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Built in Wireless Fidelity Based Parking Slot Booking System

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Abstract: ***The vehicle counts are increasing day by day which results in the demand for efficient parking solutions. Traditional parking systems often require manual intervention, leading to time-consuming searches for available spots, increased traffic congestion, and unnecessary fuel consumption. To address these issues, this paper proposes a smart car parking system that leverages the Internet of Things (IoT) and infrared (IR) sensors to automate the detection and monitoring of vacant parking slots. The system uses IR sensors to determine the presence of a vehicle in each slot, and an NODEMCU microcontroller, along with a Wi-Fi module, to transmit the real-time data to a cloud-based platform.***
Through this approach, users can remotely access the availability of parking slots via a web or mobile application, enabling faster and more efficient parking decisions. Our proposed system also provides cloud-based booking system with better efficiency. The system is designed to be scalable, cost-effective, and easy to deploy in various environments, from small parking lots to large commercial complexes. The integration of IoT technology not only enhances user convenience but also contributes to smarter urban traffic management by reducing congestion and optimizing parking space usage. This paper discusses the system architecture, implementation, and results from prototype testing, demonstrating its potential for real-world applications.
Keywords: IoT, Smart Parking, NodeMCU, IR Sensor, Ubidots, Real-time Monitoring, Cloud-based Booking.

I. INTRODUCTION

The adding number of vehicles on the road has led to serious parking-related issues, particularly in urban areas. Drivers often struggle to find vacant parking spots, which results in traffic congestion, increased fuel consumption, Traditional parking systems depends heavily on manual operations, which are not only time-consuming but also inefficient in managing space availability. With the growing technology on smart cities and intelligent infrastructure, there is a need for automated and intelligent parking solutions that can offer real-time information to users.

The integration of the Internet of Things (IoT) into parking systems offers a modern and effective approach to tackle these challenges. By using IR sensors to detect the presence or absence of vehicles in each slot and transmitting this data through a microcontroller and Wi-Fi module to a cloud server, users can access live updates on parking availability. The use of IR sensors in such systems is particularly advantageous due to their affordability, simplicity, and accuracy in short-range detection.

This smart parking solution is cost-effective, scalable, and energy-efficient, making it suitable for various applications such as shopping malls, airports, commercial buildings, and residential complexes. By automating the parking process and providing users with accurate, real-time information, the IoT-based system improves overall user experience and operational efficiency.

II. RELATED WORK

Debarati Pal et al., published in July 2023. This paper discusses the development of an IoT-based system designed to address the challenges associated with the increasing adoption of electric vehicles (EVs), particularly focusing on efficient parking and sustainable charging solutions.

Das and Dutta (2022) present the development of a smart parking system that leverages IoT technologies to make parking more efficient and user-friendly, especially in urban environments where parking space is often limited. The system is designed to automate key parts of the parking process, reduce congestion, and provide real-time information to users.

Khan and Pathan (2021) conducted a comprehensive survey on the development and deployment of IoT-based smart parking systems within the broader context of smart cities. The authors highlight key design components such as sensor networks, microcontroller units, wireless communication (Wi-Fi, Zigbee, LoRa), and cloud platforms for data storage and analytics. Emphasis is placed on system responsiveness, scalability, and cost-effectiveness. They also discuss challenges like interoperability, data security, and real-time data accuracy, which are critical for successful implementation in complex urban environments.

Abdullah and Rahman (2020) developed an IoT-based car parking management system that utilizes infrared (IR) sensors to detect the occupancy status of individual parking slots. The system was designed to help reduce the time drivers spend searching for available parking by providing real-time information about slot availability. The IR sensors detect the presence of vehicles and send this data to a microcontroller, which then transmits the information to a display module and online platform.

Raut, Patil, and Kale (2020) proposed an IoT-based smart parking management system aimed at reducing the time and effort drivers spend in finding parking spaces. The system makes use of sensors to monitor the occupancy status of individual parking slots and employs microcontrollers to process and transmit this data. A real-time database is used to store the information, which is then made accessible to users via a mobile application or web interface.

Authors (Year)	Title	Technology Used	Focus Area	Unique Contribution	Limitation
Debarathi (2023)	*IoT-enabled smart parking and charging system for electric vehicles*	IoT sensors, cloud platform, mobile app	EV parking + charging	Integrates EV charging with parking management and remote booking	Applicable only to electric vehicles
Das & Dutta (2022)	*Design and implementation of IoT based smart parking system*	IR sensors, ESP8266, cloud, mobile access	Slot detection and live updates	Low-cost, simple design with scalable IR-based system	Lacks features like booking or predictive analytics
Khan & Pathan (2021)	*A survey on IoT-based smart parking systems in smart cities*	IR, RFID, cameras, LoRa, cloud computing	Comparative literature survey	Broad overview of technologies used in modern smart parking systems	Does not present a practical implementation
Abdullah & Rahman (2020)	*IoT-based car parking management system using IR sensor*	IR sensors, NodeMCU, LCD, web dashboard	Basic vehicle detection and monitoring	Functional prototype with real-time visual feedback using low-cost components	Limited scalability and no mobile integration
Raut, Patil, and Kale (2020)	*IoT based smart parking system using IR sensors*	IR sensors, Blynk app, ESP8266	Real-time monitoring via smartphone app	Uses Blynk app for user-friendly mobile access to slot status	Designed for small-scale parking environments

III. METHODOLOGY

The proposed Built in wireless fidelity-grounded parking system is used for monitoring the slot availability status in real time and allow users to book available slots via online. The system comprises of infrared (IR) sensors for vehicle detection, a NodeMCU (ESP8266) microcontroller acts as a controlling unit with Wi-Fi communication, and the Ubidots Cloud platform for imaging the data and it is used for storage, and it communicates with the users through a web or mobile interface.

IV. SYSTEM ARCHITECTURE

The system comprises IR sensors, each installed at an individual parking slot. These sensors detect the presence or absence of a vehicle by measuring the reflected infrared signals. Each IR sensor is connected to a NodeMCU, which acts as controlling unit for reading sensor data and transmitting it to the cloud.

A. Hardware Components

1) IR Sensor: Used to detect vehicle presence based on infrared light reflection.
2) NodeMCU ESP8266: A Wi-Fi-enabled microcontroller that reads sensor data and uploads it to the cloud.
3) Power Supply: A regulated power source supplies the required voltage to all electronic components.

B. Software and Cloud Integration

1) Ubidots Platform: Used for real-time visualization, booking logic, and user interface. Ubidots receives data from NodeMCU using HTTP or MQTT protocols and displays it on widgets like LED indicators, tables, or maps.
2) Embedded Firmware: Programmed using the Arduino IDE, the firmware on the NodeMCU handles sensor reading, data formatting, and communication with the Ubidots cloud.

V. IMPLEMENTATION

The implementation can be divided into several stages: hardware setup, firmware development, and cloud integration.

A. Hardware Setup

Each parking slot is equipped with an IR sensor, which detects whether a vehicle is present. The sensor is mounted at ground level or slightly elevated, oriented toward the position where a vehicle's front bumper or tire would be detected.
These sensors are connected to a NodeMCU ESP8266 microcontroller, which has built-in Wi-Fi capability. The NodeMCU is responsible for:

- Reading digital HIGH/LOW signals from the IR sensors
- Processing this data to determine slot availability
- Transmitting the results to the cloud

The system uses a regulated 5V DC power supply to provide stable voltage to the sensors and the microcontroller.

B. Firmware Development

The firmware is written in C/C++ using the Arduino IDE. Key functionalities of the code include:

1) Sensor Initialization: Configuring IR sensor pins as input
2) Sensor status: Checking the sensor data at regular interval of time
3) Wi-Fi Connectivity: Connecting the NodeMCU to a defined Wi-Fi network
4) Data Transmission: Sending data to Ubidots using the MQTT protocol

C. Cloud Dashboard on Ubidots

Ubidots is used to:

- Receive real-time sensor data from the NodeMCU
- Visualize slot status using widgets.
- It also allows users to view the status of the slot whether it is booked or not

D. Booking Functionality

Booking is integrated as part of the user dashboard. When a user selects a free slot:

- The status is marked as "Booked"
- A timestamp is logged to record the reservation
- The slot becomes unavailable to other users until the booking period expires or is manually reset

E. Workflow

1) IR sensors detect vehicle presence.
2) NodeMCU gathers sensor data and uploads it to Ubidots.
3) Ubidots dashboard shows live parking status to users.
4) Users reserve a slot via the dashboard.
5) Reserved slots are indicated in ubidots so that the online users can view the slot status

This methodology ensures efficient management of parking resources, reduces congestion, and offers a user-friendly interface for booking and monitoring. It is also scalable and cost-effective, making it suitable for implementation in various types of parking facilities.

VI. RESULT AND DISCUSSION

The IoT-based automatic car parking system was successfully developed and tested in a controlled environment with multiple parking slots. The system's functionality was evaluated based on sensor accuracy, data transmission reliability, and the effectiveness of the booking feature through the Ubidots dashboard.

A. Sensor Accuracy

The IR sensors reliably detected the presence or absence of vehicles within their range. Tests conducted with various distances and lighting conditions showed a detection accuracy of over 95%, provided that the sensors were properly aligned.

B. Real-Time Monitoring

The NodeMCU successfully transmitted data to the Ubidots platform with minimal latency (typically under 2 seconds). The cloud dashboard updated the slot status in near real-time, allowing users to see current availability with high accuracy. Data was sent using the MQTT protocol.

Fig.1 Hardware Connections with output

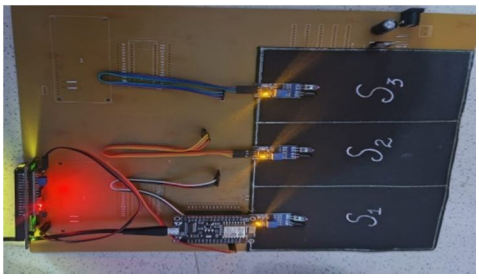
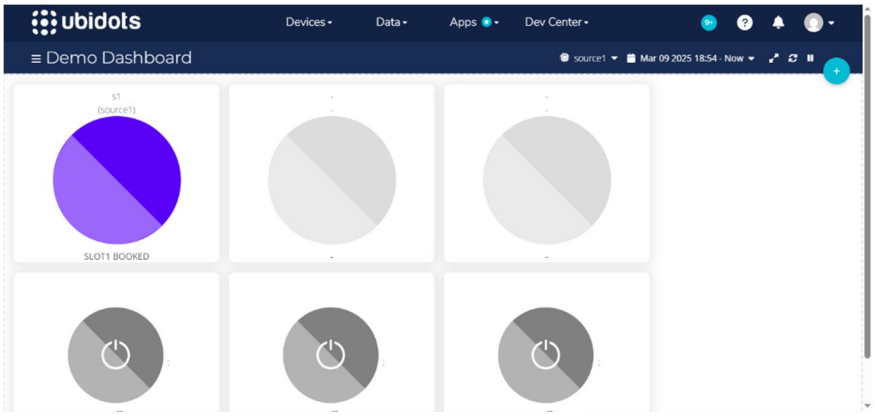


Fig.2 Hardware design

C. Booking Interface Performance

The booking functionality enabled users to reserve available slots directly from the dashboard. When a booking was made:

- The corresponding slot was visually marked as “Booked”
- Other users could not select or reserve the same slot
- The reservation was logged with a timestamp for administrative purpose.



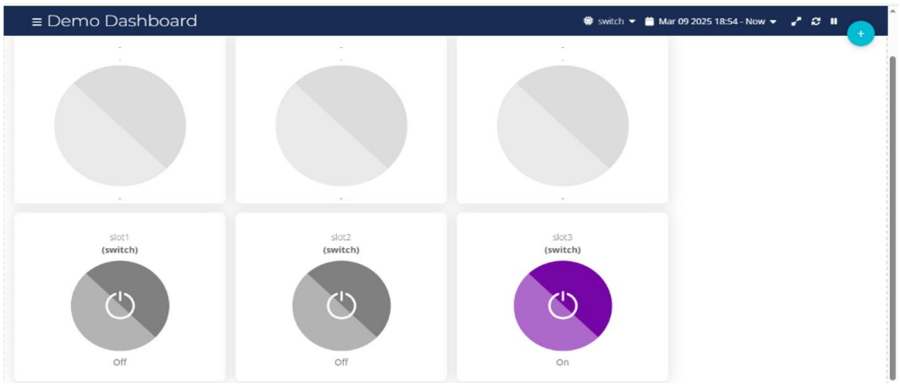


Fig.3 Ubidots communication

VII.FUTURE ENHANCEMENT

Future enhancements may include:

1) *Automatic vehicle tracking using license plate recognition*
2) *Mobile app support for a more intuitive user experience*
3) *Addition* of alert/notification features for user

VIII. CONCLUSION

This paper presented an IoT-based automatic car parking system with real-time monitoring and remote booking capabilities, utilizing IR sensors, NodeMCU, and the Ubidots cloud platform. The system effectively addresses common urban parking challenges by enabling users to view slot availability and reserve parking spaces in advance through an online interface.

Experimental results demonstrated reliable vehicle detection, fast data transmission, and a responsive cloud dashboard. The proposed solution is low-cost, scalable, and suitable for deployment in small to medium-sized parking facilities. It significantly reduces manual intervention and search time for parking, thereby contributing to improved traffic management and enhanced user convenience.

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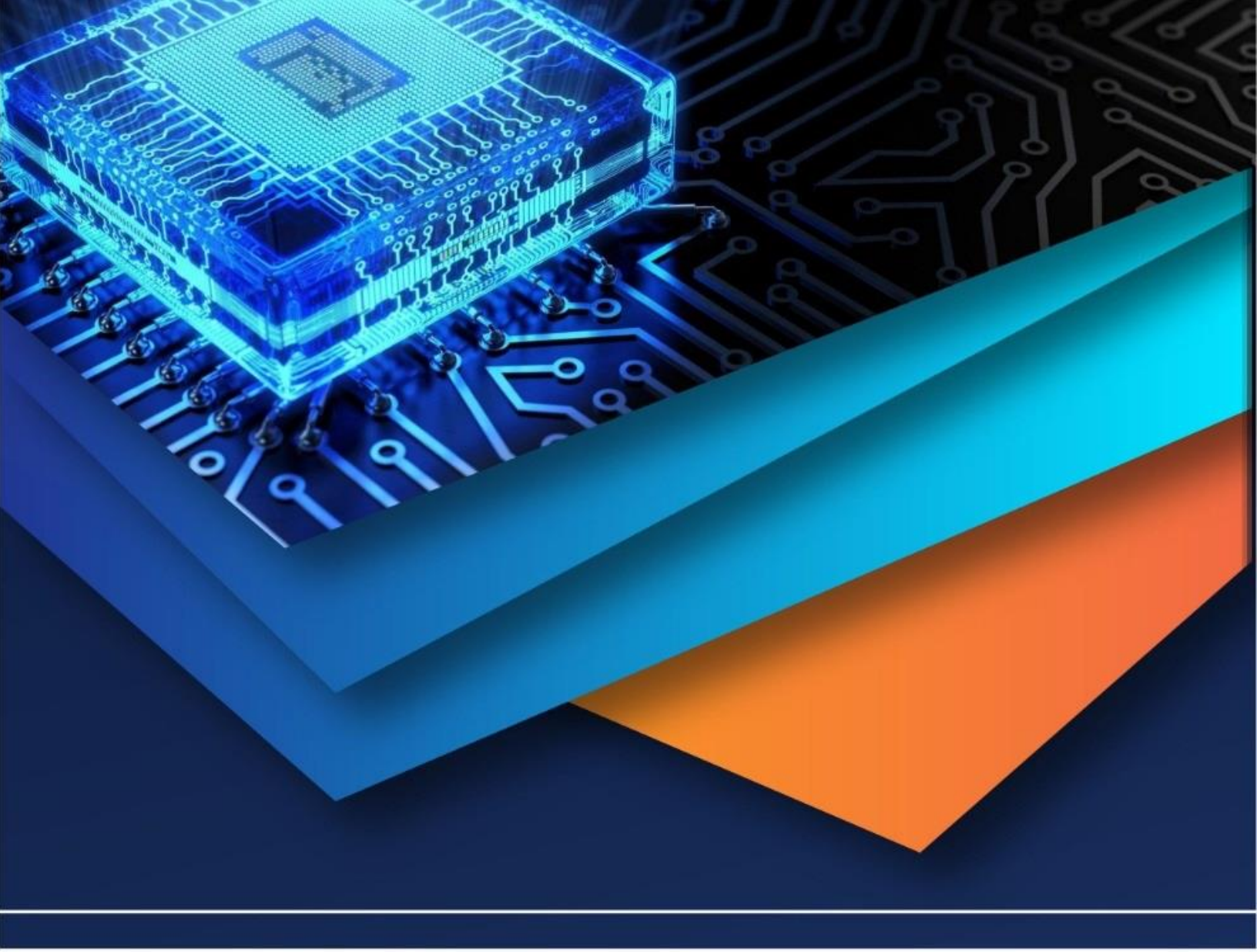

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