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IOT Based Smart Parking Management System

Ms. Waghmare Sujata Ramchandra[1], Mrs. Bhosale Nayana Vijaykumar[2]

[1]Student, Electronics & Telecommunication Engineering Department, Terna Collage of Engineering, Dharashiv, Maharashtra
[2]Associate Professor, Electronics & Telecommunication Engineering Department, Terna Collage of Engineering, Dharashiv, Maharashtra

Abstract
This Finding a parking space in busy areas is often difficult and time-consuming. This project presents an IoT-based Smart Parking Management System designed to solve this problem by helping users find available parking slots easily and quickly. The system uses sensors to detect whether a parking spot is occupied or free and sends this information to users in real-time through the internet. A microcontroller like ESP8266 or ESP32 collects the data and communicates with a cloud platform or mobile app. This helps reduce traffic congestion, saves fuel, and improves the overall parking experience. The system is low-cost, efficient, and can be implemented in malls, offices, public places, and smart cities.

Keywords: Adafruit IO, IOT (Internet of Things), RFID, Real-time Slot Detection, ESP8266.

1. Introduction

In today's fast-growing cities, finding a parking space is a common problem. People often spend a lot of time looking for a free parking spot, especially in crowded areas like shopping malls, offices, or public places. This leads to traffic jams, fuel wastage, and frustration. To solve this problem, we can use modern technology like the Internet of Things (IoT)**.** An IoT-based smart parking system helps drivers know where parking slots are available in real-time. The system uses sensors to check if a parking spot is empty or full and sends this information to a mobile app or website. This project uses a microcontroller like ESP8266 or ESP32 to collect data from sensors and send it to the internet. With this system, users can find and book parking spaces easily, which saves time, reduces traffic, and improves the overall parking experience.

2. Literature review

1. Several studies have implemented ultrasonic sensors to detect vehicle presence. Ultrasonic sensors, such as the HC-SR04, are favored due to their low cost, ease of integration, and accurate range detection. In the work by M. Idris et al. (2012), ultrasonic sensors were installed in each parking slot and linked to microcontrollers for monitoring real-time occupancy. This foundational concept continues to underpin most modern smart parking architectures.
2. Microcontrollers such as the ESP8266 and ESP32 are widely adopted in IoT systems due to their built-in Wi-Fi capabilities and compatibility with cloud platforms. Studies such as the one by Sharma et al. (2019) highlight the use of ESP8266 for transmitting parking status data to a centralized server. These microcontrollers are programmable via the Arduino IDE and can efficiently handle sensor input and Wi-Fi communication simultaneously.

3. Cloud connectivity is essential for real-time monitoring and remote control. Early systems used SMS or Bluetooth for communication, but recent literature emphasizes the use of cloud platforms such as Thing Speak, Blynk, and Firebase. However, these platforms often present limitations in dashboard customization or require complex setups. Adafruit IO, by contrast, is cited in multiple hobbyist and academic projects (e.g., Singh et al., 2021) for its simplicity and effectiveness in visualizing real-time data. It supports MQTT and HTTP protocols, making it suitable for lightweight IoT applications. Adafruit IO also allows the creation of interactive dashboards that can display slot status, manage devices, and handle user interaction such as pre-booking.
4. Recent developments in SPS have focused on enhancing user experience. Features such as mobile apps, real-time maps, and pre-booking options are discussed in studies like that of Al-Turjman et al. (2020). The ability to reserve parking spaces remotely has searched for slots and been shown to significantly reduce time spent to optimize parking lot usage during peak hours. By leveraging Adafruit IO's dashboard interface, developers can create reservation buttons, status indicators, and occupancy logs, enabling systems to support interactive functionalities without the need for complex backend development.
5. Smart Parking systems gather the necessary information about the available parking space in a user's nearby area and process it in real-time to arrange vehicles in those slots. It involves the use of less expensive sensors, real-time data collection, and a web application that allows people to park and accurately estimate where the user can find the spot. Infrared Radiation (IR) sensor and Internet of Things technology are integrated into a smart car parking system (IoT). It allows the user to locate the nearest parking spot and displays the number of available spaces in the closest parking zone. Smart parking system minimizes the emissions of C02 by removing the necessity for the people to look for a parking area in a crowded place. It also enables better management of parking spaces. Smart parking addresses one of the most challenging parts of city driving: finding open parking spaces and avoiding illegal parking. Three modules make up the Smart Parking System: monitoring, control, and a display unit.

3. Existing System

Now a days Traditional or existing parking systems are mostly manual and involve limited use of technology. In these systems, drivers must search for available parking spots on their own, which often leads to unnecessary time loss, traffic congestion, and increased fuel consumption. Payments are usually handled manually through cash or paper tickets, and there is little to no real-time information available about space availability. As a result, the overall user experience is inefficient and inconvenient.

4. Proposed System

1) **Gate Operation:** If a slot is available and the IR sensor detects vehicle.
   NodeMCU activates the servo motor to open the gate.
   Python starts a timer to calculate parking duration for billing
2) **Slot Detection:** IR sensors installed in each parking slot detect if a space is occupied**.**
   NodeMCU updates this data and sends it to the Python server.
3) **Exit & Billing:** Upon exit, the same RFID is scanned again.
   Python calculates the total parking time.
   Billing is done based on predefined rates (e.g., ₹10/hour).

A receipt is generated (console printout / PDF / database log).

4) **Data Storage**: All entry/exit times, vehicle IDs, and charges are stored using SQLite or CSV files via Python.
This data can be used for reporting, user history, and future enhancements.

5. Bock Diagram

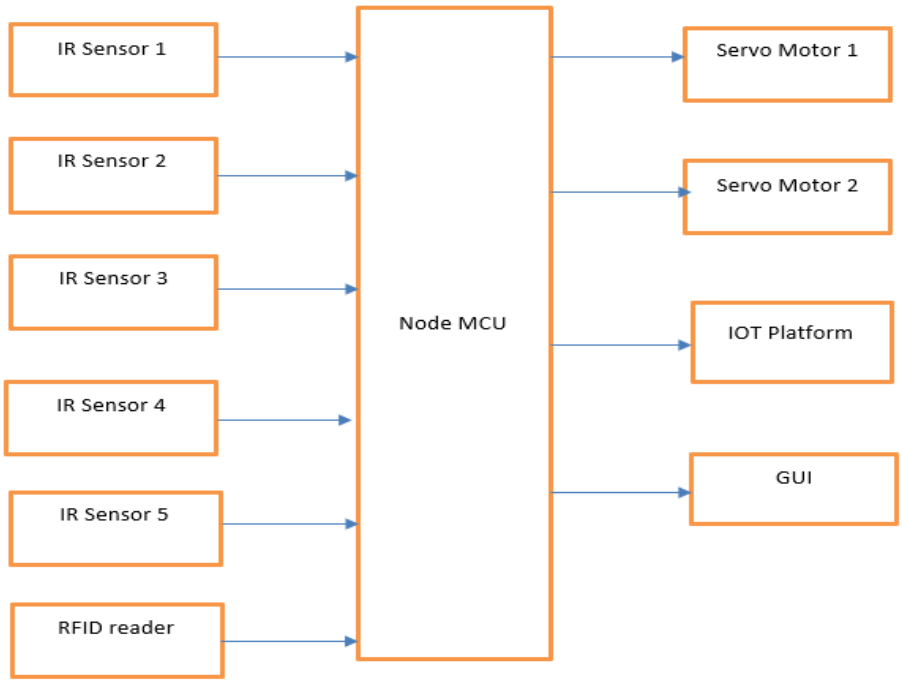
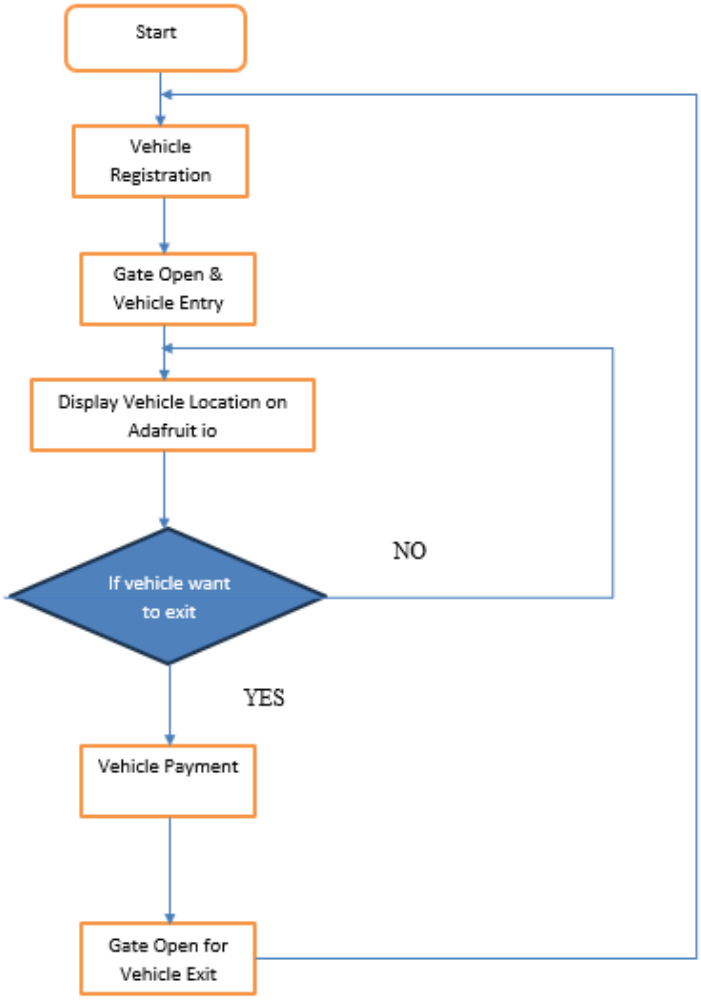


Fig. Block Diagram

6. Flow Chart



7. Working

The working of this project is being any vehicle reach at gate IR sensor will identify the object using IR sensor gate will open. There is using one servo motor for open the gate for vehicle entry. One's vehicle entered in the parking then registration is done of vehicle. Vehicle will park on available Parking Slot which is display vehicle location on Adafruit IO IOT flatform. We can easily monitor parking slot is empty or occupied using GUI. If vehicle want to left parking, then payment will do by using RFID reader. If bill paid the vehicle will exit by exit gate, then gate will open using servo motor and IR Sensor. In this way IOT based smart parking system is available. This is real time monitoring, low time, which saves time, reduces traffic, and improves the overall parking experience.

8. Hardware

NodeMCU: - It is 32-bit microcontroller. It has inbuilt ESP8266 wifi module. It can easily connect to the internet by providing SSID and Password. It can be programmed through Arduino IDE. It an work on 3.3 V. D1 and D2 will act as SCL & SDA pins of NodeMCU and is connected to the SCL & SDA pins of max30100 sensor.

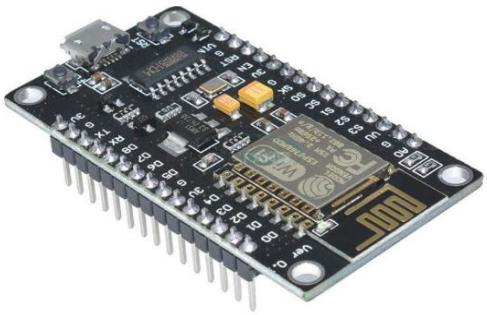


Fig. NodeMCU

IR Sensor: - IR sensor is an electronic device, that emits the light in order to sense some object of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. Usually, in the infrared spectrum, all the objects radiate some form of thermal radiation. These types of radiations are invisible to our eyes, but infrared sensor can detect these radiations. There are five basic elements used in a typical infrared detection system: an infrared source, a transmission medium, optical component, infrared detectors or receivers and signal processing. Infrared lasers and Infrared LEDs of specific wavelength used as infrared sources.

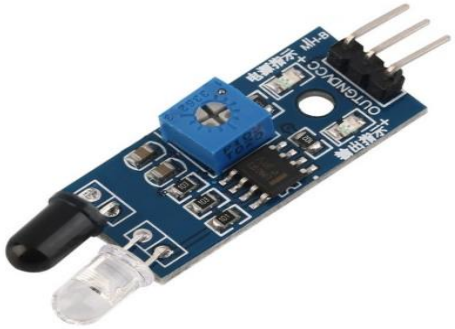


Fig.IR Sensor

RFID Reder: - An RFID (Radio Frequency Identification) system consists of two main components: a reader and a tag. The RFID reader contains a radio frequency module and an antenna that creates a high-frequency electromagnetic field around it. The RFID tag is attached to whatever object we want to identify or track. Most tags are passive, which means they don't have batteries or their own power source. Instead, they wait quietly until they enter the reader's electromagnetic field. When a tag enters this field, the radio waves from the reader create a tiny electrical current in the tag's antenna. This small current gives the tag just enough power to wake up its microchip. The microchip contains important information about the object the tag is attached to. Once powered up, the tag sends this information back to the reader. This process is called backscatter, where the tag doesn't generate its own radio signal but instead modifies the reader's signal.

Fig. RFID Reader

Servo Motor: - A servo motor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity, and acceleration. It works by using a closed-loop feedback system to maintain a desired position, continuously correcting for any deviations. This is achieved by comparing the desired position (input signal) with the actual position (feedback from a sensor) and adjusting the motor's rotation to minimize the error.

Fig. Servo Motor

9. Result

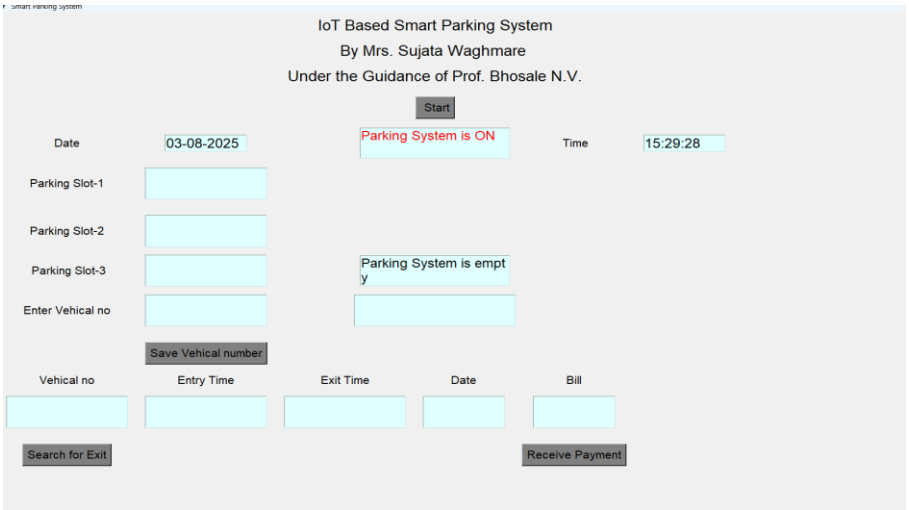


Fig.1 Parking System is ON

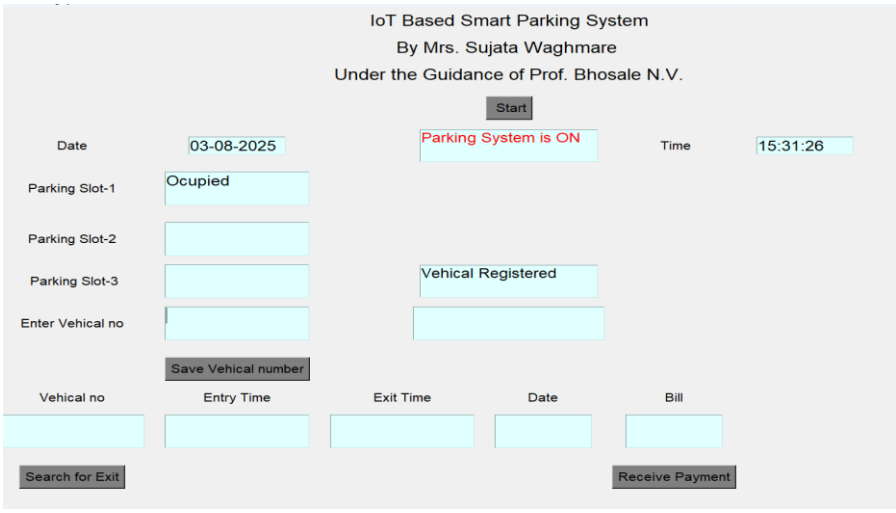


Fig.2 Vehicle Registered

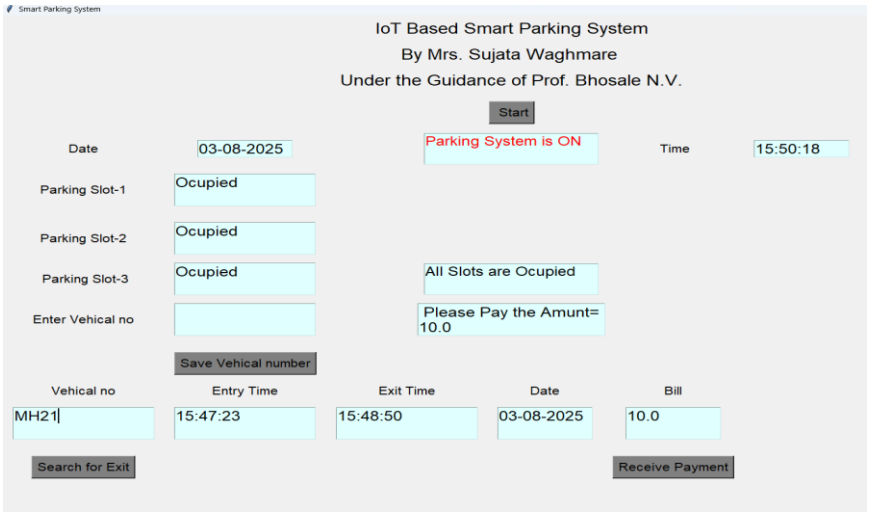
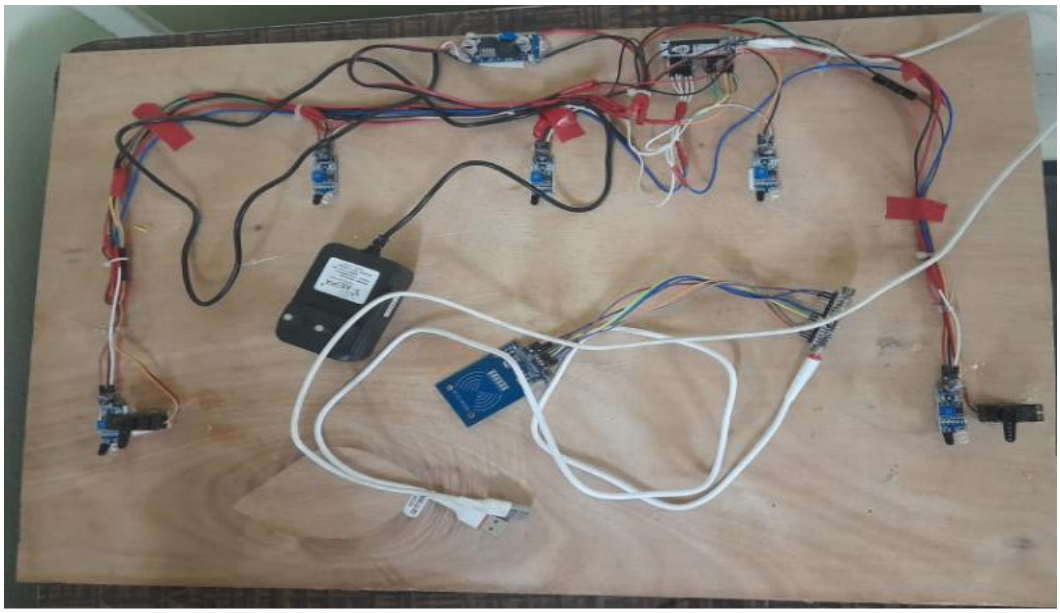


Fig.3 All Slot Occupied

10. Conclusion

The IoT-Based smart Parking Management System provides an efficient solution for managing parking spaces in urban environments or busy areas. By utilizing IoT technology, the system enables real-time monitoring, automated management, and easy access for users, thus reducing the time spent searching for parking. The integration of cloud services allows for scalable solutions that are adapted to various sizes of parking facilities. The system promotes energy efficiency and cost-effectiveness, especially the use of Ada Fruit's low-cost IOT Flatform, reliable components. Overall, the system enhances the user experience by reducing congestion and improving the convenience of parking management.

11. Project Image



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