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# IMPLEMENTATION OF AN ARDUINO BASED SMART PARKING MANAGEMENT SYSTEM WITH REAL TIME AVAILABILITY MONITORING

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ABSTRACT

Implementation of an Arduino Based Smart Parking Management System with Real-Time Availability Monitoring presents an automated solution to address the growing challenges of urban parking congestion. With the rapid increase in vehicle ownership, traditional manual parking systems often lead to inefficiencies, increased waiting time, and traffic congestion. This system utilizes an Arduino Uno microcontroller as the central processing unit to monitor parking slot occupancy and control vehicle entry through an automated gate mechanism. Five IR sensors are deployed—four for individual slot detection and one at the entry gate—to continuously monitor vehicle presence. The system processes real-time sensor data and displays slot availability on a 16x2 I2C LCD, ensuring clear guidance for drivers. A servo motor operates as an automated barrier, allowing entry only when parking slots are available and restricting access when the parking area reaches maximum capacity. The proposed system improves space utilization, reduces human intervention, and enhances traffic flow management. Experimental testing demonstrated high detection accuracy, quick response time, and reliable gate operation. The system can be further extended with IoT integration for cloud-based monitoring and smart city applications.

Keywords: ***Smart Parking System, Arduino Uno, IR Sensors, Real-Time Monitoring, Embedded Systems, Servo Motor, Automation, IoT Integration.***

## I.INTRODUCTION

Implementation of an Arduino Based Smart Parking Management System with Real-Time Availability Monitoring" focuses on solving one of the major urban challenges—inefficient parking management. With the rapid increase in vehicle ownership, especially in metropolitan and semi-urban areas, parking spaces have become limited and poorly managed. Traditional parking systems rely heavily on manual supervision, token-based entry, or physical verification of available slots, which often leads to traffic congestion, time wastage, fuel consumption, and driver frustration. In busy locations such as shopping malls, hospitals, corporate offices, and educational institutions, vehicles frequently circulate within parking premises searching for empty slots. This not only increases carbon emissions but also creates unnecessary crowding at entry and exit points. To address these challenges, the proposed system introduces an automated, sensor-based parking management solution using an embedded system approach. The system continuously monitors slot availability and controls vehicle entry using intelligent decision-making logic. By integrating hardware components such as IR sensors, a servo motor, and an LCD display with a programmable microcontroller, the project ensures real-time updates and automated gate control. The system operates as a closed-loop mechanism where sensor inputs are processed instantly, and appropriate outputs are generated without human intervention. This automation enhances operational efficiency, reduces manpower requirements, and provides a user-friendly interface to drivers. The introduction of real-time monitoring significantly improves parking space utilization while minimizing traffic congestion within parking areas.

The Smart Parking Management System is designed using an embedded systems architecture consisting of three primary layers: Input Layer, Processing Layer, and Output Layer. The Input Layer includes five Infrared (IR) sensors—four dedicated to monitoring individual parking slots and one positioned at the entrance gate to detect incoming vehicles. These sensors detect the presence of vehicles based on reflected infrared signals and send corresponding digital signals to the microcontroller. The Processing Layer is built around the Arduino Uno microcontroller, which acts as the brain of the system. The Arduino continuously reads the input signals from the IR sensors and executes programmed logic written in Embedded C/C++ using the Arduino IDE. It calculates the number of available slots and determines whether the gate should open or remain closed. The Output Layer consists of a 16x2 I2C LCD display and a servo motor. The LCD provides real-time updates such as "Free Slots: 3" or "Parking Full," offering clear guidance to drivers. The servo motor functions as an automated gate barrier, rotating to 90 degrees to allow vehicle entry when slots are available and remaining at 0 degrees when the parking area is full. The entire system operates on a 5V regulated power supply with common grounding to ensure stable operation. This structured architecture ensures accurate monitoring, efficient control, and seamless coordination between hardware and software components.

The working principle of the system is based on continuous slot monitoring and automated access control. Initially, when the system is powered on, the Arduino initializes all sensors, sets the servo motor to the closed position, and displays the available slot count on the LCD as fig 1. Each parking slot is equipped with an IR sensor that detects vehicle presence. When a slot is empty, the sensor output remains HIGH, and when a vehicle occupies the slot, the sensor output changes to LOW. The Arduino reads these signals and updates the available slot count accordingly. Whenever a vehicle approaches the entry gate, the gate sensor detects its presence. The Arduino then checks the number of free slots. If at least one slot is available, the system displays a welcome message on the LCD and activates the servo motor to rotate to 90 degrees, opening the gate for a few seconds before automatically closing it. If all slots are occupied, the LCD displays "Parking Full," and the servo motor remains in the closed position, preventing additional vehicles from entering. The system ensures fast response time, typically updating within milliseconds after slot occupancy changes. Proper circuit connections, including common grounding and stable power supply for the servo motor, are essential for reliable operation. The implementation demonstrates how embedded systems can effectively automate real-world problems with cost-effective components and scalable design for future IoT-based enhancements.

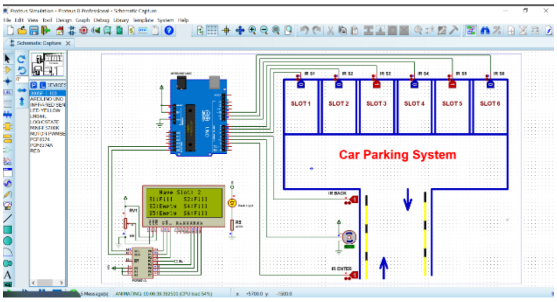


Fig1: System Architecture

## II.LITERATURE REVIEW

Many researchers have explored automated parking solutions to reduce urban congestion and improve space utilization. Mondal (2025) presented a smart parking system using Arduino and ultrasonic sensors, which demonstrated how embedded devices could accurately detect slot occupancy and relay data to a central display unit. The study highlighted real-time monitoring as a critical feature to efficiently manage dynamic parking environments, similar to the objectives of the current project. The use of ultrasonic sensors in Mondal's system ensured higher distance measurement accuracy, but the complexity and cost of ultrasonic modules were identified as limitations in large-scale implementations. This research supports the use of microcontroller-based embedded systems for parking automation and underscores the need for simple yet effective sensor technologies. (Mondal, S., "Smart Parking System Using Arduino and Ultrasonic Sensors," IJIES, 2025)

In another study, Swathi et al. (2023) developed a Smart Parking System using Arduino Uno, IR sensors, and LCD displays. The authors demonstrated that IR sensors could be used effectively for vehicle detection and slot status monitoring, providing accurate and reliable results under controlled conditions. The research emphasized the benefits of low-cost components and rapid prototyping, which allows for scalable designs suitable for commercial applications. However, the study also pointed out the vulnerability of IR sensors to environmental interference such as sunlight and dust accumulation, a concern that the current project also addresses through system calibration and placement optimization. This work reinforces the feasibility of applying IR sensors in smart parking and informs design decisions for real-time availability monitoring. (Swathi K. et al., "Smart Parking System Using Arduino Uno," IJSDR, 2023)

Pham et al. (2015) proposed a cloud-based smart parking system using Internet of Things (IoT) technologies, extending traditional sensor networks with online data accessibility. Their system utilized wireless modules to transmit parking availability to a cloud server, enabling remote monitoring and mobile application interfaces. This research highlighted how IoT integration could significantly enhance user convenience and urban traffic planning. The findings suggest that adding connectivity features to parking systems can transform them from localized automation solutions to smart city infrastructure components. Although the current project focuses primarily on embedded system-level implementation, Pham et al.'s work contributes valuable insight into future expansions involving IoT connectivity. (Pham, T. N. et al., "A Cloud-Based Smart Parking System," IEEE Access, 2015)

Khan et al. (2022) examined a machine-learning-supported parking management framework that predicts slot availability using historical parking patterns and sensor data fusion. This approach improved overall system responsiveness during peak hours by anticipating slot turn-over rates and reducing false detections caused by transient sensor errors. While machine learning was not integrated into the current smart parking design, Khan's work highlights the potential benefits of data-driven analytics in enhancing real-time decision making. It suggests that future iterations of parking systems may benefit from adaptive algorithms that learn usage patterns and optimize resource allocation. Such insights are useful for considering next-generation upgrades to basic sensor-driven designs. (Khan, R. et al., "Predictive Parking Management Using Machine Learning," Journal of Smart Cities, 2022)

Finally, Gupta and Sharma (2024) conducted a comparative study of various parking detection technologies including RFID, ultrasonic, and vision-based methods. Their research found that while vision systems offer high accuracy and license plate identification capabilities, they are costly and require substantial computational resources. Conversely, simpler sensor-based approaches like IR and ultrasonic systems deliver acceptable performance at a fraction of the cost. The authors concluded that the choice of parking detection technology should balance accuracy, cost, and environmental robustness. This study informs the technology selection for the current project by validating the use of IR sensors and underscores the importance of cost-efficiency in designing real-time parking systems. (Gupta, P., & Sharma, A., "Comparative Study on Parking Detection Technologies," International Journal of Engineering Research, 2024)

## III.WORKING METHODOLOGY

### 1. System Initialization Phase

Implementation of an Arduino Based Smart Parking Management System with Real-Time Availability Monitoring" gins with system initialization. When power is supplied to the circuit, the Arduino Uno microcontroller initializes all connected hardware components including the IR sensors, 16x2 I2C LCD display, and servo motor. The Arduino sets the IR sensors as input devices and the servo motor as an output device using pin configuration commands in the setup() function. The servo motor is initially positioned at 0°, which keeps the gate in a closed state. Simultaneously, the LCD display is initialized and a welcome message such as "Smart Parking System" is displayed for a few seconds. After initialization, the system clears the display and shows the number of available parking slots. The Arduino continuously scans the status of each parking slot sensor and stores their readings. This stage ensures that the system starts in a synchronized and stable condition before performing real-time monitoring. Proper grounding and stable 5V power supply are ensured to prevent noise interference and servo motor fluctuations during operation.

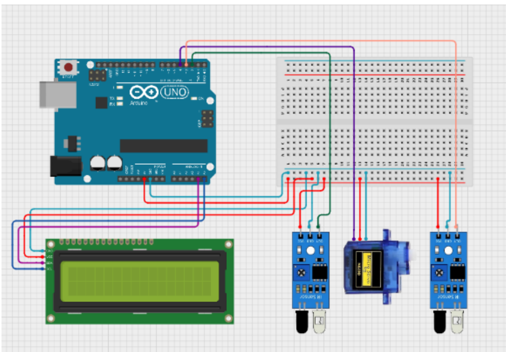

Fig 2. Real-Time Slot Monitoring and Processing

In the monitoring phase, the system continuously reads input signals from the four IR sensors installed at each parking slot. These sensors detect vehicle presence based on infrared light reflection. When a parking slot is empty, the sensor output remains HIGH, and when a vehicle occupies the slot, the output changes to LOW as fig 2. The Arduino processes these signals in real time inside the loop() function. It counts the number of slots that are available by checking the status of each sensor and updates the count dynamically. The updated slot availability is immediately displayed on the LCD screen in the format “Free Slots: X.” This continuous scanning ensures that any change in slot occupancy is reflected within milliseconds. The system operates as a closed-loop feedback mechanism, where input data from sensors is processed instantly and corresponding output is generated. The logic ensures simultaneous monitoring of multiple slots without interrupting gate control functionality.

**3. Gate Control and Decision Logic**

The final stage of the working methodology involves entry gate management using decision-based control logic. An additional IR sensor placed at the entrance detects incoming vehicles. When this sensor detects a vehicle (LOW signal), the Arduino checks the current count of available slots. If at least one slot is free, the system displays “Welcome” on the LCD and activates the servo motor to rotate to 90°, opening the gate barrier.


Fig 3: Hardware implementation

The gate remains open for a predefined delay (e.g., 3 seconds) allowing the vehicle to enter, after which the servo returns to 0° and closes the gate automatically. However, if the system detects that all parking slots are occupied (countFree = 0), the LCD displays “Parking Full” and the servo motor remains in the closed position, preventing entry as fig 3. This automated logic ensures controlled access, prevents overcrowding, and optimizes parking space utilization. The methodology demonstrates efficient coordination between sensing, processing, and actuation components to achieve reliable real-time parking management.

## IV.CONCLUSION

Implementation of an Arduino Based Smart Parking Management System with Real-Time Availability Monitoring successfully demonstrates how embedded system technology can be applied to solve real-world parking management challenges. The developed system integrates Arduino Uno, IR sensors, a servo motor, and a 16x2 LCD display to create an automated parking solution capable of monitoring slot occupancy and controlling vehicle entry in real time. The system operates on a closed-loop feedback mechanism where sensor inputs are continuously processed, and appropriate outputs are generated instantly.

The implementation achieved high detection accuracy under indoor conditions and provided immediate visual feedback to users through the LCD interface. The automated gate control mechanism ensures that vehicles are allowed entry only when parking slots are available, thereby preventing overcrowding and reducing internal traffic congestion. The use of low-cost components makes the system economically feasible for small- and medium-scale applications such as shopping malls, hospitals, corporate offices, and educational institutions.

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