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Smart Parking System based on IoT

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A B S T R A C T :

With the increase in the use of vehicles, cities are finding it tough to handle parking. Traditional parking methods cause problems like traffic jams, fuel wastage, and unused spaces. This paper talks about a Smart Parking System using the Internet of Things to make parking smoother. The system automatically finds parking spaces and allows users to book them in advance. It uses IR sensors to check if parking slots are free and to detect cars at the entrance, along with a servo motor to open the gate. An Arduino processes the sensor data, which is sent to a NodeMCU. This NodeMCU shares real-time parking updates to a server and a Django-based website. The system also lets users pre-book parking slots on an hourly basis and uses OTP authentication for secure booking and confirmation. This setup reduces manual effort, increases the use of parking spaces, and provides live parking updates for both drivers and parking staff. Tests show that it helps save time and improves parking management.

Keywords: IoT (Internet of Things), Automated Smart Parking, NodeMCU, Django.

1. Introduction

India's Smart Cities Mission was launched in 2015 with the goal of developing 100 cities to match global standards in terms of infrastructure and facilities. As smart cities evolve, the population also grows. With this increase, there is a 50% chance of more vehicles, leading to traffic congestion and a shortage of parking spaces. In busy cities like Hyderabad and Pune, finding an available parking slot during peak hours is nearly impossible. Drivers often wander around searching for parking, which worsens traffic jams and congestion. This roaming also leads to more fuel consumption, causing pollution and harming the environment. Drivers become distracted while searching for parking, increasing the risk of accidents.

To address this, a "Smart Parking System" can provide an effective solution for rapidly growing urban areas. Using advanced IoT technology, the system can monitor and manage parking spaces in real time. Sensors installed in parking slots can detect whether they are occupied and send this information to a cloud-based server. Drivers can access this data through a mobile app or a website, making it easy to find available parking spots and even reserve them in advance. This saves time, reduces traffic congestion, and minimizes fuel usage. As a result, it helps lower vehicle emissions and supports environmental sustainability. It also reduces the likelihood of accidents by allowing drivers to focus more on driving instead of searching for parking. This tech-driven solution aligns with India's Smart Cities Mission by optimizing infrastructure usage, improving urban mobility, and creating a clean and efficient urban environment. The Smart Parking System is an essential step in developing intelligent and eco-friendly cities that can handle the demands of a growing population and an increasing number of vehicles.

2. Objectives

The aim of this project is to create an efficient smart parking system that makes finding available parking spaces easy with the help of sensor technology. Sensors installed in each parking spot will detect whether the spot is occupied or vacant. Real-time data from the sensors will be displayed on a mobile application at the parking facility. This allows users to quickly find information about available and occupied parking spaces without wasting time searching for nearby parking. The mobile app will provide live updates, showing the status of each slot—whether it's occupied or vacant—and helping users locate and navigate to available spaces effortlessly. For parking managers, the application will send notifications, enabling them to manage parking spaces more efficiently. This project aims to improve the parking experience, reduce traffic congestion, and enhance the overall efficiency of parking operations.

3. Literature Review

[1] Gayatri N. Hainalkar and Mousami S. Vanjale explore a “Smart Parking System with Pre & Post Reservation, Billing, and Traffic Management.” This paper focuses on integrating IoT technology with features such as reservation before and after parking, automated billing, and traffic management. It discusses the use of RFID tags and IPA (Intelligent Parking Assistance) for roadside parking without requiring devices in drivers’ cars. The paper also reviews the system architecture and proposed design.

[2] D. Vakula and Yashwanath Krishna Koli introduce a "Low-Cost Smart Parking System for Smart Cities." This paper provides details on circuit connections, implementation processes, and system functionality, while highlighting the resources required for its development. It addresses parking challenges in cities like Hyderabad and Pune and presents an online parking booking and management system that allows users to reserve slots anytime from their mobile phones or computers.

[3] C. Ajchariyavanich, T. Limpisthira, and N. Chanjarasvichai present "Park King: An IoT-based Smart Parking System." The paper describes key features, including checking, reserving, scanning, and parking. It explains the technological components through use-case diagrams and flowcharts for a quick overview of the system. Additionally, it discusses Software Quality Assurance (SQA) by evaluating requirements, design, code quality, and overall quality control.

[4] GokulKrishna S., Harsheetha J., Akshaya S., and Jeyabharathi discuss "An IoT-based Smart Outdoor Parking System." This paper includes features like identifying vacant spots using LEDs, pre-booking with scan-and-pay, and location tracking via GPS and cameras. It explains algorithms and module components but highlights certain limitations, such as lacking user authentication and information for parking managers to optimize efficiency.

[5] G. Revathi and V. R. Sarma Dhulipala discuss "Smart Parking Systems and Sensors: A Survey." This paper provides basic insights into the use of WSN (Wireless Sensor Networks) for identifying and communicating parking information. It covers user authentication through vehicle license plate recognition using cameras and discusses the benefits of genetic algorithms for reducing greenhouse gas emissions. However, the paper points out limitations like the absence of a GUI-model interface and detailed system architecture, focusing mainly on ultrasonic sensors.

4. Problem Statement

As smart cities continue to develop, residents face parking challenges due to rising vehicle numbers and limited parking infrastructure. Traditional parking systems are inefficient in managing and monitoring spaces, leading to wasted time, fuel, and increased traffic congestion. Drivers often struggle to find available parking, especially during peak hours, which results in environmental pollution.

The proposed solution is a real-time, automated smart parking system based on IoT technology. This system will monitor and manage parking spaces using IoT sensors and data analytics, providing instant information to drivers about available spots and optimizing space utilization. This approach will reduce traffic congestion, lower emissions, and improve the driving experience while streamlining parking management.

5. Resources Used

Table 1 - Resources Used

Components	Description
Microcontroller	Arduino UNO
Sensors	IR(Infrared) Sensors
Communication Module	ESP8266 Wi-Fi module
Power Supply	Laptop/PowerBank
Frontend	HTML, CSS, JavaScript
Backend	Django Framework of python
Embedded Programming	Arduino IDE

6. Proposed System

6.1. System Architecture

The proposed Smart Parking System utilizes IoT technology, a web application, and OTP-based authentication to ensure efficient and secure parking management. Users start by accessing the system's web application, where new users can register by providing basic details, while existing users can log in directly. After logging in, users can view available parking locations and select their desired slot. They then enter booking details, such as vehicle and contact information, and proceed to payment by clicking the "Pay" button. Once payment is successful, the system sends a confirmation email containing a One-Time Password (OTP) for verification at the parking gate.

Upon arrival at the parking gate, the user provides the OTP to the admin or attendant. The admin verifies the OTP, granting parking access if correct or denying it if incorrect. Once the OTP is successfully verified, the system updates the slot status in real time on both the web application using ThingSpeak and the LCD display via Arduino. This ensures users and administrators can monitor parking slot availability accurately. The system offers convenience, enhances security, and provides real-time updates for a seamless parking experience.

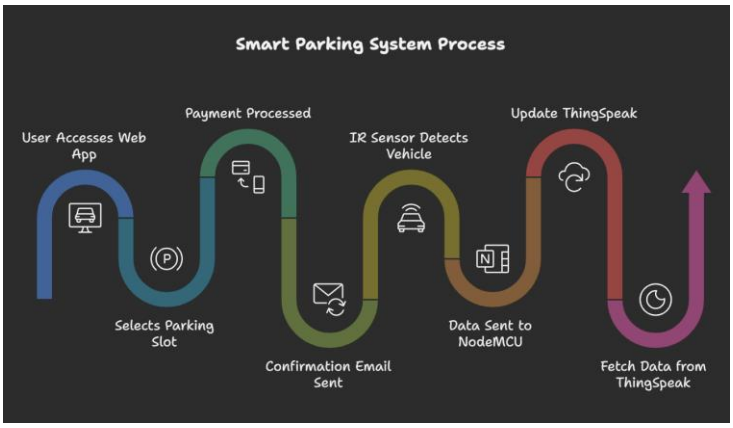


Fig.1 – Process Diagram of Smart Parking System

6.2. Hardware Implementation

The hardware implementation of the Smart Parking System uses an Arduino Uno as the main microcontroller, interfaced with essential components such as IR sensors, an LCD display, and a NodeMCU (ESP8266) for IoT connectivity. The system employs four IR sensors (IR-1 to IR-4), each positioned at a designated parking slot to detect whether a car is present or not.These sensors are connected to the Arduino's digital pins, allowing it to monitor parking slot occupancy in real time. The status of these slots—whether occupied or vacant—is displayed locally using a 16x2 I2C LCD, which reduces wiring complexity by using just the SDA and SCL lines. There is Servo motor present for gate controlling.

To enable remote monitoring, the Arduino communicates with a NodeMCU module via serial UART using TX (pin 1) and RX (pin 0). The NodeMCU sends parking data to the ThingSpeak cloud platform, where it is visualized on a webpage for users and administrators. A custom PCB is used specifically to provide a common VCC and GND connection to all components, ensuring reliable power distribution and reducing loose wiring.

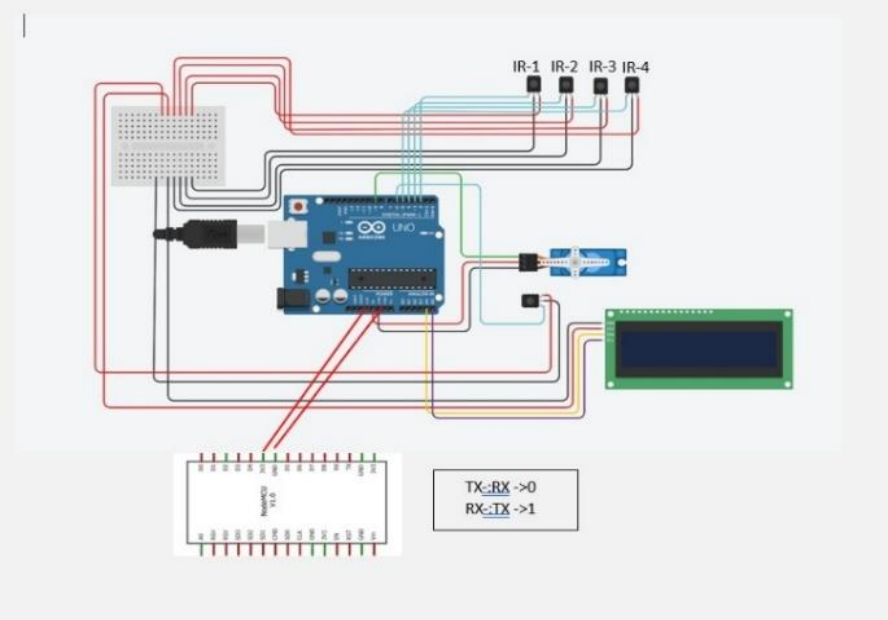


Fig.2- Circuit Diagram

6.3. Software Implementation

The software implementation of the Smart Parking System integrates both web development and embedded programming to provide a seamless user experience. The web application is developed using the Django framework for the backend, which handles user authentication, parking slot booking, OTP generation, and communication with the ThingSpeak API. For the frontend, HTML, CSS, and JavaScript have been used to design a responsive and user-friendly interface where users can register/login, view real-time parking slot availability, and initiate bookings. Upon clicking the "Pay Now" button, the system processes the booking and sends a confirmation email with a one-time password (OTP) for gate access verification.

On the hardware side, programming is carried out using the Arduino IDE. The Arduino Uno is programmed to read inputs from IR sensors, display slot status on an LCD, and communicate with the NodeMCU over serial. The NodeMCU is also programmed to send data to ThingSpeak, which acts as a bridge between the hardware and the web application. The integration of web technologies with embedded systems allows for real-time monitoring,

secure slot booking, and smooth automation of gate control.

7. Testing & Results

To ensure the reliability and accuracy of the Smart Parking System, various levels of testing were conducted. The unit testing phase involved verifying individual hardware components—each IR sensor was tested for accurate detection of vehicles, and the LCD display was tested to ensure it correctly reflected the status of parking slots. The Arduino code was uploaded and debugged using the Arduino IDE, ensuring correct readings and serial communication with the NodeMCU.

For the web application, the Django backend was tested by creating multiple user accounts, logging in, booking slots, and verifying if the OTP generation and email functionality worked as expected. The frontend was tested across different devices and screen sizes to ensure a responsive design using HTML, CSS, and JavaScript.

Integration testing was performed to check the end-to-end flow—from booking a parking slot on the web app, receiving the OTP, arriving at the gate, entering the OTP, and finally updating the slot status on both the webpage and LCD. The ThingSpeak platform was also tested for consistent data transmission and visualization from the NodeMCU. Edge cases like entering an incorrect OTP, rebooking an already booked slot, or accessing the gate without a valid booking were handled and verified.

Overall, the system successfully passed all major test cases and demonstrated stable performance under real-time conditions.

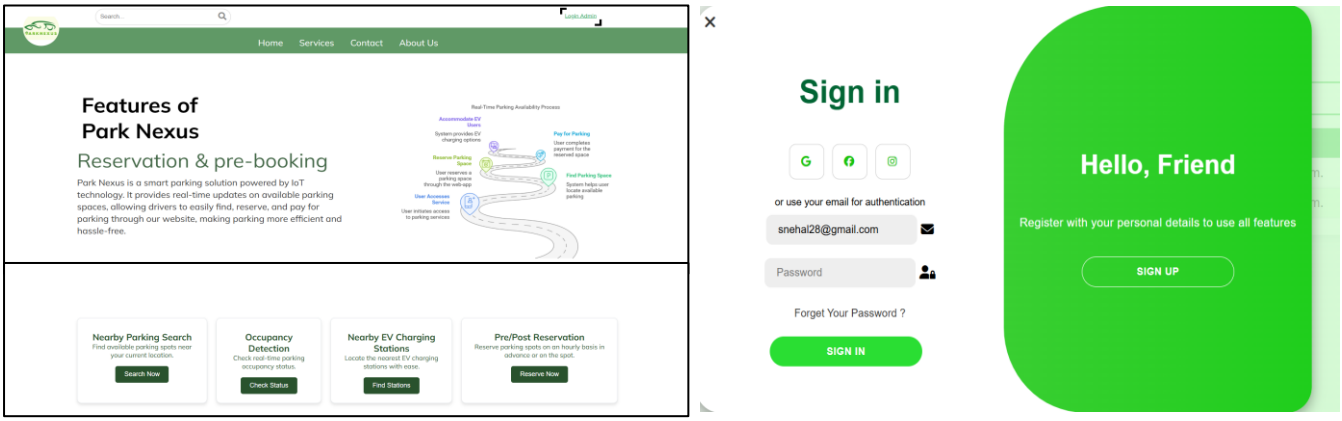


Fig.3,4- Homepage and Sign in page

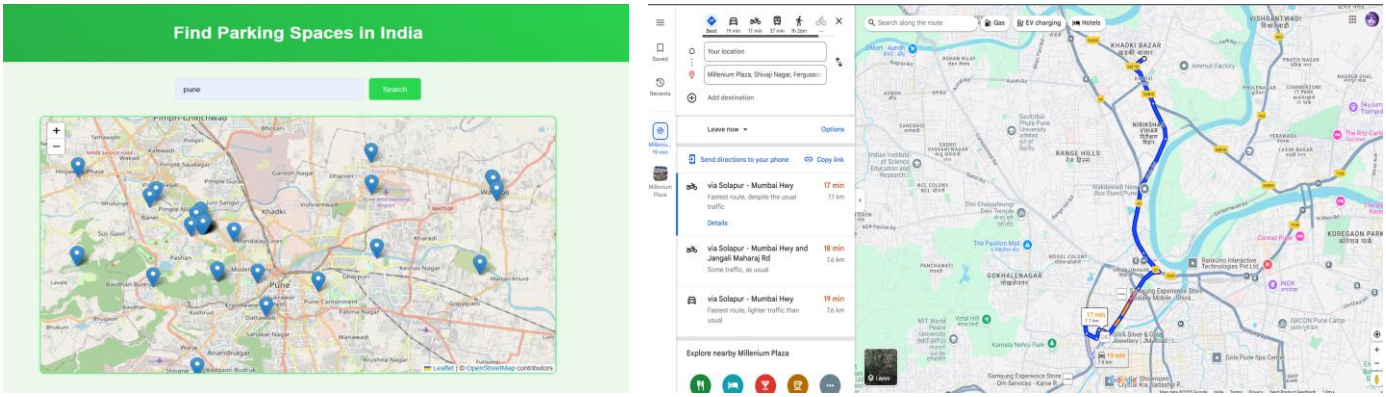


Fig.5- Nearby Parking locating page

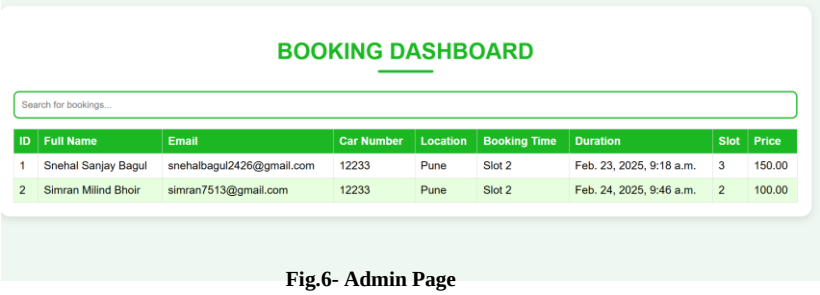


Fig.6- Admin Page

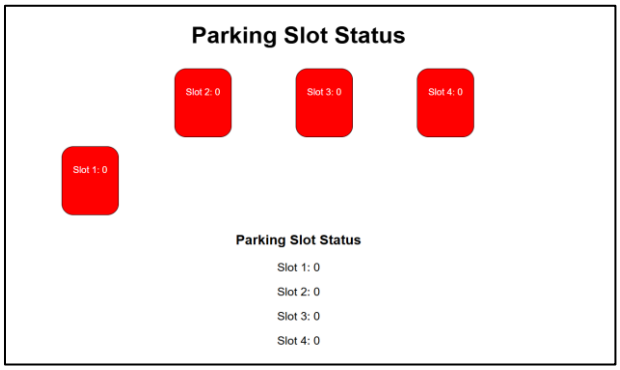
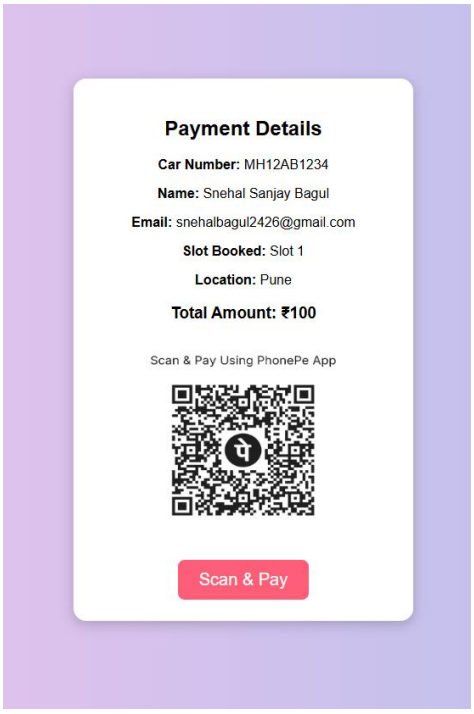


Fig 7,8- Realtime-Occupancy page and Reservation Page



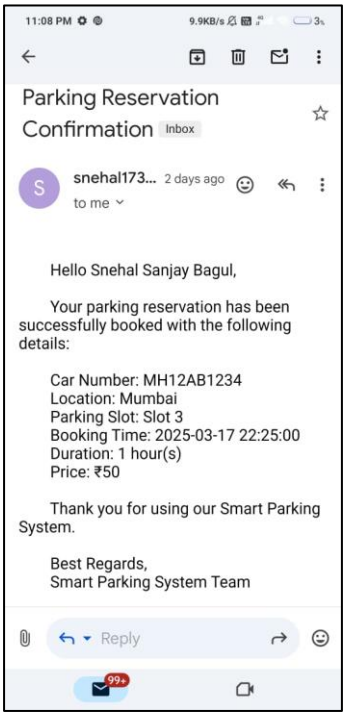


Fig 9,10- Payment popup and Confirmation Email

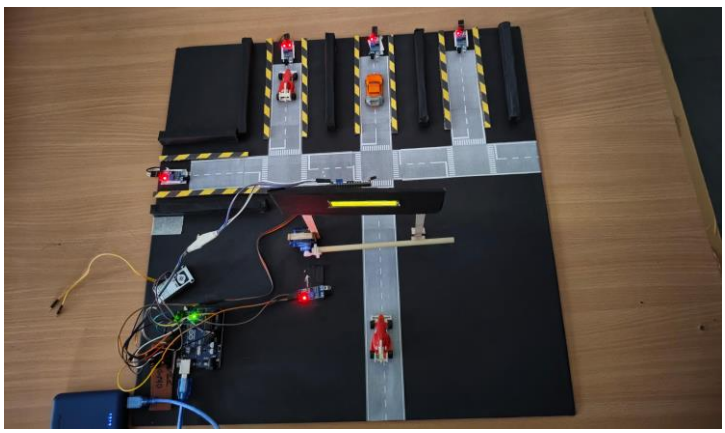


Fig 11- Actual Hardware Model

8. Future Scope

The Smart Parking System has significant potential for future enhancements through the integration of emerging technologies. AI-based slot prediction can be implemented to analyse historical data and forecast parking demand, helping users identify the best times to find available slots. Mobile app integration would enhance user convenience by allowing seamless booking, payment processing, and real-time navigation assistance directly from smartphones. Additionally, voice and chatbot assistance could be integrated to enable users to interact with the system using natural language, simplifying the process of finding and reserving parking spaces.

Advanced technologies like Automatic Number Plate Recognition (ANPR) can automate entry by scanning vehicle license plates, eliminating the need for OTP verification. A dynamic pricing system could also be introduced, adjusting parking rates based on peak hours, demand levels, or offering promotional discounts to optimize space usage. Furthermore, IoT-based smart navigation can guide drivers to their exact reserved slot using sensor-driven directions. Finally, AI algorithms can be extended to analyse traffic patterns and suggest the most efficient parking schedules, reducing congestion and improving overall user experience. These advancements would elevate the system into a more intelligent, automated, and user-centric solution.

9. Conclusion

The Smart Parking System based on IoT is a solution to contemporary parking woes in an effective and automated manner through the integration of real-time slot identification, cloud monitoring, and OTP authentication. Using Arduino, NodeMCU, and sensors, the system successfully reduces manual intervention, lessens parking search time, and increases security. The middleware server integration along with a Django-based web application ensures smooth data visualization and easy accessibility for users and administrators alike. Experimental outcomes prove the system's capability to enhance parking efficiency. With possible improvements such as AI-based forecasting, ANPR, and mobile app support, the system can be optimized further for smart city use.

REFERENCES

1. Gayatri N. Hainalkar, Mousami S. Vanjale, “Smart Parking System with Pre & Post Reservation, Billing and Traffic App,” *International Conference on Intelligent Computing and Control Systems (ICICCS)*, AISSMS IoIT, Pune, India, 2017.
2. D. Vakula, Yeshwanth Krishna Kolli, “Low-Cost Smart Parking System for Smart Cities,” *Proceedings of the International Conference on Intelligent Sustainable Systems (ICISS)*, National Institute of Technology, Warangal, Telangana, India, 2017.
3. C. Ajchariyavanich, T. Limpisthira, N. Chanjarasvichai, “Park King: An IoT-based Smart Parking System,” *IEEE International Smart Cities Conference (ISC2)*, Virginia Tech – Advanced Research Institute, Arlington, VA, USA, 2019.
4. GokulKrishna S., Harsheetha J., Akshaya S., Jeyabharathi D., “An IoT-based Smart Outdoor Parking System,” *International Conference on Advanced Computing & Communication Systems (ICACCS)*, Sri Krishna College of Technology, Coimbatore, India, 2021.
5. G. Revathi, R. Sarma Dhulipala, “Smart Parking Systems and Sensors: A Survey,” *International Conference on Computing, Communication and Applications*, Anna University of Technology, Tiruchirappalli, Tamil Nadu, India, 2012.
6. Manickam Ramasamy, Sunil Govinda Solanki, Elango Natarajan, Ham Mun Keat, “IoT-Based Smart Parking System for Large Parking Lot,” *IEEE International Symposium in Robotics and Manufacturing Automation (ROMA)*, UCSI University, Malaysia, 2018.