

IntellxPark: Intelligent Urban Parking Management System Using Real-Time Data Optimization

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Abstract- Today many metropolitan areas have seen explosive growth in the number of visitors and patrons due to urban revitalization, extension of transit services into suburban areas, and the general trend toward increased mobility of our society. As a result, there are too many vehicles on the road and insufficient parking spaces. This has led to the need for an efficient parking management system.

With the help of a computerized system we can deliver a good service to citizens who want to park their vehicle into any organization's premises using Internet of Things (IOT) based on the parking management system. In recent days, Parking allocation has become a major problem in modern cities for which numerous smart parking systems have been developed. This paper aims to provide comprehensive study, comparison and extensive analysis of Smart Parking Systems in terms of technological approach, user interface, computational approaches, and service provided. Smart car parking system mainly used for locating free space in parking slots. The system is designed to reduce the time and effort of human beings that they put in car parking.

Keywords- IOT Technology, Smart Parking Systems.

I. INTRODUCTION

Due to the proliferation in the number of vehicles on the road, traffic problems are bound to exist. This is due to the fact that the current transportation infrastructure and car park facilities developed are unable to cope with the influx of vehicles on the road. To alleviate the aforementioned problems, the smart parking system has been developed. With the implementation of the smart parking system, patrons can easily locate and secure a vacant parking space at any car park deemed convenient to them. Vehicle ingress and egress are also made more convenient with the implementation of hassle free payment mechanism. With the help of a computerized system we can deliver a good service to citizens who want to park their vehicle into any organization's premises using Internet of Things (IOT) based on a parking management system. In modern urban environments, the increase in population and vehicle ownership has led to significant challenges in managing city infrastructure, particularly in the area of parking. One of the most common problems faced by drivers today is the difficulty in finding available parking spaces in public areas such as malls, office complexes, hospitals, and urban streets. Traditional parking systems typically rely on manual monitoring or ticket-based methods that are inefficient, time-consuming, and prone to human error. In many cases, drivers circle

parking areas repeatedly in search of a vacant space, which increases vehicle emissions and adds to overall traffic congestion. These issues highlight the urgent need for a smart, automated solution that can improve parking efficiency and reduce unnecessary road traffic. A smart parking system is an intelligent parking management solution that uses modern technologies such as the Internet of Things (IoT), sensors, microcontrollers, and wireless communication to monitor and control parking space availability. The core idea is to automate the process of detecting whether a parking slot is occupied or vacant and communicate that information to users in real-time via a display system or mobile application. This eliminates the need for physical searching and manual intervention. The objective of the paper is to design and implement a miniature prototype of a smart parking system using cost effective electronic components. The sensors are connected to a microcontroller (NodeMCU), which processes the data and controls the output.

II. LITERATURE REVIEW

1] Abrar Fahim et al., In this paper the author presents a detailed review of smart parking systems, analyzing various technologies such as IoT, computer vision, multi-agent systems, and machine learning. They compare different sensor types, communication methods, and system architectures used for indoor and outdoor parking management. The paper highlights the strengths and limitations of existing solutions and identifies key challenges like accuracy, scalability, and real-time data handling, providing valuable insights for designing efficient smart parking systems.

2] Sudheer Hanumanthakari, In this paper the author proposes an IoT-based, real-time smart parking system to address the parking challenges in densely populated urban areas. The system enables users to locate and reserve parking spaces through an Android app and a web interface, leveraging real-time sensor data to optimize space usage and manage traffic flow efficiently. His work emphasizes improving user convenience and reducing parking congestion by integrating smart applications with IoT-driven infrastructure.

3] Arjyama Seal et al., In this paper the author designs a smart car parking system using the NodeMCU ESP8266 as the core IoT controller to detect vacant parking slots and efficiently manage them. They aim to reduce the time and effort drivers spend searching for parking, optimize the use of available parking spaces, and lower carbon emissions from vehicles circulating to find spots. Their system uses low-cost sensors and a connected microcontroller to continuously monitor slot occupancy,

making it a scalable solution that supports smart city infrastructure.

4] Mrs. A. Kalaiyarasi et al., In this paper the author proposes an IoT-based smart parking system using an Arduino, NodeMCU, IR sensors, and an LCD display. Their design enables authorized users to access a parking lot only when slots are available, using IR sensors to detect vehicle presence and an LCD screen to show real-time slot occupancy. The mobile application connected via NodeMCU provides detailed information including the number of occupied slots, entry time, exit time, and the availability of spaces, making it suitable for multi-floor parking.

5] G Rishika Reddy et al., In this paper the author proposes a smart parking system leveraging NodeMCU, IR or ultrasonic sensors, and a web-based interface to provide real-time monitoring of parking slots. The system detects vehicle presence in each slot, sends data to a cloud server, and presents live slot-availability via a Bootstrap-based website. Users can remotely check and reserve parking spaces, while administrators access an admin panel to manage slot usage and operations. Their work highlights how IoT, embedded systems, and web development can be combined in a scalable and cost-effective way to reduce traffic congestion, save fuel, and simplify parking for drivers.

6] Suraj Kumar et al., In this paper the author provides a detailed analytical survey of existing smart parking systems, comparing them across technological approaches, user interfaces, computational techniques, and the services they provide. They highlight the challenges in current parking allocation methods in modern cities and systematically evaluate how different systems leverage IoT, cloud computing, and sensor technologies to optimize space usage and improve user experience.

7] Hilal Al-Kharusi et al., In this paper the author proposes an intelligent management system that uses image processing techniques to detect empty parking slots. Their system uses cameras as sensors to capture images of the parking lot, then processes these images using MATLAB (e.g., HSV conversion, thresholding) to identify marked empty spots. They guide drivers to vacant spaces by analyzing “green rounded” parking markers in the images, making the parking process more efficient, reducing search time, and improving utilization.

8] Anusha et al., In this paper the author presents a review of IoT-based smart parking systems, focusing on the challenges of urban congestion and vehicle density during peak hours. Their proposed architecture combines Arduino-based slot modules with a mobile application to monitor slot availability and allow users to reserve parking spaces. They argue that such systems can significantly reduce fuel consumption, pollution, and time wasted in searching for parking, while improving overall efficiency in metropolitan parking.

9] Abdelrahman Osman Elfaki et al., In this paper the author proposes a smart parking control and monitoring system that integrates IoT devices, AI-based number-plate recognition (ANPR), and dynamic slot allocation to address inefficient slot usage, congestion, and misuse. Their system uses either motion or range-finder sensors to detect vehicle presence, captures license plate images with an ESP32-CAM, and processes them on a Raspberry Pi using a trained SSD MobileNet V2 model and OCR to identify the plate. It supports pre-booking, real-time monitoring, and ensures vehicles park in allocated slots. Experimental evaluation shows trade-offs: the range-finder module improves detection accuracy (~89%) compared to motion sensors (~51%), while keeping hardware cost low (~USD 12–13 per slot).

10] Hardik Tanti et al., In this paper the author propose an IoT-enabled smart parking system that uses sensors to monitor parking occupancy in real time and connects to a cloud-based management service. They develop a mobile application that allows users to check slot availability,

book a parking spot, and pay based on parking duration. The system also includes gate control to automatically open when a vehicle arrives, thereby reducing congestion and making the parking process more efficient and user-friendly.

III. METHODOLOGY

The proposed “Intelligent Parking Management System” integrates IoT hardware and a web-based platform to automate the entire parking process. The system uses NodeMCU ESP8266 with IR sensors to detect vehicle presence and update slot availability in real time. A Python–Flask portal allows users and parking owners to register, log in, and book parking slots online. Once a slot is booked, the user can operate a servo-based barrier to secure the space and prevent unauthorized entry. A 16×2 LCD is used to display live updates of available and booked slots within the parking area. By combining hardware automation with an online booking platform, the system ensures efficient parking management, reduces manual work, eliminates confusion, and enhances user convenience.

BLOCK DIAGRAM

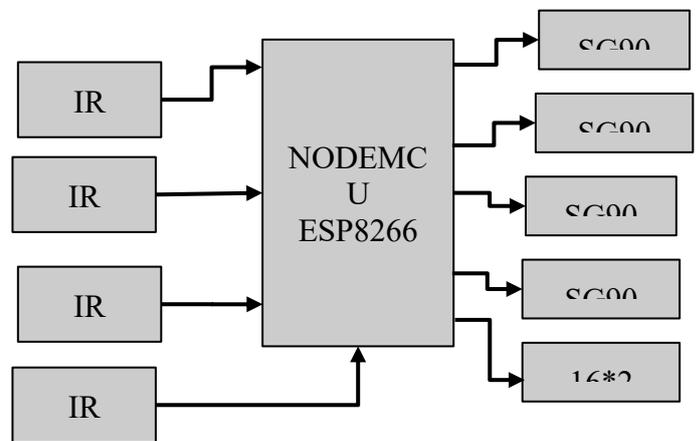


Fig 1. Shows the block diagram of the system

DESCRIPTION

In this block diagram, NodeMCU ESP8266 is used as a microcontroller. Four IR Sensors are used as an input device. The output devices are consist of four SG90 Servo Motors and 16*2 LCD. Both input and output devices are connected to NodeMCU ESP8266.

FLOWCHART

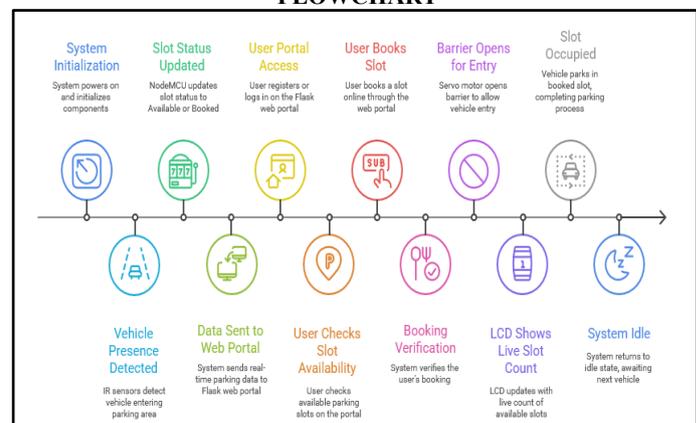


Fig 2. Shows the flowchart of the system

WORKING

The Intelligent Parking Management System works by automatically monitoring and controlling parking spaces using IoT technology. In this system, IR sensors are placed at the parking slots to detect whether a vehicle is present or not. Each parking slot is equipped with an IR sensor and a servo motor. When a vehicle enters or leaves a slot, the sensor sends a signal to the NodeMCU ESP8266, which acts as the main controller of the system. The controller processes this information and updates the status of the parking slot. The availability of parking spaces is displayed on a 16x2 LCD so that drivers can easily see which slots are free or occupied. Through the Python-Flask web portal, users can register, log in, and reserve a parking slot in advance. Once a slot is booked, a servo motor controls the barrier to allow access only to the authorized vehicle, preventing others from taking the reserved space. In this way, the system makes parking more organized, reduces confusion, and saves time for drivers.

IV. SYSTEM REQUIREMENT

HARDWARE REQUIREMENT

- 1] NodeMCU ESP8266
- 2] Servo Motor *4
- 3] IR Sensor *4
- 4] 16*2 LCD

SOFTWARE REQUIREMENTS

- 1] Python Software
- 2] Embedded C

MODULE USED

- 1] Flask

V. EXPERIMENTAL SETUP & RESULT

EXPERIMENTAL SETUP

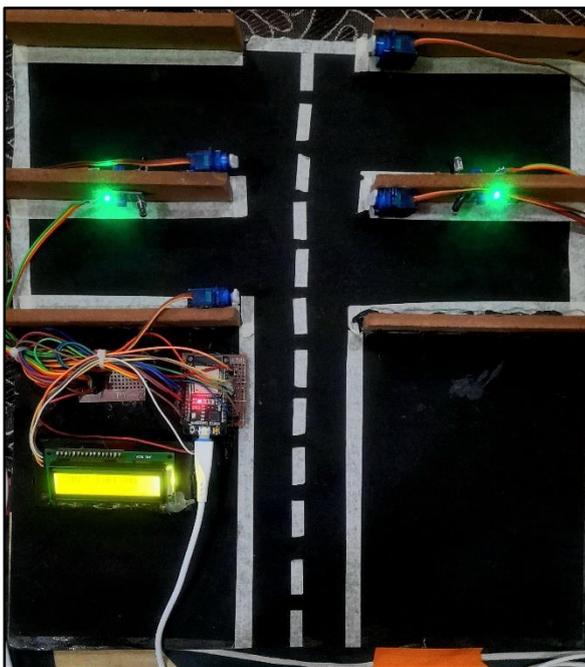


Fig. 3 Shows the Experimental Setup of the Proposed System

STEP BY STEP IMPLEMENTATION

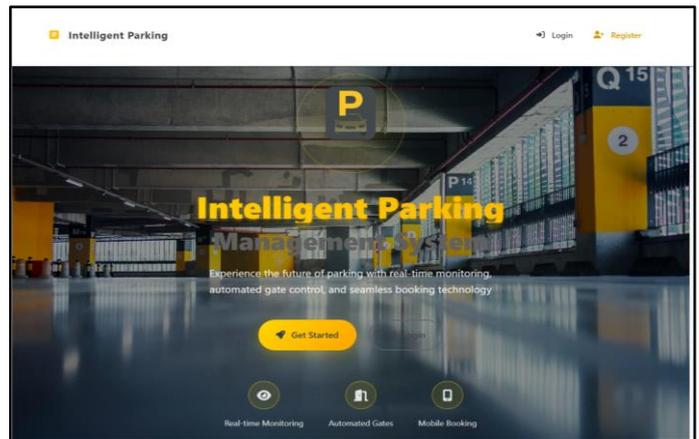


Fig. 4 Shows the Home Page of Intelligent Parking

Step 1 : Registration and Login

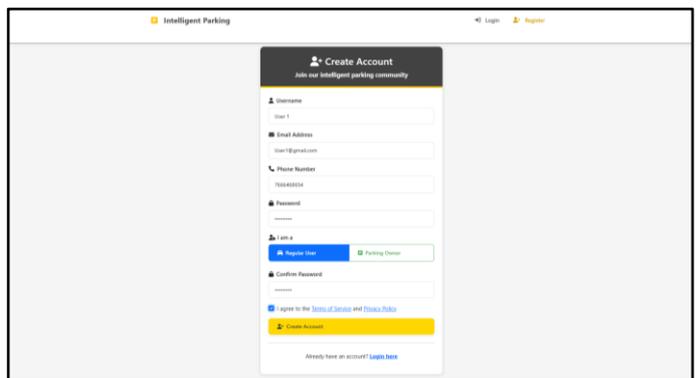


Fig. 5 Shows the Registration Interface of Intelligent Parking

Users can register themselves as regular user or parking owner by entering username, email address, phone number, password.

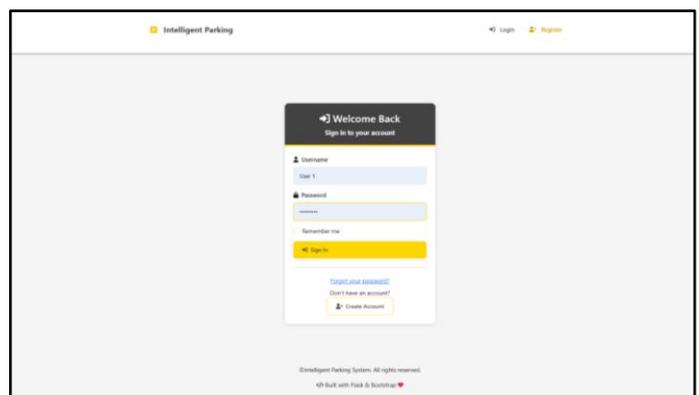


Fig. 6 Shows the Login Interface of Intelligent Parking

Users can login by entering username and password in order to access the account.

Step 2 : User can register the new car for parking booking

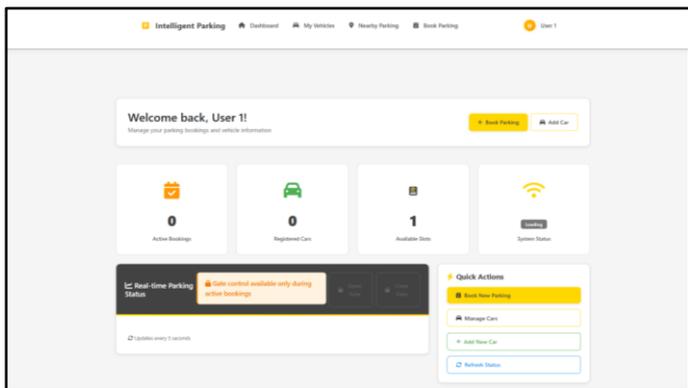


Fig. 7 Shows the Dashboard Interface of Intelligent Parking

This is the user dashboard in which it displays the active bookings, registered car, available slots and system status. Users can book the parking or add a car to register . It also shows the real- time parking status of the gate , whether the gate is open or closed.

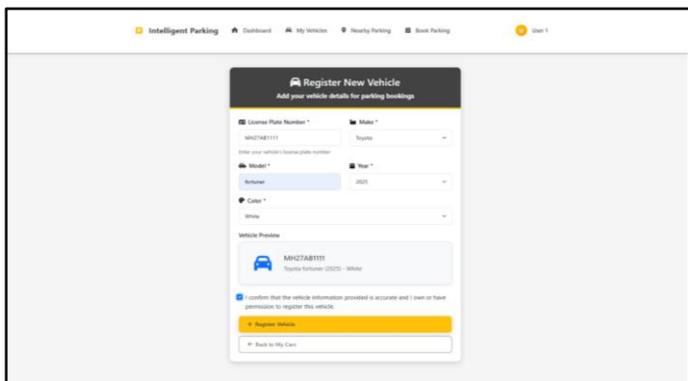


Fig. 8 Shows the Car Registration Page

Users can register their car for parking. It includes details like license plate number, name of car (make), model number, year, color of car, vehicle preview. After entering details users have to register their car for booking by clicking on option “Register Vehicle”. After registration, it displays the registered car with details and vehicle statistics. It will also display the price of parking for the first hour, additional hour and full day.

Step 3 : Booking for parking slot

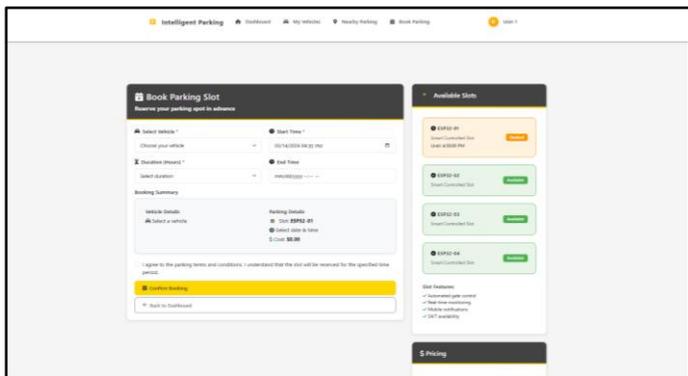


Fig. 9 Shows the Form for Booking Parking Slot

Users can book their slot for parking by entering the information which includes vehicle name, start time and end time of parking, duration in hours. It also displays which slots are available for parking and slots which are booked with the time until it is booked. After booking a notification popup will display whether to confirm the booking or not along with the total cost for parking. Then it will display the active booking at the dashboard. When the user will choose the parking, there will be a list of parking available along with details like number of available slots, price, address and features with the image of parking area. They can choose any of the parking of their choice.

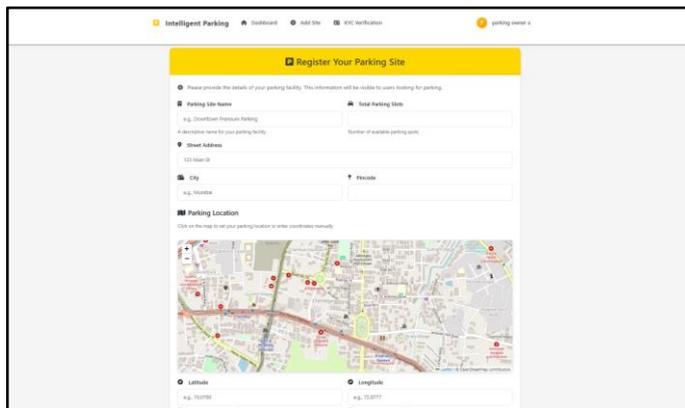


Fig. 10 Shows the Registration for Parking Site

Users or parking owners can register the site for parking by filling in the details like parking site name, total number of parking slots available, street address, city, pincode and parking location with the help of a map, latitude, longitude, etc. The dashboard will display the location of parking with name, available slots, total slots, price along with image of parking area.

Step 4 : Admin Dashboard

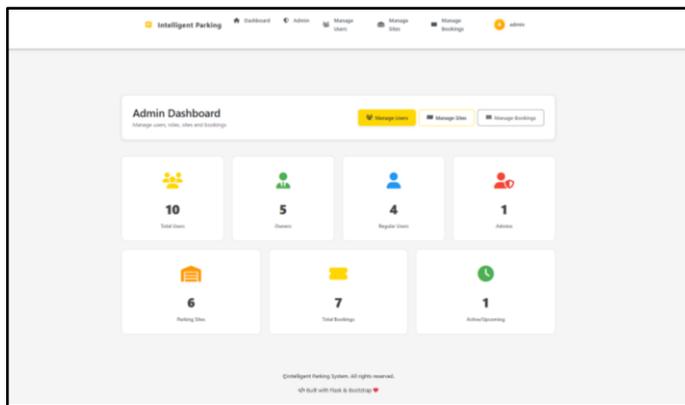


Fig. 11 Shows the Admin Dashboard

The image displays the admin dashboard which manages the user, sites, bookings. It shows total number of users, owners, regular users, number of admin, parking sites, total bookings, active/upcoming booking. Admin can view the bookings with details like user name, car name, site, slot, start & end time, status. Admin can delete the booking by clicking on the icon of delete. Admin can view the parking site also with the detailed information.

RESULT

The Intelligent Parking Management System was successfully developed and tested to demonstrate efficient parking management

using IoT technology. The IR sensors were able to accurately detect the presence of vehicles in parking slots, and the NodeMCU ESP8266 processed this data to update the parking status in real time. The 16×2 LCD clearly displayed the number of available and occupied parking spaces, helping users quickly understand the parking situation. The Python–Flask web portal allowed users to register, log in, and reserve parking slots without difficulty. The servo motor–based barrier also operated properly, allowing access only to authorized users. Overall, the system showed reliable performance and proved helpful in reducing confusion, saving time, and improving the overall parking experience.



Fig. 12 Shows the Output on LCD

The image displays the output on LCD which shows “No Parking Available”. If the parking is available then it also displays the number of slots available in parking.

V. CONCLUSION

In conclusion, a smart car parking system, empowered by Internet of Things technologies, revolutionizes the way we approach parking. The ability to reserve parking spots in advance ensures a guaranteed parking space, particularly in crowded areas or during events. IoT sensors enable parking violation monitoring, allowing authorities to detect and address violations promptly. This promotes fair utilization of parking spaces and improves enforcement. A smart car parking system improves the parking experience for drivers, optimizes space utilization. With the continued advancement of IoT technologies, smart parking systems hold great potential for transforming the way we manage parking in the future.

VI. REFERENCE

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