Smart Car Parking System using Arduino and Sensor

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ABSTRACT

With the continuous growth of population and rapid urbanization, the number of vehicles on the roads has increased sharply, which has created serious parking difficulties in most cities. Finding an empty parking space has become a frustrating and time-consuming task, especially in busy commercial areas and crowded urban zones. As a result, drivers often keep roaming around in search of parking, which leads to unnecessary vehicle movement, traffic congestion, fuel wastage, and higher levels of air pollution. To overcome these challenges, modern technology is now being used to design smart parking systems that can automatically monitor and manage parking spaces more efficiently.

The proposed system is a Smart Car Parking System using Arduino and Sensors, developed to provide a simple, intelligent, and automated way of handling parking slots. It uses an Arduino UNO as the main controller along with Infrared (IR) sensors, a servo motor, and a 16×4 LCD display. The IR sensors detect the entry and exit of vehicles and send this information to Arduino. Based on this data, the servo motor automatically opens or closes the gate. At the same time, the LCD display shows the real-time availability of parking slots, helping drivers immediately known whether a spot is free.

This system reduces manual effort, saves time, and prevents unnecessary fuel consumption caused by searching for parking. It also helps reduce pollution and improves the overall efficiency of parking areas. Because it is low-cost, reliable, and easy to implement, this smart parking system is a practical solution that supports the development of cleaner and smarter cities in the future.

Keywords: Arduino Uno, Automation, Infrared Sensors, Smart Parking System, Ultrasonic Sensors, Vehicle Detection

1. INTRODUCTION

Urban cities today face significant challenges in managing parking facilities due to increasing vehicle growth and limited space availability. Drivers often spend a long time searching for vacant parking slots, which results in unnecessary fuel consumption, traffic congestion, and environmental pollution. According to Das and Basu [1], inefficient parking management is a major contributor to urban mobility problems.

Smart parking systems have emerged as an effective solution to overcome these challenges. These systems use sensors, microcontrollers, and digital displays to provide real-time slot availability information. Modern studies show that sensor-based parking models can significantly reduce search time and improve overall parking efficiency, especially in crowded areas, as highlighted by Lin et al. [2].

Arduino-based automation is widely used in academic and prototype-level projects because of its low cost, flexibility, and compatibility with multiple sensors. Shaikh and Pathan [3] demonstrated that Arduino combined with IR or ultrasonic sensors provides accurate and reliable vehicle detection for experimental smart parking setups. Recent work by Patel and Karamta [4] supports the use of IR sensors for short-range detection in low-budget designs.

The proposed project focuses on developing a simple, economical smart car parking system using an Arduino Uno, IR sensors, and an LCD display. Prior research shows that LCD-based display guidance improves user experience by helping drivers quickly identify available slots, reducing time wastage and congestion, as noted by Kim and Lee [5]. This introduction establishes the need and relevance of smart parking systems in today's urban environment.

2.METHODOLOGY

The methodology begins with a study of existing parking issues such as difficulty in locating free spaces, congestion caused by slow vehicle movement, and increased fuel consumption. Das and Basu [1] reported that a significant portion of urban traffic arises from drivers searching for available parking.

A detailed literature review was then conducted to understand modern smart parking techniques including Arduino-based automation, IR sensor detection, and real-time display systems. Research surveys conducted by Lin et al. [2] and Shaikh and Pathan [3] provided insight into current advancements and limitations in smart parking technologies.

Based on this review, the proposed system was designed using an Arduino Uno microcontroller and IR sensors for vehicle detection. IR sensors were selected because they provide accurate short-range detection and are suitable for low-cost implementations, as demonstrated by Patel and Karamta [4]. The Arduino processes the incoming sensor signals and identifies whether each slot is occupied or free.

Slot availability is then shown on a Liquid Crystal Display (LCD), allowing drivers to easily identify free spaces. Prior studies, including the work of Kim and Lee [5], suggest that LCD-based guidance can reduce search time and improve parking flow.

Calibration tests were conducted to ensure accurate sensing under different lighting and environmental conditions. The final methodology aims to deliver a cost-effective and efficient smart parking system that enhances user convenience and reduces congestion inside parking areas.

3.LITERATURE SURVEY

Several researchers have developed Arduino- and sensor-based smart parking systems to improve slot detection and reduce manual monitoring. Gupta et al. [6] designed an Arduino-based ultrasonic parking model capable of detecting vehicle presence with high accuracy. Similarly, Patel and Kaur [7] used IR sensors to implement a low-cost parking detection system suitable for indoor environments. Raut and Kale [8] also proposed a GSM-based parking availability design that improved notification accuracy.

IoT-enabled models were introduced by Rahman et al. [9], who integrated Wi-Fi modules for cloud-based monitoring. Banerjee and Iqbal [10] studied energy-efficient sensor networks to reduce power consumption in real-time parking systems. Thomas et al. [11] presented a comparative survey of multiple urban smart parking designs and highlighted the benefits and challenges of IoT-based systems.

Hybrid systems were explored by Sinha and Mehta [12], who included automated gate control through servo motors. Choudhary et al. [13] implemented RFID-enabled secure entry systems to enhance authentication accuracy.

More advanced approaches were proposed by Fernandes and Pinto [14], who applied machine-learning techniques to predict parking slot occupancy. Khan et al. [15] developed real-time monitoring methods using optimized sensor networks for higher reliability.

From the literature reviewed, it is observed that although various smart parking models exist, many face challenges related to cost, complexity, and environmental interference. Arduino-based IR sensor systems remain an affordable and practical option for low-budget prototypes.

4.DESIGN SYSTEM

4.1 BLOCK DIAGRAM

The initial stage of the project started with a literature review and the assembly of all the required components. This was followed by preparing the block diagram as shown in Figure 1. and studying the circuit connections in detail. The Arduino microcontroller is programmed using the Arduino IDE software. When a car arrives near the entrance, the IR sensor detects its presence and sends a signal to the Arduino. The Arduino processes this signal and activates the servo motor to open the gate for the car to enter. Another IR sensor is placed at the exit to detect cars leaving the parking area, and the Arduino updates the available parking count accordingly. When all parking slots are full, the servo motor remains inactive until a vehicle exits. Arduino's built-in ADC converts the analog signals from the IR sensors into digital form for processing.

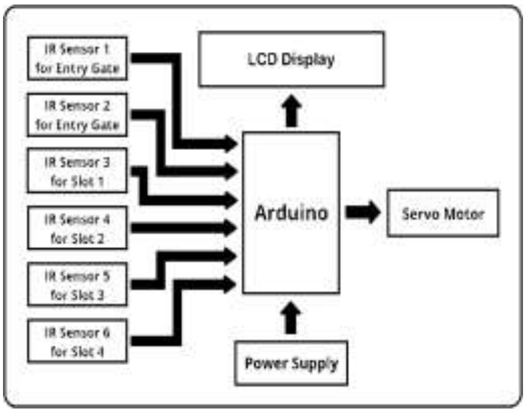

Figure 1: Block Diagram of Smart Parking System

5. COMPONENTS LIST AND SPECIFICATION

5.1. ARDUINO UNO

Arduino Uno as shown in Figure 2. is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable. It can be powered by the USB cable or by an external 9-volt battery, though

Figure 2. Arduino Uno Board

5.2. LCD DISPLAY

A Liquid Crystal Display (LCD) as shown in Figure 3. is an electronic screen that shows numbers, letters, or messages using liquid crystals. These crystals do not produce light by themselves; instead, a backlight helps make the display visible. LCDs are widely used in digital clocks, calculators, and electronic projects.

In this smart car parking system, the LCD is used to display the number of available parking spaces and system status. It works by controlling light passing through the crystals to form readable characters. The 16x2 LCD module connected to Arduino can show two lines of text, making it simple, reliable, and easy to use for small embedded systems.

Figure 3. LCD Display

5.3. I²C MODULE

I²C or IIC stands for Inter-Integrated Communication. I²C is a serial communication interface to communicate with other I²C devices. I²C uses multi-master / multi slave method. As shown in Figure 4. I²C uses 2 lines named SCL and SDA for transmission/reception and another 2 lines for power supply and ground. Each I²C device has I²C address to identify. I²C addresses of multiple devices may have the same address. The address is in the format of "0x20".

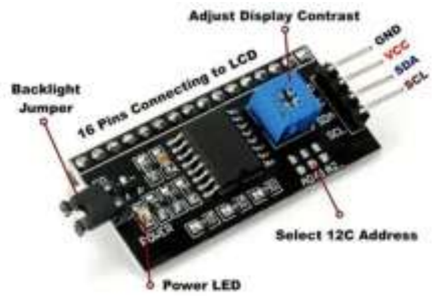

Figure 4. I²C Module

Steps to find out I²C address device is discussed in the following. The serial Clock (SCL) pin is to synchronize the transmitter and receiver. Serial Data (SDA) pin is to transfer data.

5.4. SERVO MOTOR

A servo motor is an electromechanical device designed to rotate to a specific angle with high accuracy. As shown in Figure 5. It has three main wires — one for power (positive), one for ground (0V), and one for the control signal that comes from the Arduino.

The Arduino sends a series of electrical pulses to the servo, which determines how far the motor should turn.

Servo motors are available in different sizes such as mini, standard, and giant types, depending on the torque they can handle. Most small and standard servos can be directly controlled by the Arduino without an external driver.

In this smart car parking system, the servo motor is used to lift or lower the entry gate when a vehicle is detected by the sensors. The rotation angle (generally between 0° to 180°) is controlled by the width of the signal pulse. For example, a 1.5 ms pulse turns the servo to the center (90°) position, while shorter or longer pulses move it to the left or right.

Figure 5. Servo Motor

5.5. IR SENSOR

An Infrared (IR) sensor as shown in Figure 6. is an electronic device that detects objects or motion using infrared light. Every object around us emits a small amount of infrared radiation, which cannot be seen by human eyes but can be sensed by an IR sensor. The sensor mainly consists of two parts — an emitter and a detector.

The emitter is an IR LED (Light Emitting Diode) that sends out infrared light, and the detector is an IR photodiode that receives this light. When an object comes in front of the sensor, the emitted light is reflected to the photodiode. This causes a change in resistance and output voltage, which the Arduino reads as a signal.

In this smart car parking system, IR sensors are used to detect the presence or absence of a car in a parking slot. When a vehicle is detected, the Arduino processes the signal and updates the LCD display or controls the servo motor accordingly.

Figure 6. IR Sensor

5.6. CONNECTING WIRES

As shown in Figure 7. Connecting wires are important components used to link different electronic parts in a circuit. They allow electric current and signals to pass between the Arduino board, IR sensors, servo motor, and LCD display. These wires are usually made of copper, which is a good conductor of electricity and reduces energy loss.

In the smart car parking system, connecting wires create proper electrical connections between all modules. Jumper wires are commonly used on a breadboard — male-to-male, female-to-female, or male-to-female — depending on the pin type. Proper wiring ensures smooth communication and stable operation of the entire system.

Figure 7. Connecting Wires

5.7. BATTERY

A lithium battery as shown in Figure 8. is a lightweight and high-energy rechargeable power source commonly used in electronic and embedded systems. It provides a stable DC voltage output, usually 3.7V, which makes it suitable for powering sensors, Arduino boards, and small modules. Lithium batteries have a high energy density, meaning they can store more power in a small size, and they offer longer life cycles compared to other battery types.

In the smart car parking system, a lithium battery can be used to supply backup power, ensuring that the IR sensors, servo motor, and Arduino continue to operate during power interruptions.

Its stable output helps maintain accurate sensor readings and smooth functioning of the overall system.

Figure 8. Battery

RESULT AND CONCLUSION

The smart car parking system developed in this project efficiently detects empty parking slots and helps drivers find available spaces, even in unfamiliar areas. It successfully reduces the average waiting and searching time for parking, improving convenience and reducing unnecessary vehicle movement. This leads to lower fuel consumption and less traffic congestion.

The system is based on the Internet of Things (IoT) concept, using infrared sensors to accurately detect the presence or absence of vehicles. A prototype of the IoT-based Smart Car Parking Management System was built using Arduino and sensors to monitor parking availability in real time. The IR sensors detect vehicle presence, and the data is displayed instantly on the LCD screen. The system also stores sensor data in a database and continuously updates parking information for accurate monitoring.

Although the prototype was designed for a single parking area, the concept can be extended to managing multiple parking zones. An additional management interface can record the vehicle's entry and exit time for administrative purposes. According to the results, this system can be implemented in various public and private parking areas to help drivers easily locate available slots, saving time, energy, and fuel. A user acceptance test showed that most users found the system effective and practical. In the future, the system can be enhanced with a mobile application for booking and tracking parking spaces online.

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