpose is to find and track intrusions, the authors believe that new developments should concentrate on adding payment results and handling big megacity networks. The findings suggest using both bedded technologies and wireless links to make a parking operation system that adjusts to different situations[15].

Comparative Analysis

Sl. No.	Authors	Techniques Used	Key Outcomes and Findings
1	**GokulKrishna S. et al.** *(Base Paper)*	NodeMCU, load sensors, LED indicators	Developed an outdoor-focused parking system using weight-based detection; real-time status indicated via LEDs; future plans include app support and QR-based payments.
2	**Ramesh M. et al.**	YOLOv8, deep learning, image classification	Achieved high-performance vision-based detection (99% training, 97% validation accuracy); eliminated need for physical sensors; suitable for scalable, automated environments.
3	**Khanna & Anand**	Ultrasonic sensors, Raspberry Pi, MQTT cloud	Enabled real-time monitoring, remote booking, and fine management; mobile interface built with Cordova; demonstrated integration with IBM cloud services.
4	**Y. Tanvi et al.**	Arduino Uno, ultrasonic sensors, LCD screen	Provided a cost-effective automated system with live status updates and gate control; emphasized energy efficiency and user accessibility.
5	**Jenila C. & Harshan K.**	IR sensors, Arduino UNO, servo motor	Proposed a fully offline, hardware-centric parking model; offered slot indication via LCD; ideal for environments without internet access.
6	**Deepak Bhatnagar et al.**	IR sensors, ESP32, ATmega, Blynk platform	Combined mobile app, real-time tracking, and indoor slot guidance using LEDs; demonstrated successful field testing and responsive control.
7	**Anurag Gupta et al.**	LSTM model, Pi Camera, Haar Cascade, Firebase	Implemented predictive parking using time-series data; achieved a low error rate (6.43%) and strong predictive accuracy (R^2 = 0.82); integrated cloud updates.
8	**Jan Šilar et al.**	Magnetometers, GIS tools, Sigfox IoT network	Conducted a real-world pilot project; provided spatial analysis for turnover and pricing decisions; demonstrated GIS-based parking optimization.
9	**Wong Jin Wah et al.**	License Plate Recognition (LPR), mobile app, cloud integration	Designed a digital payment system with automatic vehicle recognition and ticketless access; validated through user surveys; enhanced the contactless experience.
10	**Samyak Jain et al.**	IR sensors, Arduino UNO, NodeMCU, Blynk	Introduced a three-module system (user, slot, cloud) for real-time monitoring; app and LCD used for slot visibility; focused on cost-efficiency and simplicity.
11	**Rajalakshmi et al.**	Logical sensors, Wi-Fi communication, mobile interface	Delivered a low-power system with remote monitoring functionality; emphasized modularity and smart city compatibility.

Sl. No.	Authors	Techniques Used	Key Outcomes and Findings
12	**YOLOv8 Enhanced (Ramesh M)**	Deep learning (C2f, SPPF), large dataset	Outperformed earlier models like YOLOv5 and Mask-RCNN in detection tasks; ideal for environments requiring real-time vision-based classification.
13	**LSTM Enhanced (Gupta et al.)**	LSTM + Firebase integration	Offered advanced forecasting of parking slot usage; useful for proactive traffic management and reduced vehicle wait time.
14	**ParkSmart (Wah et al.)**	LPR + mobile payment	Provided a fully automated, contactless parking experience; included QR code payments and real-time booking via app.
15	**Smart City GIS (Šilar et al.)**	Magnetometric detection + spatial analysis	Highlighted use of geographic data to manage occupancy and pricing; required minimal infrastructure expansion.

Results/Discussion

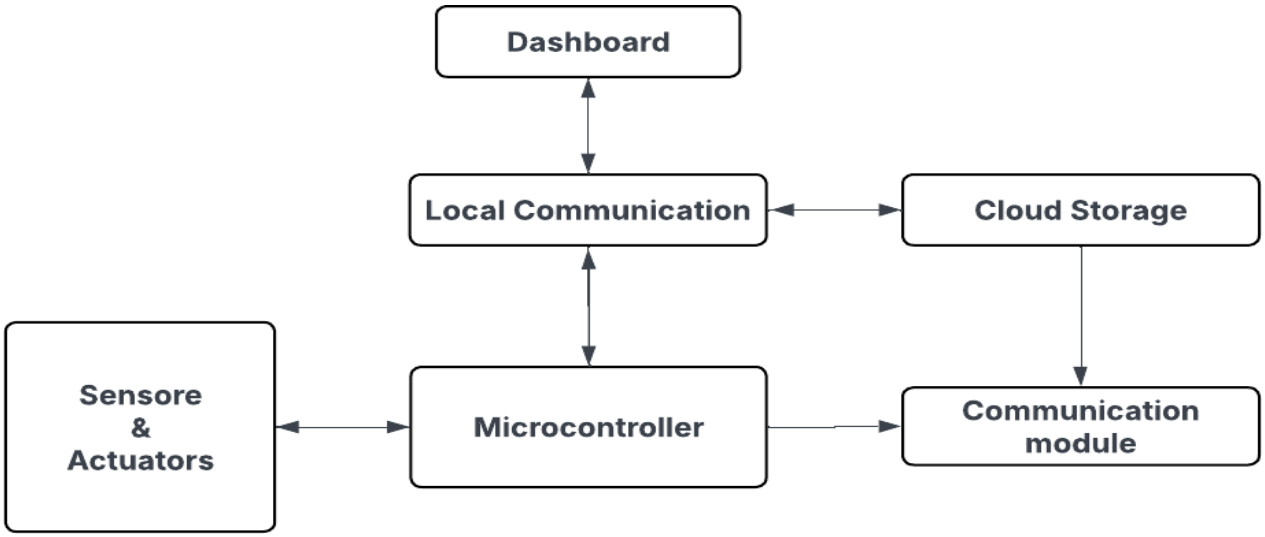


Fig 1: Block Diagram of SPS

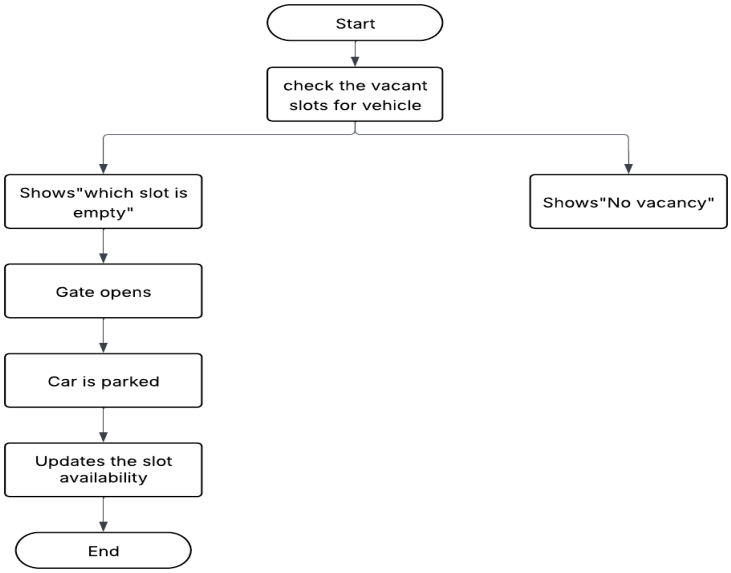


Fig 2: Proposed Flowchart

The flowchart illustrates the functional flow of an automated vehicle parking system, starting with a check for available places upon vehicle arrival. However, the system displays the empty niche information, opens the gate , if places are available. Once situated, the system updates the vacuity of parking slots. However, the system shows a “No vacancy” communication and the process ends, if no places are available. This flowchart effectively visualizes a smart parking system where automated niche discovery, gate control, and dynamic vacuity updates insure smooth vehicle operation.

Conclusion

The growing adoption of IoT, artificial intelligence, and embedded systems has significantly advanced the development of smart parking technologies. A variety of approaches—from sensor- based detection and cloud-enabled monitoring to AI-driven image processing and predictive algorithms—illustrate a clear move away from traditional parking methods toward more intelligent, automated frameworks. Practical implementations, such as those by Khanna and Anand, and Y. Tanvi et al., demonstrate how microcontrollers and mobile platforms can support real-time monitoring and slot access. Advanced models by Anurag Gupta et al. (LSTM) and Ramesh M et al. (YOLOv8) further highlight the role of machine learning in forecasting occupancy and enhancing detection accuracy. Additional innovations, including indoor navigation (Bhatnagar et al.) and GIS integration for urban analytics (Šilar et al.), reflect the growing importance of spatial intelligence in urban mobility. These systems consistently emphasize scalability, security, and user experience, often through app-based interfaces and real-time dashboards. The ParkSmart system also illustrates a shift toward digital payments and contactless user interaction. Looking ahead, developments such as edge computing and reinforcement learning are expected to make smart parking systems faster, more autonomous, and better suited for high-density urban environments—ultimately supporting smarter, more sustainable cities.

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