RESEARCH PAPER

PARKSENCE: A Real-Time Vehicle Tracking System With Integrated Slot Management And Advanced Lane Detection

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Abstract: This paper deals smart parking system that utilizes an ESP32 as its central control device and IR sensors to detect the presence of vehicles in addition to receiving live updates of the status of each space via the Internet when users scan a QR code. The proposed system provides to the users with instant updates on the status of real time parking spots and incorporates a buzzer that notifies drivers of illegal parking activity. A central database server is used to maintain the status of each parking space by keeping track of the status of booking transactions and maintaining historical records for the continued pursuit of quality improvement. The prototype provides a user-friendly interface, improved space management and decreased congestion. The implementation of the prototype contributes to the smart cities initiative by providing effective and sustainable solutions. The proposed system provides a reliable, scalable solution for future parking frameworks.

Keywords: Smart Parking, ESP32, IR Sensor, QR Code Payment, central database server, Real-time parking Slot, Booking Portal etc

How to cite this article: Ediga CG, A A, Chiluka SK, Sheik AG, T N. PARKSENCE: A Real-Time Vehicle Tracking System With Integrated Slot Management And Advanced Lane Detection. Int J Drug Deliv Technol. 2026;16(41s): 928-939. DOI: 10.25258/ijddt.16.41s.97.

1. Introduction

Library customers face critical parking problems including traffic congestion and space inefficiency and elevated fuel use thanks to fast-growing urban transportation rates. Standard parking management methods depend on manual methods that operate at slow speeds and produce minimal effect. Smart parking systems utilize IoT technologies to perform real-time monitoring functions and establish automatic slot management systems which solve these parking issues. Modern infrastructure automation depends on IoT systems to function as its core essential element. Smart devices working with cloud-based storage through real-time monitoring give us IoT systems which deliver better efficiency alongside stronger security along with enhanced scalability. An IoT-enabled system runs independently to carry out parking slot management without requiring human operations which leads to precise slot allocation and automated system operations. A modern parking system powered by IoT technology has become necessary to address current parking problems.

Urban areas deal with escalating parking problems which result in traffic jams and superior pollution rates and unnecessary fuel consumption together with driver wrath. Current parking management tactics deteriorate because they do not employ real-time tracking along with automation therefore people must spend lengthy periods searching for available parking spots. An efficient smart parking system that operates through IoT-based automation stands crucial for managing smart cities because it maximizes parking space utilization and lowers traffic issues and elevates parking security. The development of an IoT-based parking solution stands as an emergency because it requires real-time updates with remote access and automated management functionalities. Many researchers are extensively worked in the intelligent parking systems over a decade[1][2].

A new parking system [3] using USP CCTV cameras was developed based on User Centered Design to provide a simple solution without major infrastructure changes, involving stakeholders like staff, students, and visitors in the design process. The research evaluated users residential parking difficulties by way of interviews and co-design workshops and demonstrated to the developers usable techniques for implementing IT tools have been developed collaboratively with users [4]. Hainalkar and Vanjale proposed an entire solution for managing parking resources [5], which includes the functionality for reserving spaces, processing payments, and monitoring traffic flow; the goal of this solution is to increase the ease of the user's journey through allowing both pre- and post-reservation processes via a dedicated mobile application. The final product will have reduced wait times as well as providing greater convenience to the driver. The integration of billing

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with the parking process should enhance the overall parking experience.

In addition to proposing a novel smart parking system design that integrates technologies like WSN, IoT and RFID, this article compares different architectures and self-organization protocols for managing urban parking lots [6]. To increase WSN performance and endurance, optimize sensor node deployment, reduce implementation costs, the suggested system incorporates a hybrid, flexible self-organization protocol [7][8]. To solve typical parking problems in buildings, the article suggests an IoT-integrated smart parking system [9]. By simplifying parking access, lowering traffic, maximizing lot usage, and acting as an affordable substitute for valet services, SPS is anticipated to benefit patrons, parking employees, and mall management. It may also find wider use in other congested locations of Jakarta [10]. A multi-layer IoT-based smart parking system using LoRa communication [11] was suggested to enhance parking services by allowing bookings in advance, using fog computing to process real-time data, and implementing dynamic pricing to optimize profits [12]. Improved arrival times and higher parking authority revenue were shown by the technology when it was implemented and simulated at the Kudai parking lot.

This feasibility study [13] proposes a smart parking architecture leveraging IoT technologies to deliver innovative services for both public and private urban parking management. Through outlining technical requirements, design choices, and information flows, the study demonstrates that a reservation-based parking policy can streamline operations and reduce city traffic congestion. To solve wasteful slot usage [14], traffic, and security concerns, this paper presents a clever real-time parking management system that uses artificial intelligence (AI). It provides dynamic slot allocation, booking, and accurate parking verification through two sensor-based technical solutions. The system has been tested in the field for validation of its effectiveness and existence. The system also has real-time web-based vehicle identification capabilities via IoT Devices [15].

Askarbek and Bahrami [16], addressed the user interface design of the smart parking system. There are numerous features associated with enhancing user interaction and facilitating increased operational efficiency. They provide examples of how user-centric design can solve real-world problems associated with urban parking. A focus on usability also provides valuable insight for influencing the adoption of smart parking systems. A hardware-focused IoT solution for addressing urban parking challenges has been developed by Jenila and Harshan [17]. This solution allows for real-time monitoring of parking space availability and the effective allocation of parking resources. The publication illustrates how the Internet of Things (IoT) devices can provide accurate data to assist in the daily use of parking spaces to improve user experience and optimize parking space management to minimize congestion. In their work above, Dalal, et ai., D. R.K. Raja, and U. Ashwin Kumar [18], create a low-cost/sustainable smart parking solution utilizing IoT technology powered by renewable energies, specifically the use of solar energy to reduce environmental impact. This design will provide cash flow while assisting with the development of global sustainability and green urban infrastructure [19].

The authors also explore the ability of LoRa technology [20] to assist with the development of a scalable smart parking system. Because of its ability to transmit data very long distances with minimal use of electricity, LoRa is very suitable for large cities. In this paper, we show how LoRa enables dependable communications between sensors and management systems. Our proposed system takes advantage of LoRa's capabilities to increase scalability and minimize power and operating costs. The Smart Bike Parking System proposed in [21] is built upon an Arduino Uno with infrared sensors to automatically facilitate bicycle parking by enabling access through a gate and providing updates on availability of parking slots through an LCD display and voice module. The Smart Bike Parking System improves efficiency and customer service by conducting automatic slot assignments and allowing voice instructions to navigate customers to their assigned slots without requiring them to use a mobile application.

Multiple urban development setbacks result from insufficient parking spaces combined with weak monitoring practices together with parking lot congestion problems [22]. The absence of intelligent management collects both transportation resources and available parking space to their optimal potential. The current manual parking approaches experience multiple disadvantages including human mistakes along with unlawful parking practices and unsafe conditions [23]. An advanced automated parking system requires development because it needs to track slots in real-time to maximize parking management efficiency [24]. The present parking management systems driver irritation combined with raised emission levels through excessive idle times and poor allocation of parking areas remains a critical issue. Real-time data accessibility creates difficulties for drivers to locate vacant parking spots thus their search durations increase, and traffic congestion intensifies [25]. The lack of a centralized database stops parking facility managers from successfully tracking available slots and implementing parking rules which leads to disorder in parking spaces [26].

The Intelligent Parking Lane Detection and Slot Management System resolves urban parking problems through combination of IoT-enabled automation and real-time monitoring with cloud computing infrastructure. The combination of infrared sensors with an ESP32 microcontroller and a Firebase centralized database enables the system to achieve real-time parking slot monitoring, and it provides users with uninterrupted service through its operation. The parking system achieves higher security through its LPR technology which monitors unauthorized

vehicles, and its web interface enables users to use remote QR codes to check availability and reserve spaces. The system features work together to decrease traffic jams and decrease fuel consumption and maximize space use which leads to efficient parking operations. Sustainable smart parking system implementations occur through this project which supports smart city development strategies. The parking system removes human operator involvement through automation and reduces environmental effects and delivers structured parking administration methods. The system could be improved by AI analytics for forecasting parking needs as well as mobile app integration and support for multiple floor parking facilities in future development. This smart parking system builds an effective base for contemporary technology-based parking solutions through its enhancements to mobility efficiency and security systems and real-time automation abilities. The primary mission of this project involves creating an IoT-based parking management system to boost operational efficiency and create user-friendly and secure systems.

In this research study, the recommended approach are organized in section 2. The design and Implementation have discussed in the section 3, the functioning model with results is presented in section 3, and the conclusions are presented in the last section. The system was planned to implement these functions:

- IoT-based sensors when combined with microcontrollers establish real-time slot detection parameters in the smart parking system.
- Atmospheric pollution decreases and vehicle fuel drains minimizes because users get instant notifications about available parking spots.
- A real-time parking data management solution will be achieved with Google Firebase as the centralized cloud database.
- A camera module that performs license plate recognition should be added to the system for security purposes so only authorized vehicles can access.
- Users can access parking slots and book space information through a web-based system that implements QR code scanning capability.
- A notification automation system should deliver instant alerts to users about reservation availability and receiving booking verifications along with security notifications.

2. Proposed Method

The proposed solution integrates an IoT-based smart parking system which employs ESP32 microcontroller and IR sensors with camera module to perform vehicle detection tasks and security management. Real-time updates as well as remote accessibility through a web-based dashboard together with seamless data storage are made possible by the centralized cloud database (Google Firebase). Instant notifications through the system together with automated booking facilities and unauthorized parking prevention capabilities improve parking management capabilities.

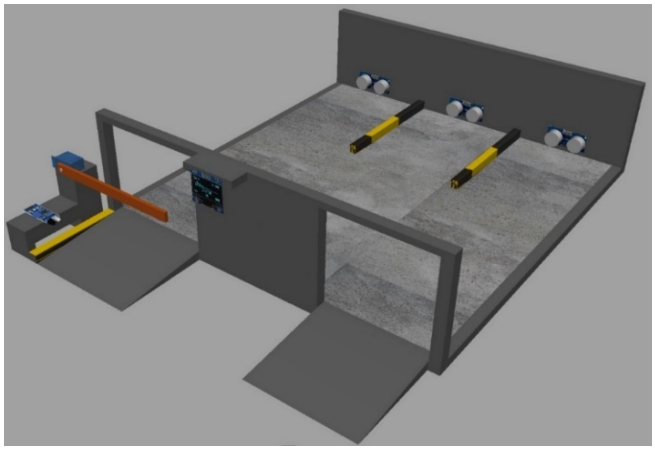

Figure. 1 Proposed Method 3D Model.

The combination of IoT technologies that share information helps parking management with fewer hassle from confused drivers. With its smart interface users can obtain current parking status across distances to guide them toward accessible spots leading to better user satisfaction. The system maintains flexibility in its structure to adapt to accommodating various parking spaces from airports to smart city setups and corporate campuses together with shopping malls. This initiative unites automation with security and remote system access to develop major effects on urban mobility technology and smart infrastructure construction.

The Intelligent Parking Lane Detection and Slot Management System operates through IoT technology to establish a smart parking system that delivers higher efficiency with better convenience along with safety benefits. Traditional parking systems present two main problems that include human-manual slot observation and poor space optimization together with dangerous vehicle congestion and security risks. This project resolves current difficulties through its implementation of real-time observation systems which combine automatic parking slot control and cloud-focused

information management to boost parking user satisfaction.

Real-time slot detection functions through the combination of infrared (IR) and ultrasonic sensors according to this system's main purpose. The data from parking slots gets sent to web-based dashboards that users can access through their devices by means of vehicle detection sensors. Real-time slot availability checks through this system do not require human assistance and enable drivers to locate parking spots more efficiently thus reducing their search duration. This system works to decrease traffic slowdowns together with fuel needs and pollution giving cities a more environmentally friendly profile.

Parking management systems are becoming more efficient and scalable by using Google Firebase as a cloud database platform for all the data related to parking management. With Firebase, everyone (both users and parking administrators) can access and manage their parking data in real-time, which will improve the overall experience for each user because they will not have to wait to receive their information about slot availability, parking history, etc.

In addition to being an efficient way of managing parking data, the system also incorporates a camera module that provides LPR (License Plate Recognition) to help improve the security of each reserved parking space because only authorized vehicles with 'valid' licenses plates can be allowed access to the reserved spaces. By using LPR technology, it becomes easier to enforce parking regulations and eliminate unauthorized vehicles from taking up parking spaces that should be available for users of the parking management system.

A notably important part of this initiative involves creating a simple user-friendly web interface that allows users to view slots available, book them, and complete their payments via QR code (for the purposes of automating many aspects of today's antiquated ticketing and manual checking of parking payments). There is also an automated notification feature within this system; users will receive real-time notifications alerting them to their new reservations (bookings) as well as alerting them to security risks associated with their current parking situation. By using automation (via IoT), the cloud, and Computer Vision, the overall service; this program provides both a scalable and future-ready smart parking solution that can yield better utilization of available space, reduced congestion from traffic, greater security for parked vehicles, and an overall higher experience for users meeting objectives set forth in creating smart cities and sustainable communities.

3. Design and Implementation

The hardware architecture for the Intelligent Parking Lane Detection and Slot Management System is designed for efficient real-time automated management of parking systems. A fully integrated architecture consisting of the ESP32 Microcontroller, IR Sensors, Ultrasonic Sensors, Camera Module (for plate detection using Optical Character Recognition), OLED (for displaying data), Servo Motor (for moving gates), and Buzzer (for notifying users when their vehicles have entered/left an assigned space).

The ESP32 Microcontroller is used as the central processor to collect and communicate data in real-time. Infrared and Ultrasonic Sensors are used for accurate detection of vehicles, and the camera module uses OCR to recognize vehicle plates for automated security purposes. The servo motor functions through the OLED display for displaying real-time information while operating the parking barrier to achieve continuous parking access. The buzzer improves user interactions through its capability to generate audio alerts which notify users about confirmation messages and warning signals. The system demonstrates economic power usage combined with precise calculation and consistent operational capability because of its thoughtfully selected hardware elements which enable system scalability for smart city purposes. The system delivers an intelligent solution to urban parking problems while optimizing space efficiency and minimizing traffic congestion and delivering better user comfort.

An Intelligent Parking Lane Detection and Slot Management System runs through a well-designed software architecture that combines sensor data processing operations with slot management functionalities and user interface functionalities. Real-time port and automation functions work through embedded programming and cloud and web technologies while communication pathways are enabled through the software architecture. The ESP32 microcontroller requires programming through the Arduino IDE for data acquisition from IR and ultrasonic sensors enabling Wi-Fi network transmission to the centralized system. Embedded C has been implemented to drive the ESP32 and enhance its data processing while maintaining real-time control over sensors. The Google Firebase system provides the data storage solution for real-time cloud operation. Through the Google Firebase platform users obtain real-time parking slot status updates while they can reserve slots remotely. Firebase enables users to authenticate their accounts and manage database structures as well as send notifications. The platform uses HTML and JavaScript together with CSS to build a user-friendly dashboard system to monitor and reserve parking spaces on the web interface. The ESP32 uses HTTP or MQTT protocol for backend communication to deliver secure and rapid data exchange with Firebase. The system achieves a dependable automated and user-oriented smart parking solution through the integration of embedded programming and web technologies with cloud services. The web interface is constructed with HTML and CSS and JavaScript elements that combine to build an appealing interface for user experience. A web interface starts with HTML which serves as its base development code. The webpage's structural design as well as its

organizational scheme is determined by this code. Web interfaces gain their visual design elements from CSS which stands for Cascading Style Sheets. The dynamic aspects and interactive functions of web-based interfaces result from JavaScript application. The page avoids reloading because JavaScript supports interactive features that include form validation as well as animations and real-time updates. The API integration capabilities of JavaScript allow it to exchange data with servers. When developers apply these three technologies, they can build contemporary web interfaces which reply to different screens and offer full interaction for applications ranging from basic websites to complicated web-based systems.

The cloud interface based on Firebase allows developers to build applications that connect web and mobile platforms while using real-time database and cloud services. Google's Firebase platform provides backend capabilities which include authentication along with database management capability and cloud storage solution and hosting services through an interface while eliminating the need for advanced server-side programming. Through its Realtime Database and Firebase platform Applications can perform real-time data storage and synchronization operations. The authentication services support protected user access through email accounts together with phone numbers and various social media options. The web application deployment service Firebase Hosting works together with the server-side logic execution capability of Firebase Cloud Functions. Because of its built-in security features along with its adaptable nature and platform compatibility Firebase delivers uncomplicated cloud-based development which works optimally for producing complex connected applications requiring minimal backend maintenance.

Current urban development alongside rising motor vehicle numbers makes efficient space management for parking vehicles a priority in contemporary metropolises. The traditional parking approach leads to chaotic street scenes while causing vehicle fuel consumption problems and driving stress because it fails to utilize parking space well and makes vehicle owners waste time searching for empty parking spots. IoT-based Smart Parking System overcomes existing parking issues through the implementation of ultrasonic/IR sensors as well as ESP32 microcontrollers and cloud resources alongside QR codes for interface control and automated accounting systems. Right-time data management, cloud service connectivity, and smartphone-enabled access combine to create a system that optimizes parking spots while decreasing traffic delays and providing users with enhanced solutions.

The smart parking system detects empty parking spots through Internet of Things (IoT) technology which transmits the information to users through cloud-based software. High-tech assets including vehicle detection sensors and wireless transmission module (ESP32) data storage housed on a centralized cloud server with mobile or web user interface functionality make up the system fundamental components. The system implements an automatic gate entry and exits process through a servo motor along with the automated control mechanism. The proposed technique functionality of this system are:

- Real-time Parking Slot Detection: Monitors available and occupied slots continuously.
- Automated Access Control: Uses QR code authentication to manage entry and exit.
- Remote Monitoring & Management: Enables parking lot administrators to oversee operations via a centralized dashboard.
- Security operations along with space management compliance become more efficient because the system stops unauthorized parking and optimizes space organization.
- Real-time data presented to users minimizes vehicle traffic due to the reduced need to search for empty parking spaces.

The system proves suitable for different parking facilities ranging from malls through corporate offices to residential sites and public parking's. The system establishes pioneering standards in intelligent urban mobility by using IoT and cloud-based technologies together.

The connected components which support efficient parking management are depicted in the diagram for IoT-based Smart Parking System. Real-time data transmission occurs between ultrasonic sensors and infrared sensors and the ESP32 that stands as the central processing unit of the system. The Wi-Fi communication capability of the ESP32 transfers sensor readings from its devices to a cloud server while enabling perpetual remote data updates. Parking spaces have real-time occupancy data records saved in the cloud and available to users via web systems and other digital interfaces.

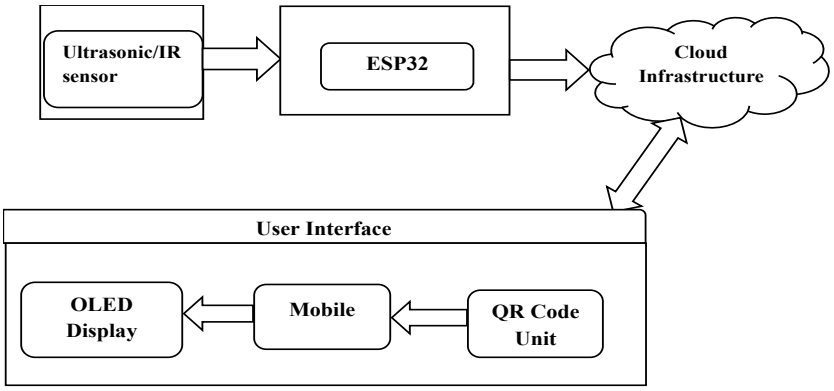

Figure. 2 Block diagram of the PARKSENSE.

The entrance of the facility has an OLED display that provides drivers with immediate visual information about available parking spaces so that they can decide which one to utilize. Authentication of parking spaces is provided via QR code scans that allow users to reserve parking far in advance. A servo motor-controlled gate will open and grant access to the vehicle once it is allowed access due to the availability of reserved or unreserved spaces. Buzzer alerts within the system will provide warnings to drivers if there is a violation of the parking authorization system so that the parking system can remain orderly and efficient. The entire system streamlines the convenience of parking by reducing congestion for parking and preventing unauthorized access while maximizing the efficiency of parking by using active space monitoring and artificially controlled access systems. This system also provides very flexible commercial and residential and public parking solutions that provide secure and easy ways for users to manage their urban parking needs.

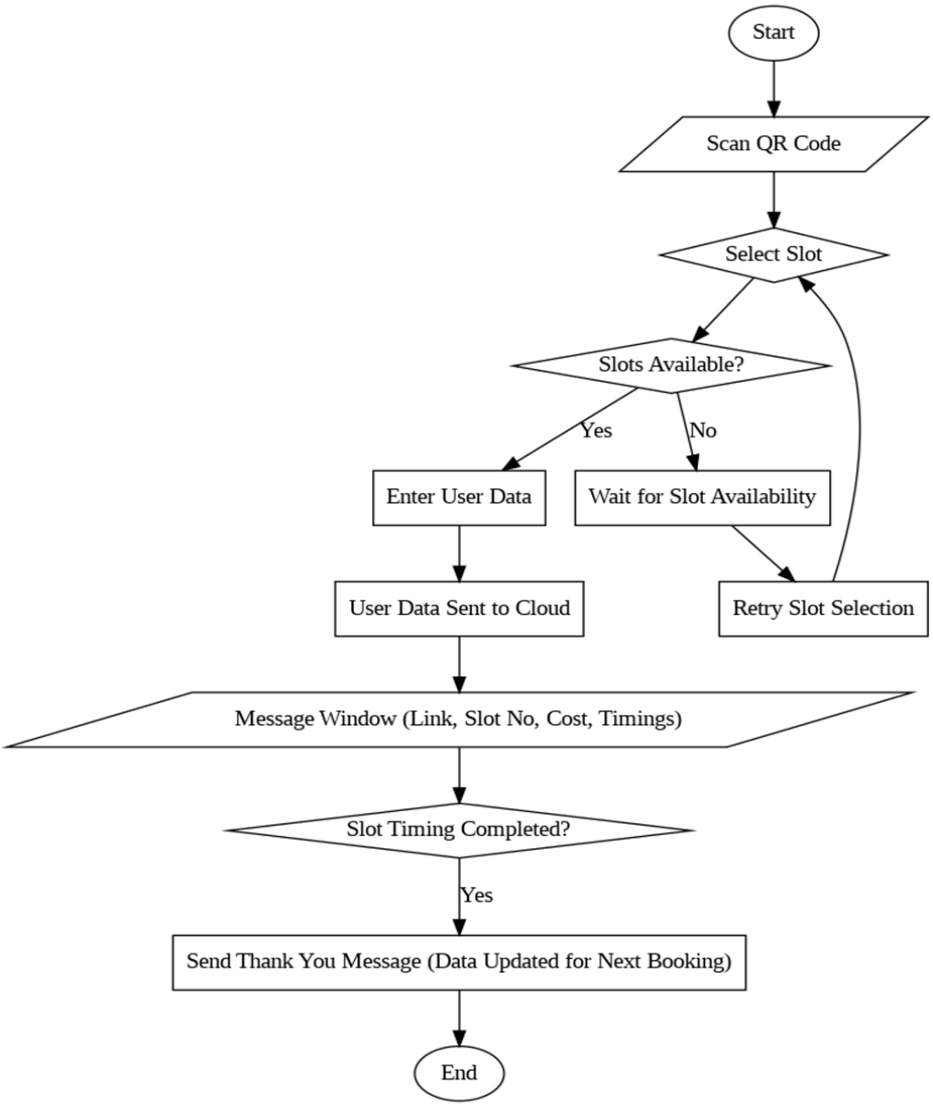

Figure. 3. Proposed Flow Chart for PARKSENCE.

It helps manage parking slots by detecting vehicles parked or moving in/near them through sensors. The ESP32 microcontroller acts as the main computational unit that connects the various peripheral devices (ultrasonic and infra-red sensors, servo motors, and an OLED display). This unit oversees all communications with these devices, and processes received signals from these devices to provide real-time information about available parking slots for users on a live feed. The microcontroller supports I2C for regulating display control plus UART for external network connectivity. The system obtains operating power from a 5V supply that supports all necessary components.

The system operates with three ultrasonic to determine vehicle distance measurements together with detection of parked vehicles. The system connects trigger and echo pins to the ESP32 which enables instant sensor data processing. Two IR sensors operate with the main purpose of improving vehicle detection efficiency in short-distance scenarios. Two servo motors operate automated barriers through slot availability to control entry and exit operations. The user interface for viewing up-to-date parking status works through an OLED display module. The IoT technology-based smart parking system improves urban mobility through automatic, effective and instant parking lot space oversight capabilities. The development and functionality have pictorially represented in the given flow chart figure 3.

Initially live data monitoring detects free parking slots instantly through sensor networks which use cloud systems. The system delivers active updates to end users alongside administrators which minimizes parking jam occurrences. Reporting and detection immediately allow administrators to take swift decisions which leads to better parking efficiency together with enhanced user convenience. The system uses sensor technology and intelligent algorithms together to perform automated distribution of free parking spaces without needing human involvement. The system increases operational speed while decreasing errors made by humans and expanding parking operation speed. This approach

delivers maximum parking space efficiency which stops excessive vehicle density thus creating a better parking environment. Cloud-Based Data Management: Ensures remote access and centralized storage.

Users can easily access parking information because the system provides both mobile and web applications through an interface that is easy to use. Intuitive navigation system exists alongside real-time update features and makes secure payment processing accessible. Simple user interfaces lead to more system usefulness which in turn generates more users for managing parking efficiently. The system achieves energy efficiency through its adoption of low-power components which include IoT sensors along with LED indicators. The equipment uses negligible electricity which cuts operational expenses without affecting system availability. An energy-efficient system promotes environmental sustainability because it lowers power requirements as well as dependence on non-renewable fuel sources. The system stops unauthorized access through its security features based on QR code authentication methods. Accurate real-time information about parking slot availability decreases the amount of vehicle traffic inside parking lots. Vehicle operators locate open parking spaces more rapidly so both traffic slowdowns and vehicle delays decrease. The system boosts traffic management by saving fuel and reducing pollution which enhances overall efficiency of busy areas. Hotel and vehicle locations are saved to databases that establish parking patterns to support resource development.

Through IoT-based Smart Parking System urban parking management receives a modern transformation which combines real-time monitoring with cloud-based data processing and user-friendly automation. By implementing this system building space better while also decreasing traffic congestion and boosting security levels. The system delivers an intelligent parking solution through its tools of automated slot detection and wireless communication and QR code authentication. This smart parking organization can support three kinds of locations: businesses, homes, and public facilities. The introduction of intelligent parking services will help form a stronger base for fast and reliable urban movement services in cities as they grow. Through integrating AI-based analytics and forecast modelling in developing areas, city management of parking areas will be able to operate much more efficiently so parking management can be done with the least amount of work possible.

4. Working Model and Results

The Parking Lane Detection & Slot Management System is a web-based, interactive system that facilitates the monitoring of parking availability at any moment in time and allows users to book parking slots with ease. The system's range of functionality includes the integration of IoT based sensors, a camera module for monitoring real-time activity, and an intuitive user interface that is designed to make managing parking more efficient. Below are the steps taken for working with this system and the results are follows as

How it Works:

STEP 1: Booking a spot after scanning to see if any are available - if no spaces are open, the user must wait until they are available.

Figure. 4 Booking Process QR Code**.**

STEP 2: After reading QR code, a user interface will appear on the screen to review lane detection and select a spot. When a spot (e.g., SLOT 1, SLOT 2, etc.) becomes available, the user must enter the following:

- **Name:** required for identifying who is reserving the spot.
- **Telephone Number:** for notifying the user and communicating.
- **Email Address:** for receiving confirmation and a receipt.
- **Choose an available spot** (ex. SLOT 1, SLOT 2, etc.)
- **Time of Reservation:** the expected time of arrival and departure (using 24-hour clock).
- **Payment Scanner** - used to complete transaction.

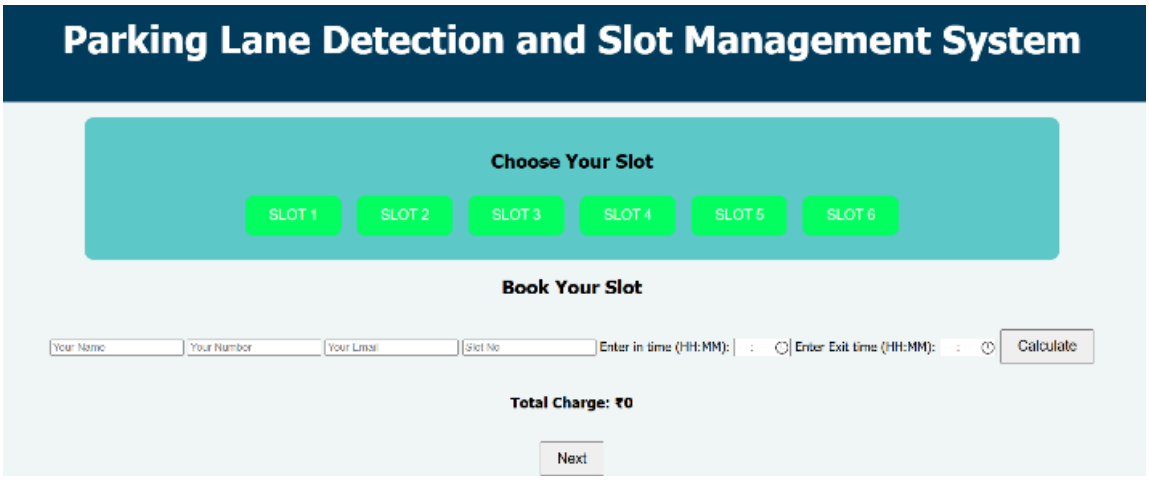

Figure. 5 UI Window of Booking Process.

STEP 3: Data sent to cloud service provider - information entered is securely transmitted from the mobile device to a cloud service provider where it is processed. Once processed, booking will be confirmed.
STEP 4: USER receives confirmation via email or text based on data collected during registration.
STEP 5: When the correct time has been used for your reservation, you will be sent an email and a text message informing you of this via the original reservations system. In the event you go beyond your reservation time, you may incur additional costs and you will receive a warning letter of the expiration. If you have exceeded your reservation period, that slot will now be made available to other users to book new reservations against at that point in time. Your final email confirmation will include the following statement: "Your time is now complete! Thank You for using our original reservations system! You can make a new reservation at any time and from any place by clicking [here] to reserve ". This email is confirmation of a booking and will facilitate an easy check-in for you. Users can also modify or cancel their booking by replying to the email if necessary.
IMOU cameras are smart security cameras that provide surveillance to parking management system. IMOU camera must first connect to Wi-Fi network; then configure your IMOU camera via the IMOU App or desktop software. For monitoring of vehicles, camera must be installed in a manner that allows to monitor the entrances and exits. With the IMOU Cameras can access the live feed of the camera with RTSP (Real Time Streaming Protocol) or using the IMOU SDK on centralized web application or embedded into IoT based platform.
Video feeds can be used for capturing license plates and processing them using OpenCV and OCR software; this processed information can subsequently be stored in a database. This information can then be sent to a cloud or an on-premises server, so users can keep track of the information as logs or real-time. When a vehicle enters and leaves, it can potentially trigger an alert, improve security and reduce manual efforts to do so.

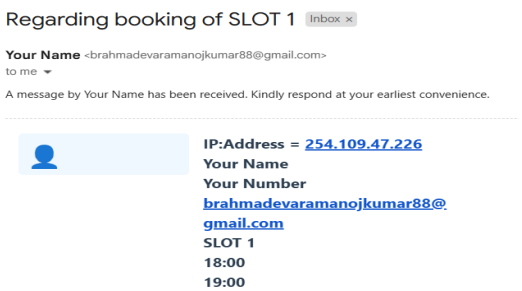

Figure. 6 Email Confirmation.

Once a vehicle enters the parking garage, the user will then be able to scan a QR code to gain access to the slot booking system. The user can then select an available slot and enter in their name, contact number, and email ID, as well as any timing constraints. After that, the app will display a payment scanner for completing the booking.

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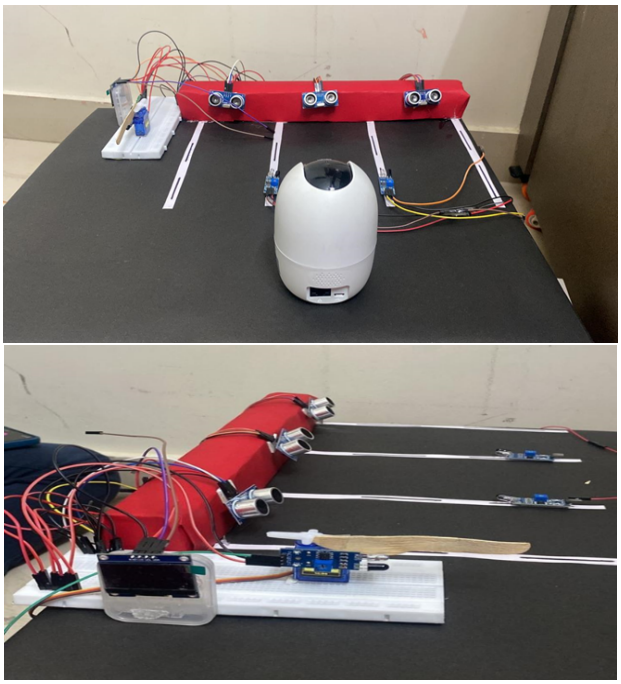

Figure. 7 The proposed method working model with camera.

Figure. 8 The Slot Booking Confirmation.

This working model has objectively illustrated that in combination, IoT, Cloud Computing, and Automated Control Mechanisms can provide the Smart Parking Management solution that is Secure, Scalable, and Smart. Booked parking slot messages will be sent from Firebase to the user via email or SMS (see figure 8). The user's data, once the booking has been completed, will also be sent to the Cloud with a confirmation email containing information on their reserved parking slot, including the time period for which the reservation was made, and the Wi-Fi Camera's IP address to be used for monitoring verification. The Wi-Fi camera will provide the capability to monitor the parked vehicle to assure its safety and for tracking the vehicle during the parking stay. Figure 7 shows the working model of the proposed approach. At the end of the slot time period the user will receive an email notification confirming that their parking reservation has expired and they can rebook the reservation any time and from anywhere. If the vehicle has not left the reserved parking space after the reserved time, an alert will be sent and will assist with proper management of parked vehicles and make spaces available to other users in an efficient manner.

5. Conclusions

To improve urban infrastructure by providing more efficiency from a smart parking system that uses the internet of things to automate the management of parking while providing real-time information. The smart parking system uses a variety of technologies to achieve this, including real-time monitoring through automated control of entry and exit, cloud-based data storage and mobile access for users. Utilization of sensors via ultrasonic and infrared along with the use of ESP32 microcontroller/wi-fi technology in conjunction with QR codes as a means of verifying user identity helps to distribute parking spaces more effectively, reduce demand for space and limit traffic congestion. The system operates without human touchpoints to deliver an automatic parking journey for drivers so they

can access real-time navigation to open spots thus reducing vehicle search time along with fuel usage.

Furthermore, this system solves more than technological challenges since it offers sustainable and intelligent mobility solutions. The system tracks parkers through its automatic gate functions and cloud-linked systems which synchronize data in real-time with IoT network security for trusted access. History-based data analysis produces vital parking trend data which enables better space optimization and improved operational workflows. The system offers scalability along with affordable costs to function in shopping malls and office complexes as well as airports and residential areas and public parking facilities.

The innovation stands as a future-proof solution because of its minimal servicing needs and energy-efficiency qualities making it compatible with modern smart city concepts. Urban parking management will require automated and intelligent solutions because population growth creates rising parking demands in cities. The IoT-based Smart Parking System creates a major advancement which solves efficiency problems and decreases traffic jams while promoting the development of sustainable contemporary cities. The system will link with smart city initiatives to minimize space inefficiencies while controlling urban traffic. An eco-friendly parking zone system includes automated waste management and green infrastructure. The support of electric vehicles requires the installation of easily accessible EV charging stations.

Conflicts of interest

The authors declare no conflict of interest.

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