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Coimbatore – 641402.

MINI PROJECT REPORT

SMART PARKING SYSTEM

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BONAFIDE CERTIFICATE

Certified that this Mini Project report, **"SMART PARKING SYSTEM"** is the bonafide work of **KAMESH P (711522BCB025), SATHYA S (711522BCB053), SUDALAI ESWARAN V (711522BCB059)** who carried out the Mini Project work under my supervision. Certified further, that to the best of my knowledge, the work reported here in does not form part of any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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DECLARATION

We jointly declare that the Term Project report "**SMART PARKING SYSTEM"** is the result of original work done by us and best of our knowledge, similar work has not been submitted to **"ANNA UNIVERSITY, CHENNAI"** for the requirement of Degree of Computer Science and Business Systems. This Mini Project report is submitted on the partial fulfillment of the requirement of the award of Degree of Computer Science and Business Systems.

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ABSTRACT

The IoT-based Smart Parking System is an innovative solution aimed at addressing urban parking challenges by utilizing Internet of Things (IoT) technology to automate and optimize parking management. This system combines IoT sensors, microcontrollers, and a user-friendly display to monitor parking space availability in real-time. When a vehicle approaches, sensors detect its presence, and the system checks for available parking slots. If slots are available, the gate opens, and the number of free slots is displayed. Conversely, when the parking area is full, the system restricts gate access and displays "0 slots available," ensuring a seamless and transparent experience. This smart system reduces the need for manual intervention and enhances the efficiency of parking management by eliminating unnecessary vehicle movement, thus reducing traffic congestion and saving time for users. Its implementation is scalable and adaptable to various parking environments, such as shopping malls, offices, residential complexes, and public spaces, making it a versatile solution for modern urban infrastructure. In addition to its operational benefits, the system also promotes environmental sustainability by minimizing idle vehicle emissions caused by searching for parking spots. The integration of IoT technology ensures real-time data collection and analytics, providing insights for facility management and enabling further optimization of parking operations. By bridging the gap between technological advancement and urban infrastructure, the IoT-based Smart Parking System exemplifies a step forward in creating smart cities with efficient resource management and enhanced user convenience. With potential for further enhancements, such as mobile app integration and advanced analytics for predictive parking trends, the system can evolve to offer even greater convenience and efficiency. This project not only solves immediate parking challenges but also paves the way for smarter, more connected urban living solutions.

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LIST OF ABBREVIATION

1. ATmega328P - AVR microcontroller model used in ArduinoUno
2. EEPROM - Electrically Erasable Programmable Read-Only Memory
3. GND - Ground
4. I2C - Inter-Integrated Circuit
5. IOT - Internet of Things
6. IR - Infrared
7. LCD - Liquid Crystal Display
8. PWM - Pulse Width Modulation
9. SCL - Serial Clock Line (used in I2C communication)
10. SDL - Serial Data Line (used in I2C communication)
11. SG90/MG90S - Standard servo motor models commonly used in robotics
12. USB - Universal Serial Bus
13. VCC - Voltage Common Collector (power supply pin)

CHAPTER 1

INTRODUCTION

In today's rapidly urbanizing world, parking management has become a significant challenge in metropolitan areas. Conventional parking systems are often inefficient, leading to traffic congestion, wasted time, and increased pollution. To address these challenges, an IoT-Based Smart Parking System is proposed as an innovative solution.

The IoT Smart Parking System leverages sensors, microcontrollers, and network connectivity to automate and streamline the parking process. The system aims to enhance user convenience and optimize parking area usage by providing real time information about parking availability and automating entry and exit mechanisms.

Key Features:

1. Automated Gate Control:

- A sensor detects the presence of a vehicle at the parking entrance.
- The gate automatically opens if free slots are available.
- If the parking area is full, the gate remains closed, preventing unnecessary entry attempts.

2. Real-Time Slot Availability Display:

- The system displays the number of free parking slots on a digital screen at the entrance.
- When the parking area is full, it prominently displays "0 slots available."

3. IoT Integration:

- Sensors and IoT devices are interconnected to monitor and update the availability of parking spaces.
- Data is processed and transmitted in real-time, ensuring accurate and dynamic updates.

CHAPTER 2

LITERATURE REVIEW

Numerous studies have explored various IoT technologies, such as ultrasonic detectors, machine learning (ML), and cloud integration, to enhance parking management and improve user experience. These researchers have applied advanced methods to automate parking processes, monitor slot availability in real-time, and optimize parking resource utilization.

Pise et al.[1]. introduced an IoT-enabled smart parking system that integrates sensor-based detection for efficient parking management. The system provides real-time monitoring of parking slots and updates through a LCD display, allowing users to check slot availability. By leveraging IoT technology and real-time data transmission, the proposed architecture aims to reduce parking congestion, minimize search times, and improve the overall user experience.

Bhatti et al. [2] introduced a real-time parking assistance system using Arduino and sensors to manage parking availability. Their system allows users to check parking spot status in real-time and assists in efficiently allocating spaces based on demand, reducing waiting time and improving parking management.

Abdulsaheb et al. [3] presented a system based on IoT technology that enables real-time monitoring of parking availability. Their research focuses on integrating sensors and cloud platforms to manage parking spaces efficiently. The system provides dynamic updates and remote access to parking information, which optimizes space utilization and reduces parking time.

Alsafar et al. [4] proposed a smart parking management system using IoT that monitors parking space availability with the help of sensor networks. The system collects data from parking spaces and makes this data available to users, enabling them to find and reserve parking slots more efficiently, thus alleviating the challenges of parking in urban areas.

Angare et al.[5] developed an IoT-based real-time parking system using Arduino and the Blynk application. The system utilizes sensors to detect parking slot occupancy and transmits this data to users via a mobile app, enabling remote access to parking availability. This architecture integrates Arduino boards and IoT technologies to streamline parking management, reduce search times, and improve user satisfaction through real-time updates.

Ismail et al. [6] presented an IoT-based smart parking system that employs a network of sensors and a centralized platform for monitoring parking spaces. The system provides real-time data on parking availability to users, improving parking management efficiency and reducing search times through IoT integration

Tanti et al. [7] developed a smart parking system leveraging IoT technology to manage parking spaces effectively. The system uses sensors to detect slot occupancy and updates a user-friendly interface in real time, enabling users to access parking availability remotely and reduce congestion.

Rao et al. [8] proposed a smart parking system combining machine learning and IoT. The system employs predictive algorithms and sensor data to optimize parking management, reduce search times, and provide a seamless user experience through real-time slot availability and forecasting.

2.1 Conclusion from Literature Review

In conclusion, various IoT-based smart parking systems utilize sensor networks, machine learning algorithms, and cloud technologies to enhance parking management. Ultrasonic sensors, machine learning, and cloud platforms have proven effective in improving parking efficiency, reducing congestion, and providing real-time availability updates. The integration of machine learning in some studies enhances the prediction accuracy of parking demand, further optimizing space utilization. These advancements highlight the importance of using IoT technologies to automate and optimize parking systems, contributing to better urban mobility and reducing the time spent searching for parking spots.

CHAPTER 3
SYSTEM ANALYSIS

3.1. EXISTING SYSTEM

The current parking system utilizes Arduino microcontrollers, IR (Infrared) sensors, and servo motors to automate and streamline parking operations. IR sensors are used to detect the presence of vehicles at entry and exit points, transmitting signals to the Arduino microcontroller. The microcontroller processes these signals and commands the servo motors to operate the gates accordingly, ensuring efficient entry and exit. Additionally, the system includes an LCD display that provides real-time updates on the total availability of parking slots, helping drivers gauge the overall occupancy of the parking area.

While the system effectively manages entry and exit gates, it does not assist drivers in locating specific vacant spots within the parking facility. Drivers must manually search for available spaces, which can lead to delays, especially in larger or more crowded parking lots. This limitation highlights a need for enhancements, such as slot-specific guidance or navigation systems, to improve the efficiency and convenience of parking management.

3.1.1. DRAWBACKS

- **Manual Monitoring**: Most systems require staff to track parking availability, which is time-consuming and prone to errors.
- **No Real-Time Updates**: Traditional systems fail to provide real-time slot availability information to users.
- **Inefficient Space Utilization**: Lack of dynamic slot management often leads to poor use of available parking spaces.
- **Traffic Congestion**: Drivers spend excessive time searching for parking spots, causing congestion and frustration.
- **Limited Scalability**: These systems are not scalable to accommodate growing populations and increasing vehicle counts.

3.1.2 CIRCUIT DIAGRAM

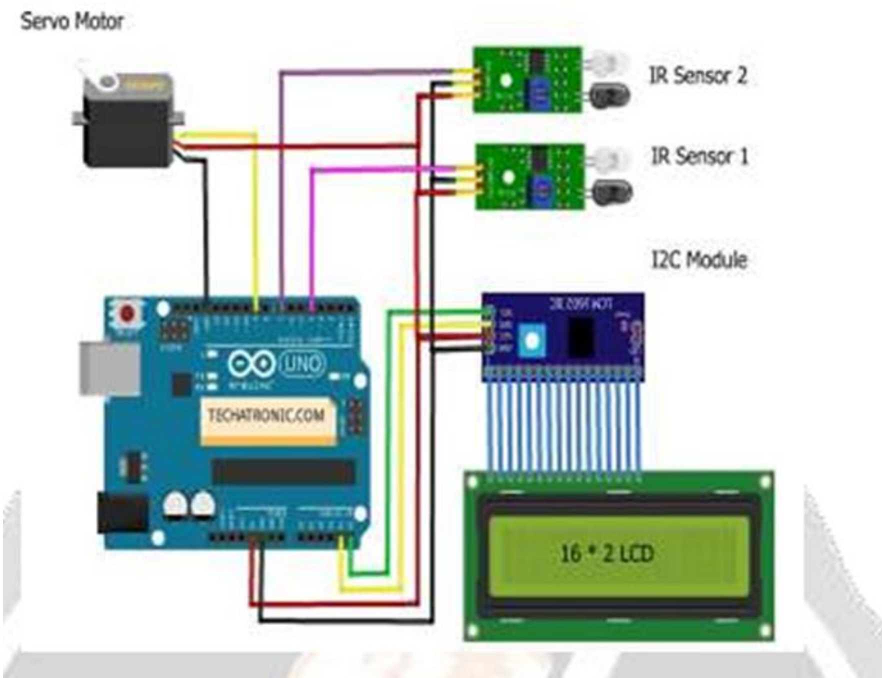

Figure 3.2 – Circuit Diagram of Existing System

3.2. PROPOSED SYSTEM

The IoT-Based Smart Parking System is designed to overcome the inefficiencies of traditional parking systems by incorporating advanced Internet of Things (IoT) technology for seamless and automated parking management. This innovative solution integrates sensors, microcontrollers, and real-time data processing to monitor parking slot availability with precision, while automating gate control to streamline the entire parking experience. By optimizing space utilization, reducing traffic congestion, and offering accurate real-time updates, the system aims to enhance convenience and efficiency for users.

Key features of the system include:

- **Vehicle Detection**: Sensors installed at the entrance and individual parking slots detect the presence of vehicles, ensuring accurate and dynamic tracking of parking space usage.

- **Real-Time Slot Availability Display**: A digital display at the entrance provides users with up-to-the-minute information on the number of available parking slots, enabling informed decision-making and reducing time spent searching for parking.

- **Automated Gate Control**: The system automatically opens the gate when slots are available and keeps it closed when the parking area is full. This prevents unnecessary entry attempts, reducing delays and enhancing traffic flow.

3.2.1. MERITS

- **Real-Time Slot Availability Display**

  The system provides users with accurate, up-to-date information about the number of free slots available in the parking area. This minimizes the time spent searching for a parking spot, reduces vehicle idle times, and alleviates traffic congestion, especially during peak hours.

- **Automated Gate Control**:

  Advanced sensors detect incoming vehicles and seamlessly automate gate operations. The system ensures smooth entry and exit by automatically opening the gate when slots are available and keeping it closed when the parking area is full, enhancing efficiency and reducing delays.

- **Efficient Space Utilization**:

  Dynamic real-time updates on parking slot availability allow for optimal management of parking spaces. This ensures that every available slot is utilized effectively, maximizing the parking facility's capacity.

- **Cost Efficiency**:

By automating routine processes such as slot monitoring and gate control, the system reduces the need for manual intervention. This lowers operational costs significantly while maintaining high levels of accuracy and efficiency.

- **Scalability**:

The system is designed to grow with demand. It can easily be expanded to support more vehicles, additional parking slots, or multi-level parking facilities, making it a future-proof solution for evolving needs.

- **User Convenience**

The integration of real-time monitoring and automated gate operations minimizes delays and ensures a hassle-free parking experience. This enhances user satisfaction by providing seamless access to parking services.

- **Environmentally Friendly**:

By reducing unnecessary vehicle movement and idle times during the search for parking, the system lowers fuel consumption and emissions. This contributes to a cleaner, more sustainable urban environment.

- **Traffic Flow Improvement**:

The automated processes and real-time updates help streamline vehicle movement in and out of the parking area, reducing bottlenecks and ensuring a smoother traffic flow around the facility.

3.2.2 BLOCK DIAGRAM

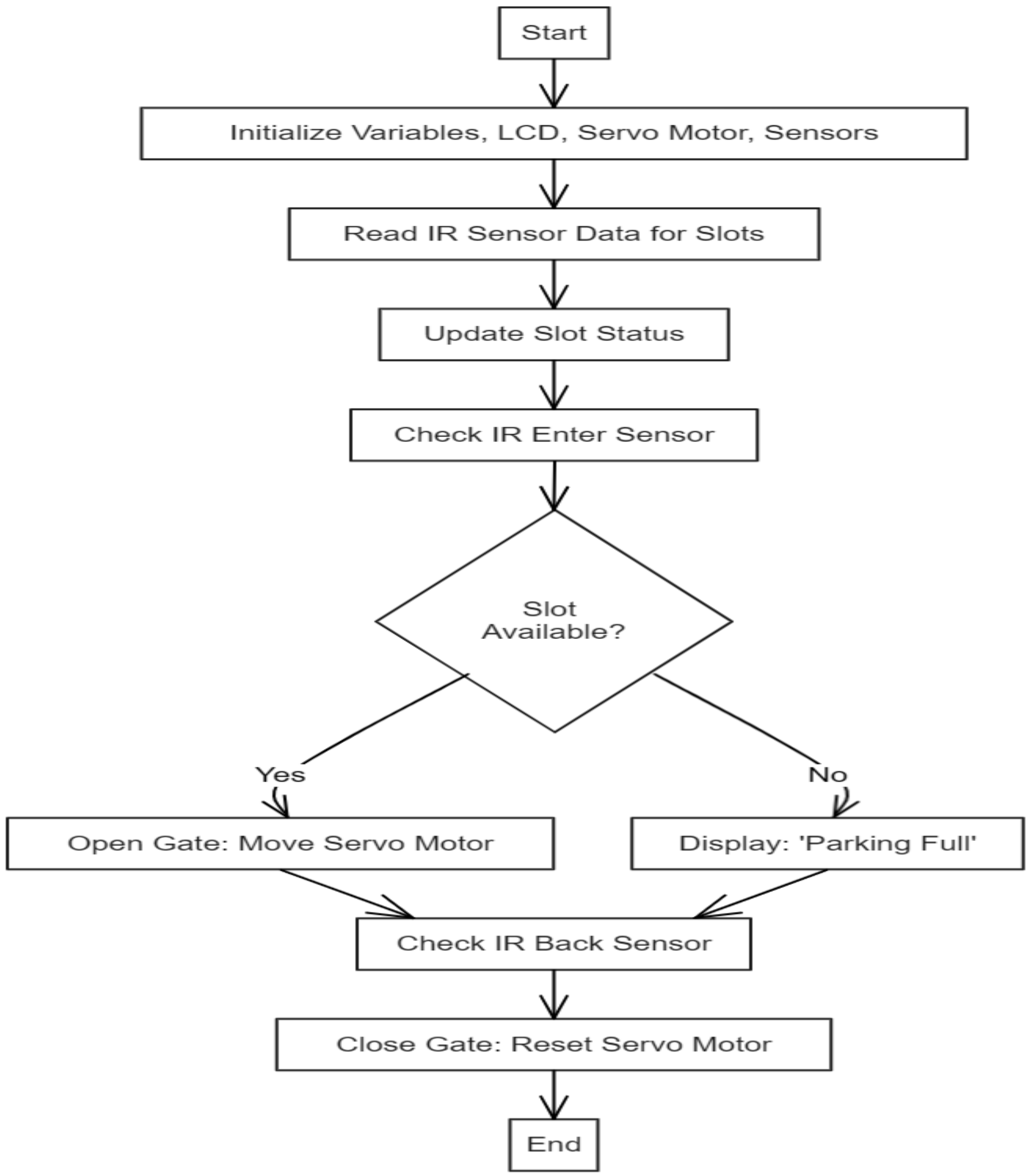

Figure 3.2 - Block diagram of Proposed System

CHAPTER 4

MATERIALS METHODS

4.1. HARDWARE SPECIFICATIONS:

Arduino Uno:

Function:

The Arduino Uno serves as the central microcontroller for the smart parking system. It processes data from the IR sensors to detect whether parking slots are occupied or vacant. Based on this data, it controls the servo motor to open or close the parking gate and updates the 20x4 LCD display with the parking availability status.

Specification:

- **Microcontroller:** ATmega328P
- **Operating Voltage:** 5V
- **Digital I/O Pins:** 14 (of which 6 are PWM capable)
- **Analog Input Pins:** 6
- **Clock Speed:** 16 MHz
- **Memory:** 32 KB Flash, 2 KB SRAM, 1 KB EEPROM
- **Interface:** USB, 16 MHz crystal oscillator
- **Power Supply:** USB or external adapter (7-12V)

The Arduino Uno is chosen for its simplicity, ease of use, and extensive community support. Its GPIO pins are used to interface with the IR sensors, servo motor, and LCD display.

Figure 4.1 Arduino UNO

IR Sensors (Infrared Sensors)

Function:

IR sensors are used to detect whether a parking slot is occupied or free. These sensors emit infrared light and detect the reflection from objects (e.g., a car). When a car is parked, the reflected IR light is detected, indicating that the parking spot is occupied.

Specification:

- **Type:** Infrared Reflective Sensors (e.g., TCS3200, FC-51)
- **Working Voltage:** 3.3V to 5V
- **Detection Range:** Typically 3 to 15 cm (depending on the sensor model)
- **Output Type:** Digital (HIGH/LOW) or Analog (based on the reflection level)
- **Response Time:** Fast, suitable for real-time detection of vehicle presence

Each IR sensor is installed above the parking space to detect a car's presence. The sensors send signals to the Arduino, which processes the data to determine whether a parking slot is occupied or free.

Figure 4.2 IR Sensor

Servo Motors

Function:

Servo motors are used to control the opening and closing of the parking gate. When a parking slot is available, the Arduino sends a signal to the servo motor to open the gate. If the parking lot is full, the gate remains closed.

Specification:

- **Type:** Standard Servo Motor (e.g., SG90, MG90S)
- **Operating Voltage:** 4.8V to 6V
- **Torque:** Approximately 1.2 to 2.5 kg-cm (depending on the model)
- **Rotation:** Typically, 180° rotation, suitable for opening and closing gates

- **Control:** PWM (Pulse Width Modulation)

The servo motor is controlled by the Arduino using PWM signals to rotate the motor shaft to a specific angle (e.g., 0° for closed and 90° for open).

Figure 4.3 Servo Motor

20x4 LCD Display

Function:

The 20x4 LCD display is used to show the number of available parking slots in real time. The display updates whenever a car enters or leaves the parking lot, providing users with the current parking availability.

Specification:

- **Type:** 20x4 LCD (Liquid Crystal Display) with I2C module
- **Display Size:** 20 characters x 4 lines
- **Interface:** I2C for easier connection (only 4 pins required for communication)
- **Voltage:** 5V
- **Backlight:** Blue or Green backlight (customizable)
- **Control Pins:** SDA (Data Line), SCL (Clock Line)

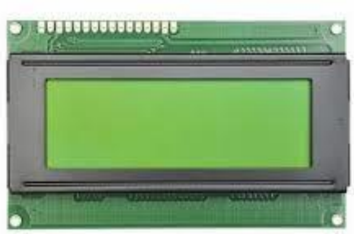

Figure 4.4 LCD Display

CHAPTER 5

EXPERIMENTAL SETUP AND PROCEDURE

Introduction

The IoT-based Smart Parking System is a hardware project designed to automate the process of parking management. It uses Arduino Uno as the central controller, IR sensors to detect the presence of vehicles, a servo motor to control the parking gate, and a 20x4 LCD display to show the number of available parking spaces. The system is designed to automatically open the parking gate when a car arrives and display the number of free parking slots. If the parking lot is full, the gate remains closed, and the display shows "0 slots available." The goal of this project is to provide an efficient parking solution by integrating sensors and automated control, reducing human intervention and enhancing the parking experience.

Prerequisites

To set up and implement this project, ensure that the following hardware and software prerequisites are met:

Hardware:

- Arduino Uno
- IR Sensors (e.g., TCS3200 or FC-51)
- Servo Motor (e.g., SG90 or MG90S)
- 20x4 LCD Display with I2C
- Breadboard and Jumper Wires
- Power Supply (5V for Arduino and 5V-6V for Servo Motor)

Software:

- Arduino IDE for programming the Arduino Uno
- Arduino Libraries:
    - Servo.h for controlling the servo motor
    - LiquidCrystal_I2C.h for the LCD display

To install the Arduino IDE, download it from https://www.arduino.cc/en/software. Once installed, connect your Arduino Uno via USB and ensure the IDE recognizes the board and port.

Environment Setup

To set up the project, follow these steps:

1. **Hardware Setup:**
    1. **Connect the IR Sensors**: Place the IR sensors above the parking slots. Connect the VCC and GND pins of each sensor to the 5V and GND pins of the Arduino. The signal pin (OUT) of each sensor should be connected to a digital I/O pin (e.g., D2, D3).
    2. **Connect the Servo Motor**: Connect the servo motor's VCC to 5V, GND to GND, and the control pin to a PWM-enabled pin (e.g., D9).
    3. **Connect the LCD Display**: For the I2C LCD, connect SDA to A4, SCL to A5, VCC to 5V, and GND to GND.
2. **Software Setup**:
    1. Install the Arduino IDE and ensure the required libraries (e.g., Servo.h, LiquidCrystal_I2C.h) are available.
    2. Open the Arduino IDE and write or upload the provided code for controlling the system.

Installing Dependencies

This project uses the Arduino IDE to program the microcontroller, so no additional Python libraries or dependencies are required. However, the Servo.h and LiquidCrystal_I2C.h libraries must be included in the code to control the servo motor and the LCD display.

- Open the Arduino IDE.
- Go to Sketch → Include Library → Manage Libraries.
- Search for Servo and Liquid Crystal I2C, and click Install for both libraries.

Understanding the Project Structure

The project consists of the following key components:

1. **Arduino Code**: The core logic for controlling the IR sensors, servo motor, and LCD display. The code uses the Servo library to control the servo motor . The LiquidCrystal_I2C

library is used to control the 20x4 LCD display. IR sensors detect the presence of cars in the parking slots and send signals to the Arduino to adjust the gate and display accordingly.

2. **Hardware Components**:
    1. **Arduino Uno**: Central controller that processes input from IR sensors and controls the servo motor and LCD display.
    2. **IR Sensors**: Detect the presence of cars in the parking slots.
    3. **Servo Motor**: Controls the parking gate (opens/closes).
    4. **LCD Display**: Shows the number of available parking slots.

Experimental Setup

1. Connect all hardware components according to the wiring diagram.
2. Upload the Arduino Code:
    - Write the Arduino code to initialize the IR sensors, servo motor, and LCD display.
    - The code checks the status of the parking slots (using IR sensors) and updates the LCD display accordingly.
    - If a slot is occupied, the gate remains closed. If there is an empty slot, the gate opens.

Running the System

To run the system, follow these steps:

1. **Upload the Arduino Code**:
    - Open the Arduino IDE, select the correct board and port under Tools → Board
    - Click on Upload to transfer the code to the Arduino Uno.
2. **Power the System**:
    - Connect the Arduino Uno to the power supply via USB or an external adapter.
    - The system will now run and control the parking gate and display the number of available slots based on sensor data.

Testing the System:

- Test by placing a car in a parking slot and observe the behavior of the gate (opens/closes) and the display (updates with available slots).
- The system should accurately detect the availability of parking spaces and show "0 slots available" when the parking lot is full.

Customizing the System

To customize the system for different parking scenarios or configurations, you can:

- **Adjust the Number of IR Sensors**: If you want to monitor more parking slots, add additional IR sensors and modify the code to handle the new inputs.
- **Change Gate Operation**: You can adjust the servo motor's angle or timing to modify how the gate opens and closes based on your needs.
- **LCD Display Customization**: Modify the display messages to show more detailed parking information or customize the layout.

Enhancing Functionality

For advanced features, you can integrate additional functionalities such as:

1. **Mobile App Integration**: Integrate the system with a mobile app or web interface to remotely check parking availability.
2. **Real-time Parking Data**: Implement a cloud-based solution to send real-time parking data to a server for monitoring multiple parking lots.
3. **Automated Payments**: Add sensors or software to detect when a car leaves and calculate parking fees automatically.

Debugging and Deployment

1. **Debugging**:
    1. If the system isn't responding as expected, check the wiring and ensure all components are connected properly.
    2. Use the Serial Monitor in the Arduino IDE to check the status of the sensors and verify if data is being sent correctly to the Arduino.
    3. Ensure the correct library versions are being used.

2. Deployment:

- Once the system is fully functional, it can be installed at the parking lot.
- Consider weatherproofing the IR sensors and securing the hardware in an enclosure to protect it from environmental factors.
- If deploying in a large-scale parking system, consider adding more sensors and connecting multiple Arduino units for centralized control.

CHAPTER 6

RESULTS AND DISCUSSION

6.1. Results

Project Overview and Results Summary

The IoT-based Smart Parking System was developed to provide an automated solution for managing parking spaces in a given area. The system utilizes IR sensors, a servo motor, and a 20x4 LCD display to detect available parking slots and control the entry gate accordingly. Testing the system with multiple parking scenarios demonstrated that it effectively detects the presence of vehicles, updates the number of available parking slots, and controls the gate based on availability. The IR sensors provided real-time data on parking space occupancy, while the LCD display accurately showed the number of free slots, and the servo motor controlled the gate's opening and closing, making the parking process automated and efficient.

Testing and Accuracy of Responses

The system performed well during testing in identifying the availability of parking spaces. The IR sensors accurately detected the presence of vehicles in parking spots, and the LCD display updated the number of free slots accordingly. For instance, when one car occupied a parking space, the system accurately decreased the available slots. The gate controlled by the servo motor responded appropriately: it opened when spaces were available and remained closed when the parking lot was full. The responses were reliable and consistent with the system's design, confirming the system's functionality.

Performance Under Varying Conditions

The system performed efficiently when tested under standard conditions, such as with typical car entry and exit patterns. However, there were some minor performance issues when the IR sensors experienced obstruction due to environmental factors like weather conditions or small objects blocking the sensor's path. In such cases, the LCD display did not update immediately, or there were delays in opening the gate. These issues are likely due to the limitations of the IR sensor's sensitivity and could be addressed by recalibrating the sensor placement or enhancing the hardware used.

User Interface and User Experience

The LCD display provided a simple but effective user interface that allowed users to clearly see the number of available parking slots. The servo motor performed as intended, opening and closing the gate in response to available parking spaces. While the system worked as expected, the user experience could be enhanced by adding visual cues such as LED indicators or color-coded messages on the LCD display to make the status of the parking lot clearer (e.g., green for available and red for full). Additional feedback mechanisms could also be introduced to alert users when parking is full or when the system is malfunctioning.

Limitations of the Current System

Although the system functioned well under typical circumstances, it does have some limitations. The IR sensors may not detect smaller vehicles or those with unusual shapes, which could lead to incorrect readings of available spaces. Additionally, the system lacks advanced features such as real-time notifications for users or a mobile app interface for remote monitoring. The servo motor’s speed of operation is another area that could be improved to allow faster gate opening and closing. Furthermore, the system’s scalability is limited to the current configuration, and modifications would be required to support larger parking lots or multiple entry points.

Opportunities for Technical Improvement

To enhance the system's performance, there are several opportunities for technical improvement. One improvement could be the integration of more advanced sensors, such as ultrasonic sensors, to improve the accuracy and reliability of vehicle detection, especially in poor lighting or adverse weather conditions. Additionally, incorporating a real-time database would allow the system to keep track of parking availability across multiple parking lots and provide dynamic updates. Improving the servo motor’s response time could also reduce wait times for drivers. Implementing a mobile application could also enhance the user experience by providing live updates and enabling remote monitoring of parking availability.

Enhancing Training Data for Better Coverage

Currently, the system relies heavily on IR sensors for detecting vehicle occupancy. Expanding the system's coverage by integrating additional sensors or refining the current sensor's calibration would improve its ability to detect vehicles with high accuracy. Data augmentation techniques could be applied to simulate various parking scenarios, ensuring that the system can handle a wide range of conditions. Furthermore, the LCD display could be enhanced to show more detailed information, such as the exact number of occupied spaces or notifications about parking time limits.

User Interface Improvements

To improve the user experience, the LCD display could be enhanced with additional visual elements, such as color-coded status indicators (e.g., green for available, red for full) or a more intuitive design to show the parking status more clearly. A mobile application could be developed to provide real-time updates, including availability alerts or notifications when parking spaces are about to be filled. This could significantly enhance the accessibility of the system for users who are not physically present at the parking lot but want to check availability remotely.

Potential Integration with Advanced Features

The system could benefit from integrating advanced features, such as an automated payment system or license plate recognition (LPR) for seamless entry and exit. Additionally, a cloud-based or web-based interface could allow users to monitor parking availability across multiple locations in real-time. Real-time data analytics could also be implemented to optimize parking space usage and predict peak times. Integrating voice control could further enhance user interaction, allowing for hands-free operation of the system.

Summary and Future Prospects

In conclusion, the IoT-based Smart Parking System successfully automates the process of parking space management using IR sensors, servo motors, and an LCD display. While the system works effectively for small-scale implementations, there is potential for significant improvements. Upgrading sensors, enhancing the user interface, and adding advanced features like real-time updates or mobile integration could greatly enhance its scalability and usability.

CHAPTER 7
CONCLUSION

The IoT-based Smart Parking System represents a significant advancement in managing parking spaces through automation and real-time monitoring. By leveraging IR sensors, a servo motor, and a LCD display, the system successfully automates the process of detecting available parking spots, controlling the entry gate, and displaying the number of free slots. This project demonstrates the potential of IoT in providing efficient solutions for parking management, enhancing both user convenience and parking space utilization.

While the system effectively addresses basic parking needs, such as real-time parking slot availability and gate control, it has some limitations. These include sensor sensitivity issues, lack of dynamic data handling, and the absence of a user-friendly mobile interface. These limitations highlight areas for potential growth, such as integrating more advanced sensor technology, improving the user interface, and adding features like remote monitoring or real-time data access.

Future improvements could include incorporating additional sensors for more accurate vehicle detection, implementing a mobile application for user interaction, and using a cloud-based system for real-time updates and enhanced scalability. By continuing to refine the system and integrating more advanced technologies, the IoT-based Smart Parking System has the potential to become a highly effective and scalable solution for modern urban parking challenges. With further enhancements, it could evolve into a comprehensive tool that simplifies parking management, reduces congestion, and improves the overall parking experience for users.

In conclusion, this project demonstrates the feasibility of an IoT-powered solution for smart parking. With ongoing improvements, it could serve as an essential component of smart cities, offering a convenient, automated, and user-friendly solution to parking management.

APPENDIX

A. SAMPLE CODING:

```
#include <Servo.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x3F, 20, 4);
#define IR_ENTRY 2
#define IR_EXIT 4
#define SERVO_PIN 3
const int slotSensors[6] = {5, 6, 7, 8, 9, 10};
int slotStatus[6] = {0, 0, 0, 0, 0, 0};
int availableSlots = 6;
bool entryFlag = false, exitFlag = false;
Servo barrierServo;
void displaySlots() {
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Available Slots: ");
  lcd.print(availableSlots);
  for (int i = 0; i < 6; i++) {
    lcd.setCursor((i % 2) * 10, 1 + (i / 2));
    lcd.print("S");
    lcd.print(i + 1);
    lcd.print(":");
```

```
    lcd.print(slotStatus[i] == 1 ? "Full " : "Empty");
  }
}
void updateSlotStatus() {
  for (int i = 0; i < 6; i++) {
    slotStatus[i] = (digitalRead(slotSensors[i]) == LOW) ? 1 : 0;
  }
  availableSlots = 6 - countOccupiedSlots();
}
int countOccupiedSlots() {
  int count = 0;
  for (int i = 0; i < 6; i++) {
    if (slotStatus[i] == 1) count++;
  }
  return count;
}
  void setup() {
  Serial.begin(9600);
  barrierServo.attach(SERVO_PIN);
  barrierServo.write(90);
  pinMode(IR_ENTRY, INPUT);
  pinMode(IR_EXIT, INPUT);
  for (int i = 0; i < 6; i++) {
    pinMode(slotSensors[i], INPUT);
  }
  lcd.init();
```

```
  lcd.backlight();
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("SMART PARKING");
  lcd.setCursor(0, 1);
  lcd.print("SYSTEMS..!");
  delay(5000);
  lcd.clear();
  updateSlotStatus();
}
void loop() {
  displaySlots();
  if (availableSlots == 0 && digitalRead(IR_ENTRY) == LOW && !entryFlag && !exitFlag) {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("SORRY PARKING");
    lcd.setCursor(0, 1);
    lcd.print("IS FULL :)");
    barrierServo.write(90);
    return;
  }
  if (digitalRead(IR_ENTRY) == LOW && !entryFlag && !exitFlag) {
    entryFlag = true;
    barrierServo.write(180);
    lcd.setCursor(0, 0);
    lcd.print("Vehicle Entering...");
```

```
    delay(500);
  }
  if (entryFlag && digitalRead(IR_EXIT) == LOW) {
    barrierServo.write(90);
    lcd.setCursor(0, 0);
    lcd.print("Gate Closing...");
    delay(1500);
    entryFlag = false;
  }
  if (digitalRead(IR_EXIT) == LOW && !exitFlag && !entryFlag) {
    exitFlag = true;
    barrierServo.write(180);
    lcd.setCursor(0, 0);
    lcd.print("Vehicle Exiting...");
    delay(500);
}
  if (exitFlag && digitalRead(IR_ENTRY) == LOW) {
    barrierServo.write(90);
    lcd.setCursor(0, 0);
    lcd.print("Gate Closing...");
    delay(1500);
    exitFlag = false;
}
  updateSlotStatus();
  delay(500);
}
```

OUTPUT:

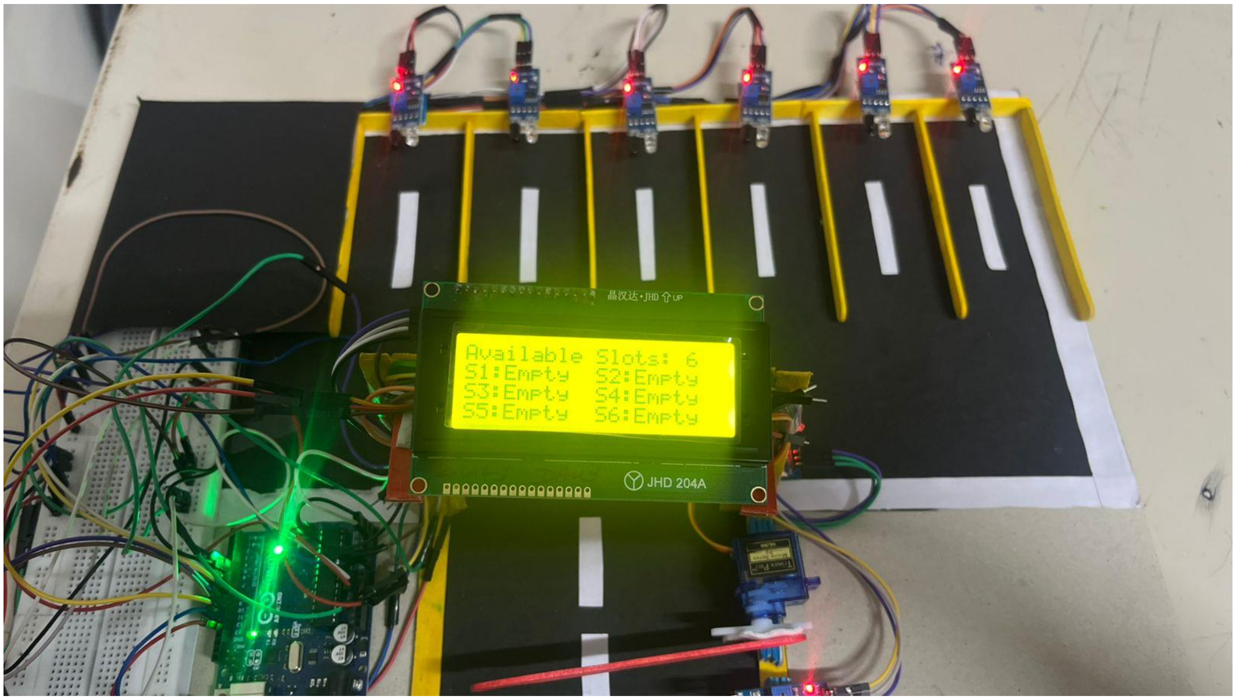

Fig 1: Parking lot with six empty slots

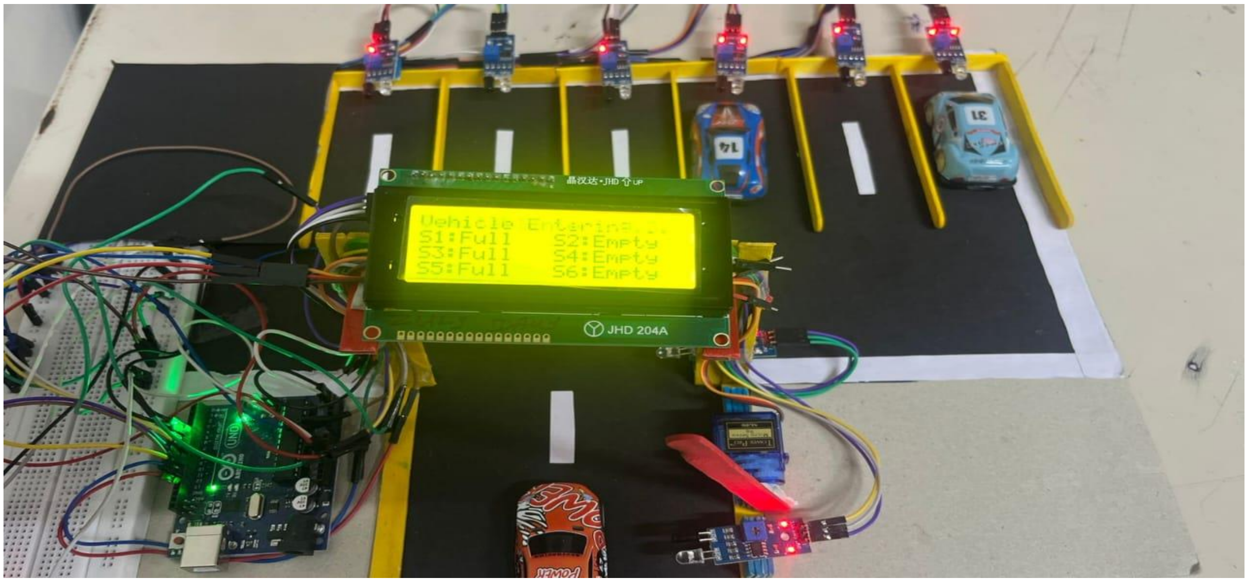

Fig 2: Parking lot with three full and three empty slots

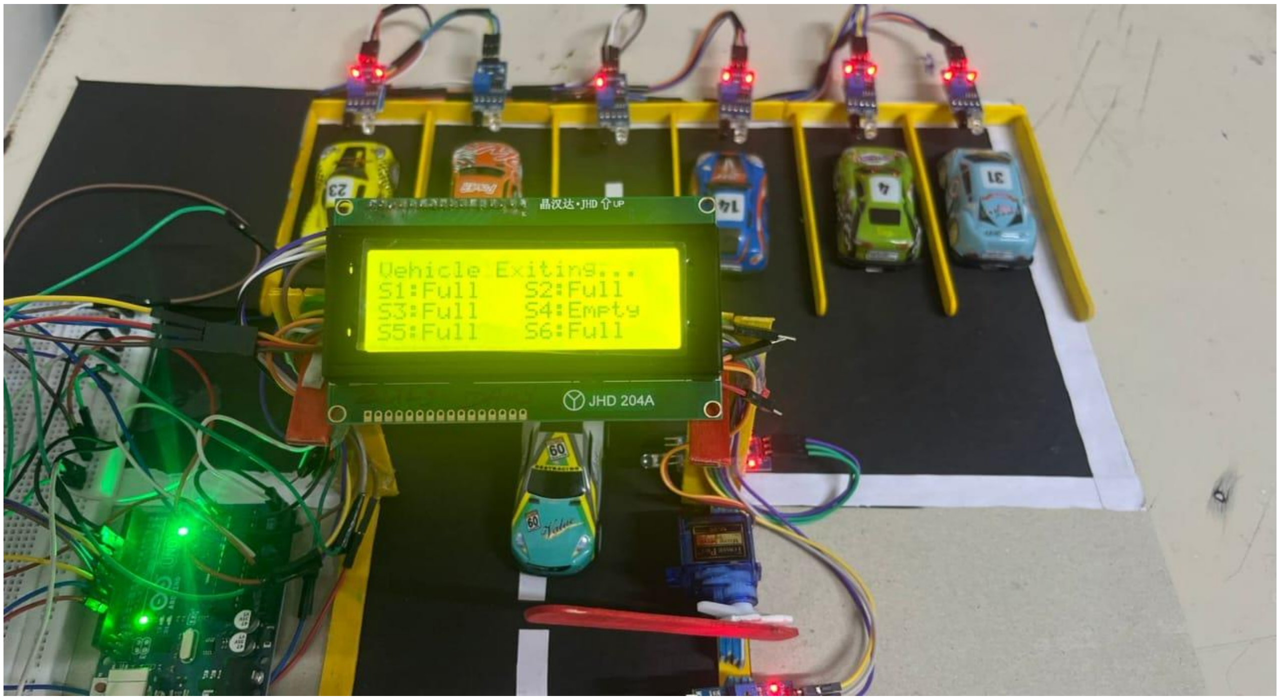

Fig 3: Parking lot with one empty space

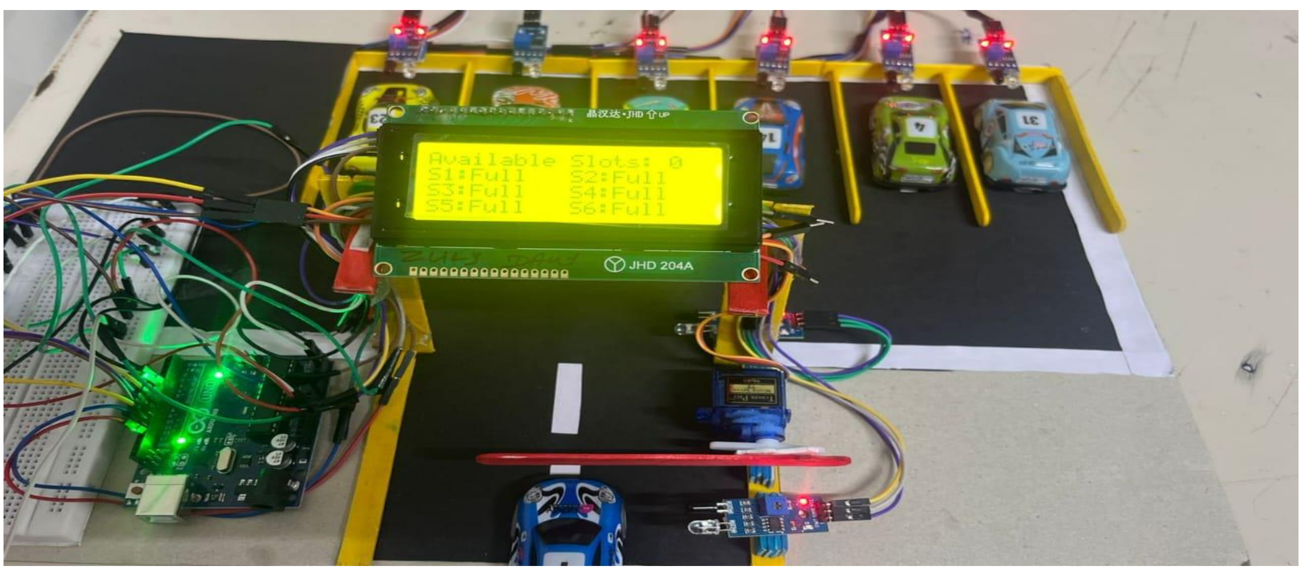

Fig 4: Full parking lot

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