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Revolutionizing Urban Mobility: The Role of Smart Parking Systems

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Abstract

The Smart Parking System is an efficient and cost-effective solution for modern parking challenges, designed using an Arduino Uno, IR sensors, I2C display, servo motor and breadboard. This system aims to optimize parking space utilization, reduce vehicle congestion, and enhance user convenience. The IR sensors detect the presence of vehicles, providing real-time feedback on parking slot availability. The data is processed by the Arduino Uno microcontroller and displayed on an I2C LCD screen, enabling users to easily locate available spaces. A servo motor operates the barrier gate, which automatically opens or closes based on the availability of parking slots and the presence of a vehicle. The breadboard facilitates the integration and prototyping of the components, ensuring flexibility and simplicity in design. This prototype demonstrates a scalable and user-friendly system suitable for various applications, including commercial parking lots and residential complexes. The Smart Parking System promotes efficient parking management, reduces manual intervention, and contributes to a seamless parking experience.

Keywords: Smart Parking System, Arduino Uno, IR Sensors, I2C LCD Display, Servo Motor, Parking Management, Vehicle Detection, Real-time Parking Availability, Automated Parking, Parking Slot Optimization, IoT-based Parking, Parking Automation, Embedded systems, Parking Solutions, Prototype Development, Smart City Infrastructure, Automated Barrier Gate, Vehicle Congestion Reduction, Parking Efficiency, Cost-effective Parking Solutions.

1. INTRODUCTION

Now a days in metropolitan cities it is very difficult to find free parking slot due to the high growth of vehicles. It is especially difficult to park a car in metro city. In this project we aim at solving this problem of the driver by knowing the available for the car to be parked [7][8]. Internet of things (IoT) has the ability to transfer data through network without involving human interactions. IoT helps user to maintain transparency The idea of the IoT started with the identity of the things connecting various devices [1]. We propose smart outdoor parking without requiring manual intervention with the convenience of similar systems [3]. By

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integrating IR sensors, an Arduino Uno microcontroller, and an I2C LCD, the system provides real-time slot monitoring and automated gate control using a servo motor. The intelligent IoT-based vehicle parking system is a close solution for high population cities. through this system user do not have to waste money and time [4]. The objective is to optimize parking space utilization while reducing the reliance on human supervision.

2. PROBLEM FORMULATION

Traffic congestion has become a growing concern by 2025 as vehicle numbers are continue to rise, the situation is expected to worsen leading to even more pronounced traffic issue in urban areas [4]. Inefficient parking systems lead to problems such as:

A) Congestion: Drivers spend significant time searching for a available parking spots, leading to traffic congestion and increased fuel consumption.
B) Manual Oversight: Traditional parking systems require human supervision, which can result in inefficiencies and errors.
C) Lack of Real-Time Information: Drivers often lack timely updates on parking slot availability, causing delays and frustration.
D) Space Utilization: Inadequate monitoring and allocation of parking spaces result in underutilized or overcrowded parking lots.

To address these issues, a Smart Parking System is proposed. This system is designed to:

- Detect vehicle presence using IR sensors.
- Display real-time parking slot availability on an I2C LCD screen.
- Control a servo motor for automated barrier operation based on slot availability.
- Provide an easy-to-develop prototype using an Arduino Uno and breadboard.

This formulation identifies the inefficiencies in traditional parking management and establishes the need for a low-cost, automated solution to improve parking experiences in urban and semi-urban environments [3].

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3. RELATED WORK

The result of this paper is to make the parking area connected the world as well as reduces time and can be cost effective to the user. The result of this paper to reduce the car theft. This paper reduces overall fuel energy of the vehicle which is consumed in the search of the free parking slot [1]. This Paper introduces an advanced framework for outdoor parking. The main goal of this project is to develop a companion app that enables users to quickly locate available parking spaces and easily make parking payments. The sensor based system offers greater convenience in identifying vacant spots and ensure enhanced security and efficient vehicle parking. These enhancements will focus on achieving more accurate localization of outdoor parking spaces, making the system more user-friendly [3]. This system assigns a unique VP_ID to each user during registration for identification purposes, which is particularly useful for the sensor port. Additionally, this document introduces a new algorithm called IOTPS, which is designed to help users to find the available parking spaces and record the location of the parked vehicle [4]. As the demand for smart parking system continues to

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grow in the metropolitan cities, India is expected to have 100 smart cities by 2030. This project introduces additional features, such as displaying the available number slots and distance from the vehicle to the available parking slot. In the future, smart parking systems may become essential not only in urban cities but also in semi-metropolitan areas. This system will allow users real-time access to the availability of parking spaces [7]. In this study we introduced an automated for vehicle storage and parking management that utilizes an Android application as the user interface. This application communicates with the emended system, which primarily consists of an Arduino Mega board and Arduino Wi-Fi shield. The Arduino Mega board plays a key role in collecting data on vehicle entry and exit [5].

4. METHODOLOGY

The Smart Parking System is designed to automate parking management by integrating hardware and software components that work together seamlessly. The system consists of sensors for vehicle detection, a microcontroller for data processing, an LCD for displaying parking slot status, and a servo motor for gate control. In this project we use various hardware and software components which are as follows:-

A) Hardware Components:

- Arduino Uno: It is a compact board which can be used in various devices and various fields. It has the total 22 input/output fields out of which 14 pins are the digital pins. It serves as the central processing unit, handling input from sensors and controlling the servo motor. This module is breadboard friendly board which can be easily used anywhere.

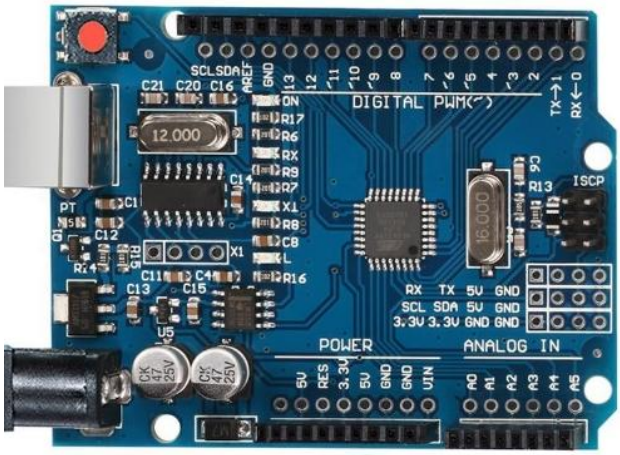

Figure 1. Arduino UNO

- IR Sensors: An infrared sensor is basically an electronic device which is used to detect the presence of an objects. Infrared light is emitted by this device. If this device does not detect Any IR light reflected back that means there is no object present. If the light is detected by the sensor there is an object present.

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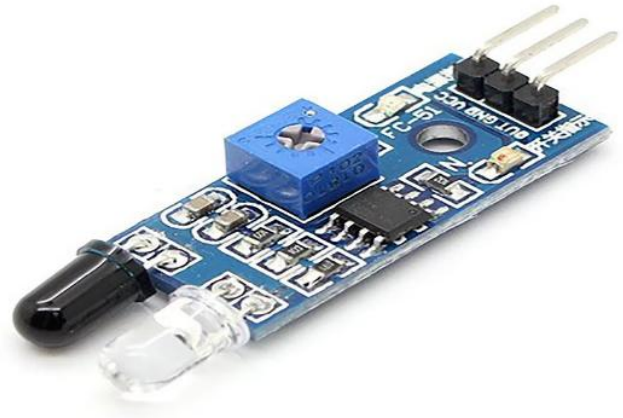

Figure 2. IR Sensor

- I2C LCD Display: It is used to provide visual feedback and information to users. The LCD display shows the status of parking slots, prompts for recharge or entry acknowledgements, and other relevant messages.

Figure 3. I2C LCD Display

- Servo Motor: It is a rotator device that allows the control of angular as well as linear motion. It controls the barrier gate for automated entry and exit. Servo drive transmits electrical signals to the servo motor for producing motion.

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Figure 4. Servo Motor

- Connecting Wires: Various wires, cables, and connectors are needed to establish connections between the Arduino board and the other hardware components. These connections include digital pins for the servo motor, IR sensors, and I2C connections for the LCD display.

Figure 5. Connecting Wires

- Breadboard: A breadboard is a solderless device for temporary prototype with electronics and test circuit designs. Most electronic components in the electronic circuits can be interconnected by inserting their leads or terminals into the holes and then making connections through wires where appropriate. The breadboard has strips of metal underneath the board and connect the holes on the top of the board.

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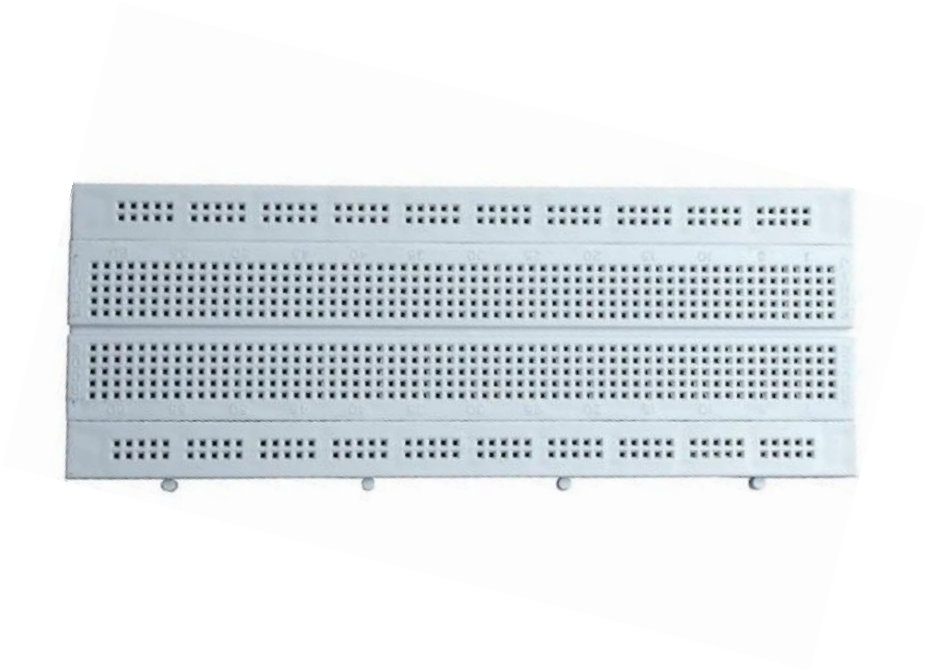

Figure 6. Breadboard

- Arduino USB Cable: The Arduino USB Cable for UNO and Mega (50 cm) is a type of USB cable designed specifically for the Arduino UNO and Mega microcontroller boards. It has a standard USB connector on one end and a type B USB connector on the other, allowing it to be connected to a computer or other USB device.

Figure 7. Arduino USB Cable

B) Software Implementation:

- Arduino IDE: Used for programming the microcontroller.
- Libraries: Include Liquid Crystal for LCD operation and Servo library for motor control.
- Algorithm:
  1. IR sensors monitor slot occupancy.
  2. The Arduino processes sensor data and updates the LCD display.
  3. If a slot is available, the servo motor opens the barrier gate.

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4. Once the vehicle passes, the gate closes automatically.

5. SCHEMATIC DIAGRAM

The Smart Parking System using Arduino Uno, IR Sensors, I2C Display, Servo Motor, and Breadboard is designed to efficiently manage parking spaces. The system works by detecting whether a parking slot is occupied or available using IR sensors. When a vehicle is detected, the sensor sends a signal to the Arduino Uno, which processes the data and updates the I2C display to show the number of available spaces. The system's user interface on the display can show messages such as "Available Slots" or "Parking Full". Additionally, the Arduino controls a servo motor to open or close the parking barrier based on availability, allowing vehicles to enter or exit the lot.

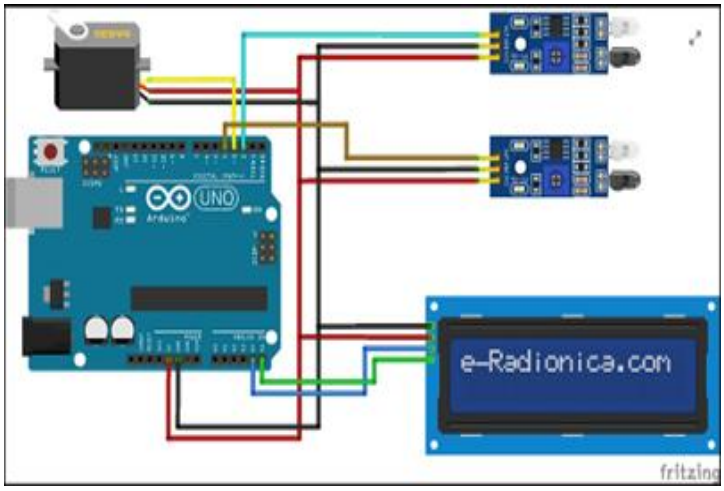

Figure 8. Schematic Diagram

6. RESULTS & DISCUSSION

Testing of the Smart Parking System yielded the

following key observations:

- The IR sensors accurately detected vehicle presence with minimal errors. It helps to open and close the door when car is entering and exiting the parking.
- The LCD display updated in real-time, allowing drivers to identify available slots.
- The servo motor functioned reliably, ensuring seamless barrier gate operation.
- Potential limitations include sensitivity to ambient light affecting sensor accuracy.

While the system proved effective for small-scale applications, further enhancements such as cloud- based data storage and mobile app integration could increase usability in large parking facilities.

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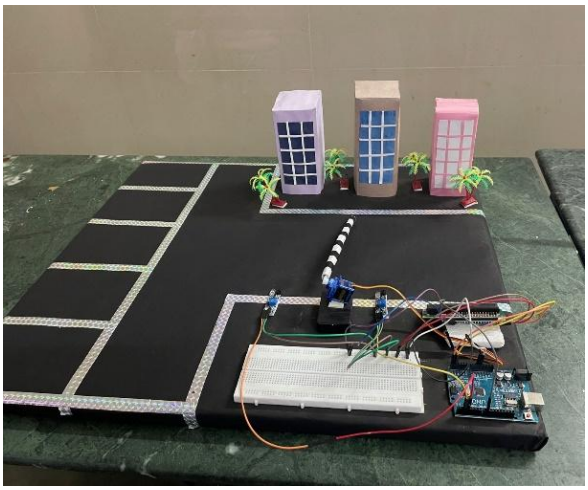
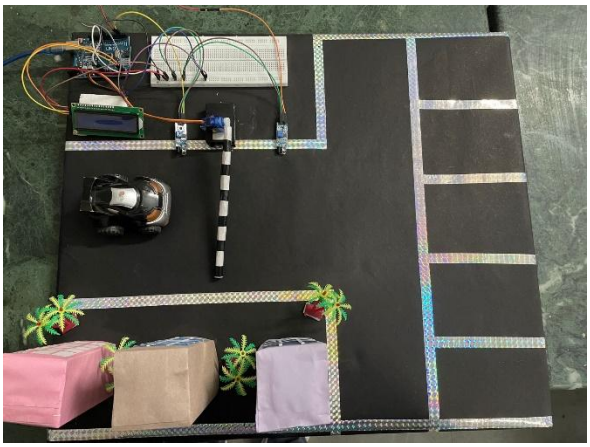
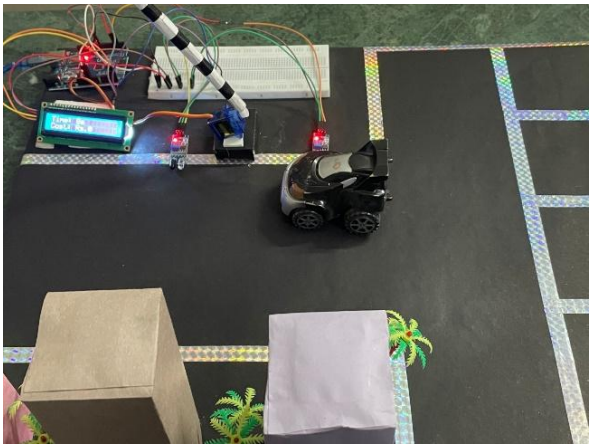


(a) Hardware View



(b) Car is Coming



(c) Working Model

Figure 8. Final Output

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7. FUTURE SCOPE

To further improve the Smart Parking System, several enhancements can be considered:

- Integration with Mobile Apps: Real-time parking slot updates and reservations can be facilitated through smartphone applications.
- Cloud-Based Data Analytics: Storing and analyzing parking data in the cloud can enhance decision-making and predict parking trends.
- Advanced Sensor Technology: Incorporating ultrasonic or camera-based systems can improve accuracy in vehicle detection.
- Scalability for Large Facilities: Adapting the system for multi-level parking garages and public spaces can expand its usability.
- IoT Integration: Connecting the system with smart city infrastructure can enable automated traffic management and enhance urban planning.

By integrating these advancements, the system can evolve into a comprehensive smart parking solution

that contributes to the efficiency of modern
urban transportation.

8. CONCLUSION

The Smart Parking System developed in this research offers an efficient, automated solution to parking challenges. It reduces congestion, optimizes space utilization, and minimizes human intervention. The integration of IR sensors, Arduino Uno, and servo motors provides a seamless user experience, ensuring real-time parking slot detection and automated gate control. The system is cost-effective and can be implemented in various parking environments, including commercial complexes and residential areas. Despite minor limitations such as sensor sensitivity to ambient light, the prototype demonstrates significant potential in enhancing urban mobility and reducing traffic congestion.

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