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# IOT- Smart Parking System

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**Abstract:** The IoT-based Smart Parking System is a cost-effective solution to automate parking management in urban areas. It uses eight IR sensors to monitor parking slot availability and control gate operations via two servo motors. A 16x2 LCD with I2C backpack displays available slots, while the Arduino Uno manages the system. The NodeMCU module ensures real-time updates on slot availability to users' mobile devices from any location. This system optimizes parking efficiency, reduces manual intervention, and supports scalability for large parking areas, making it an ideal solution for smart city projects.

**Keywords:** IOT, Smart Parking, Arduino, NodeMCU, IR Sensors, Automation, LCD Display, Parking Management.

## I.INTRODUCTION

With the increasing population and urbanization, parking management has become a significant challenge. Traditional parking systems are labor-intensive and inefficient, leading to unnecessary delays and fuel wastage. This project proposes an IoT-based solution to automate parking operations, from slot detection to gate control, while providing real-time information to users via a mobile application. The system enhances user convenience, reduces labor costs, and aligns with smart city goals for efficient urban infrastructure.

## II.LITERATURE REVIEW

Several studies have explored automated parking systems using RFID, ultrasonic sensors, or camera-based detection. While effective, these systems are costly and complex. IoT integration has gained traction due to its scalability and cost efficiency.

## III.SYSTEM DESCRIPTION

Block Diagram-

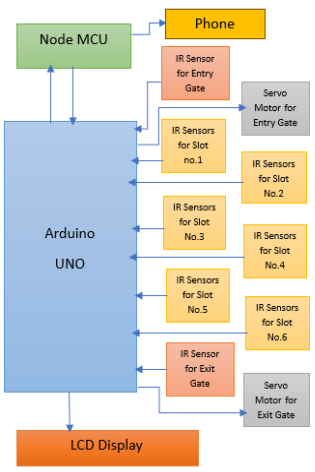


Figure 1

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Hardware Components-

1. Arduino Uno (Microcontroller)
2. IR Sensor
3. Servo Motor
4. NodeMCU (ESP8266) – Wi-Fi Module
5. 16x2 LCD Display with I2C Module

✓ Arduino Uno (Microcontroller)-

Figure. 2

The **Arduino Uno** is a popular microcontroller board based on the **ATmega328P**. It features **14 digital input/output pins** (6 of which can be used as PWM outputs), **6 analog inputs**, a **16 MHz quartz crystal**, a **USB connection**, a **power jack**, an **ICSP header**, and a **reset button**. It operates at **5V** and can be powered via USB or an external power source (7-12V recommended). The board is widely used for electronics projects, automation, IoT applications, and robotics due to its **ease of use, open-source nature, and compatibility with various sensors, motors, and shields**. It is programmed using the **Arduino IDE**, which supports a simple C/C++-based language, making it ideal for beginners and professionals alike.

✓ IR Sensor-

Figure. 4

It was used to sense the automobiles that they were present in parking lot or not. It detects the presence of obstacle. It can measure the heat of an object as well as motion.

✓ Servo Motor-


Figure. 3

A **servo motor** is a rotary or linear actuator designed for precise control of angular or linear position, speed, and torque. It operates through a closed-loop system, using a feedback mechanism to ensure accurate movement. Typically, servo motors consist of a DC or AC motor, a control circuit, a position sensor (such as a potentiometer), and a gearbox to enhance torque. They receive control signals in the form of pulse-width modulation (PWM), where the pulse duration determines the motor's rotation angle. Commonly used in robotics, automation, and IoT applications, servo motors are widely utilized in projects requiring precise motion, such as robotic arms, smart parking systems, and RC vehicles.

✓ NodeMCU (ESP8266) – Wi-Fi Module-

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Figure. 5

The **NodeMCU (ESP8266)** is a low-cost, open-source Wi-Fi module that enables wireless communication in IoT applications. Built around the ESP8266 microcontroller, it features an integrated TCP/IP stack, making it capable of connecting to Wi-Fi networks and acting as a standalone microcontroller. The module operates on a 3.3V power supply and includes GPIO, PWM, I2C, SPI, and ADC functionalities, making it highly versatile for various IoT projects. NodeMCU supports the Lua scripting language and can also be programmed using the Arduino IDE, allowing for easy development and integration. Its built-in Wi-Fi capability enables remote monitoring and control of connected devices, making it a popular choice for smart home automation, industrial applications, and real-time data transmission. Additionally, NodeMCU can interface with sensors, motors, and other electronic components, facilitating seamless communication between hardware and cloud-based platforms.

✓ 16x2 LCD Display with I2C Module-

Figure. 6

The **16x2 LCD display with an I2C module** is commonly used in embedded and IoT projects to display data efficiently. The I2C module reduces the required connection pins from 16 to just 4 (VCC, GND, SDA, and SCL), simplifying wiring and conserving microcontroller pins. It operates using the I2C communication protocol, allowing multiple devices to share the same bus. The LCD can display two lines of 16 characters each, supporting alphanumeric and custom characters. It is widely used in Arduino and NodeMCU projects for real-time data visualization, such as sensor readings, system status, or user instructions.

Working Process-

**1. Vehicle Arrival and Entry Gate Operation-**

- When a vehicle **arrives at the entry gate**, the **IR sensor at the entry gate detects the vehicle**.
- The **Arduino Uno checks** the number of **available parking slots** using data from the **6 IR sensors** placed in each slot.
- If **slots are available**, the **Arduino sends a signal to the servo motor**, which **opens the entry gate**.
- The vehicle enters the parking area, and the **entry gate closes automatically after 3 seconds**.
- If **all slots are occupied**, the **entry gate remains closed**, and "PARKING FULL" is displayed on the **LCD display and mobile app**.

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**2. Parking Slot Detection and Updates-**

- Each **IR sensor** is placed at **individual parking slots** to detect vehicle presence.
- When a vehicle occupies a slot, the **IR sensor detects it** and sends the signal to **Arduino Uno**.
- The **Arduino updates the count of available slots** and displays the **real-time slot availability on the LCD screen and mobile app**.
- NodeMCU transmits the **updated parking data** to the **Blynk app on the mobile phone**, enabling **remote monitoring**.

**3. Vehicle Exit and Gate Control-**

- When a vehicle moves toward the **exit gate**, the **IR sensor at the exit gate detects it**.
- The **Arduino signals the servo motor to open the exit gate**, allowing the vehicle to leave.
- After 3 seconds, the **exit gate closes automatically**.
- The **IR sensor detects that the slot is now free**, and the **Arduino updates the available slot count**.
- The **LCD display and mobile app are updated** with the new availability status.

**4. Remote Monitoring via Mobile App (Blynk)-**

- **NodeMCU (ESP8266) acts as a bridge** between **Arduino and the Blynk app**.
- The **Blynk app displays**:

✅ Total parking slots
✅ Available parking slots
✅ Individual slot status (Occupied/Free) using **LED indicators**

- Users can **check slot availability remotely** before reaching the parking lot, reducing **search time and congestion**.

## IV.IMPLEMENTATION

Hardware Setup:

1.Connect IR sensors to Arduino digital pins for input.
2.Interface servo motors with Arduino PWM pins for gate control.
3.Attach the LCD to Arduino via I2C for display.
4.Connect NodeMCU to Arduino for Wi-Fi communication.

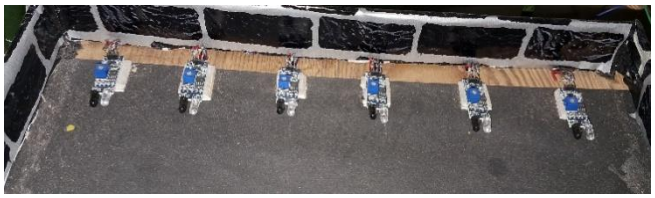

Figure. 7

Software:

1.Arduino IDE for programming the microcontroller.
2.NodeMCU configured for IoT communication to blynk app
3.Mobile app development for real-time display of slot availability.

## V.RESULT & DISCUSSION

➢ Displaying Available Slots on LCD-

**If slots are available:**

- LCD displays:


Figure. 8

- Vehicles are **allowed to enter** as the **entry gate opens**.

**If all slots are full:**

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- LCD displays:


Figure.9

- The **entry gate remains closed** to prevent additional vehicles from entering.

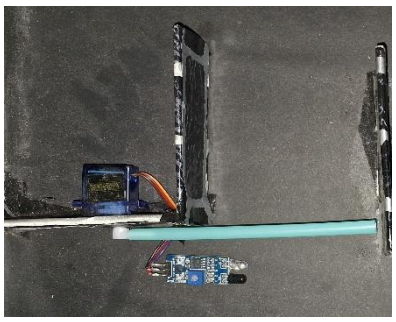

Figure.10

➢ Blynk App Display of Available Slots & Individual Slot Status:

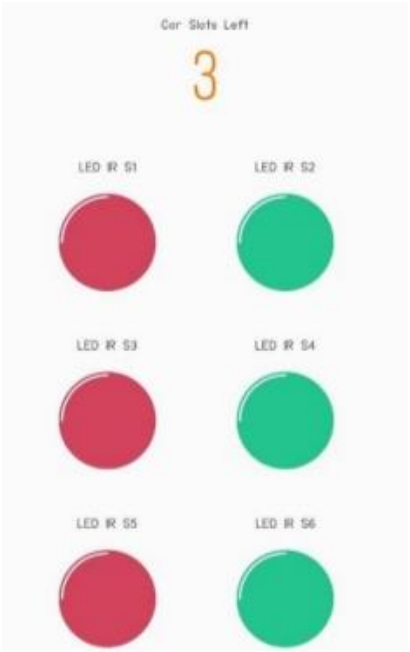


Figure. 11

## VI.BENEFITS & APPLICATIONS

Benefits

1. Real-time slot availability display.
2. Automation of gate control and parking management.
3. Reduced labor costs and operational overhead.
4. Increased efficiency and user convenience.

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5. Scalable for larger parking lots.

Applications:

1. Commercial parking lots (malls, airports).
2. Residential complexes.
3. Public parking areas.
4. Industrial zones and smart cities

## VII.CHALLENGES & LIMITATIONS

1. **IR Sensor Limitations**: Sensitivity to environmental factors like sunlight or dirt.
2. **Power Dependency**: Requires continuous power supply for operation.
3. **Network Issues**: Real-time updates depend on stable Wi-Fi connectivity.
4. **Scalability**: Adding more slots may require higher processing power or additional controllers.

## VIII.CONCLUSION

The **IoT-Based Smart Parking System** successfully automates the process of parking slot detection, entry/exit gate control, and real-time monitoring using **Arduino, NodeMCU (ESP8266), IR sensors, servo motors, an LCD display, and the Blynk mobile application**. The system ensures that parking availability is accurately detected and displayed, allowing users to check available slots remotely via the **Blynk app**, while also preventing entry when all slots are occupied. The integration of **IR sensors** for slot detection significantly reduces human intervention, improving accuracy and efficiency. The automated gate control using **servo motors** ensures smooth vehicle flow, reducing congestion and improving parking management. The **real-time data transmission** between the Arduino and NodeMCU via Wi-Fi allows for seamless updates, ensuring users always have the latest parking information. Furthermore, the system significantly reduces the time required to find a parking spot, optimizing space utilization and minimizing traffic congestion at parking entrances.

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