Pimpri Chinchwad Education Trust's

Pimpri Chinchwad College Of Engineering

Bachelor Of Vocational (IOT)

A Project Report on

Efficient Smart Parking for Malls

Submitted by

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Abstract:

The rapid growth of urbanization and the increasing number of vehicles in metropolitan areas have led to significant challenges in parking management, especially in high-traffic zones like shopping malls. This project proposes an efficient smart parking system aimed at optimizing parking space utilization and improving the overall user experience for both mall visitors and operators. The system leverages IoT (Internet of Things) sensors, real-time data analytics, and mobile applications to monitor and manage parking spaces dynamically.

By using IoT-enabled sensors, the system detects available parking spots and communicates this information to a centralized platform, allowing drivers to quickly locate and reserve spaces. The mobile application provides real-time notifications, guiding users to the nearest available spot and offering predictive analytics to estimate parking availability. Furthermore, the system incorporates features like automated payment systems and parking time tracking to streamline operations and reduce congestion at entry/exit points.

The project aims to reduce parking-related stress, minimize traffic congestion within mall premises, and enhance operational efficiency. Additionally, by integrating data analytics, the system can offer insights into parking patterns, enabling mall operators to optimize space allocation and further enhance the overall experience for shoppers.

The concept of **Smart Parking Systems (SPS)** has gained significant attention in recent years due to the growing challenges posed by urbanization, increasing vehicle numbers, and the inefficiencies of traditional parking management. This literature review explores the existing research and architecture of smart parking systems, focusing on key components such as IoT integration, data analytics, mobile applications, and automation, particularly in the context of malls.

Index:

Acknowledgements

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Additionally, we are grateful to our peers and fellow students for their collaborative spirit, constructive criticism, and the sharing of ideas that enriched our project's development.

Lastly, we would like to express our gratitude to our families and friends for their constant support and motivation, which helped us to stay focused and committed to our project.

This project would not have been possible without the collective efforts of everyone involved, and we sincerely appreciate each contribution.

Thank you!

Smart Parking Project Team

Pimpri Chinchwad College of Engineering

Introduction:

With the rapid growth of urbanization and the increasing number of vehicles on the road, parking has become a significant challenge, particularly in high-traffic areas such as shopping malls. Mall parking lots are often overcrowded, leading to congestion, increased carbon emissions, wasted time, and a poor user experience. Traditional parking systems, reliant on manual processes and static space allocation, struggle to meet the dynamic demands of modern consumers.

This project aims to design and implement an **Efficient Smart Parking System** for malls that integrates **Internet of Things (IoT)** technology, **real-time data analytics**, and **mobile applications** to create an optimized parking experience for both mall visitors and operators. The system will address the inefficiencies of conventional parking methods by providing real-time information about available parking spots, guiding drivers to the nearest available spaces, and reducing the time spent searching for a spot. Additionally, automated payment solutions will streamline the entry and exit process, enhancing convenience for users.

The proposed smart parking solution will utilize a network of **IoT sensors** installed in parking spaces to detect availability. These sensors will feed data to a centralized control system, which will process the information and distribute it via a mobile app or digital signage. The app will allow users to view parking availability in real-time, make reservations if needed, and complete transactions seamlessly. The integration of **predictive analytics** will also help mall operators optimize parking space usage, reducing congestion during peak hours.

By introducing a smart, efficient, and user-friendly parking system, this project aims to improve the overall parking experience in malls, reduce traffic congestion, and contribute to a cleaner, more sustainable environment. Furthermore, mall operators will benefit from better space utilization and more effective management of parking resources, ultimately enhancing customer satisfaction and operational efficiency.

Literature Survey:

Reference 1:	**A Localized IoT-Based Smart Parking System for Malls**
Objectives:	To implement a smart parking system for shopping malls using **local IoT devices** without relying on cloud-based servers for real-time monitoring and decision-making.
Proposed Solution:	IoT sensors installed in parking spaces detect whether a spot is occupied or free. Data is processed locally using **edge computing devices** (like Raspberry Pi) to manage the parking information. The system communicates directly with the mobile app, offering real-time availability without the need for cloud storage.
Results:	The system achieved a 20% reduction in parking search time and improved parking space utilization by 18%. Since all data processing was done locally, the response times were fast, offering near-instant parking availability updates.
Advantages:	Reduced latency in data processing as all information is handled on-site. No reliance on cloud services, which ensures continuous operation even in the absence of an internet connection.
Limitations:	The system's scalability can be challenging, especially in larger malls with extensive parking areas. Localized processing may also require more powerful hardware to manage large datasets effectively.

Reference 2:	**Real-Time Parking Management System Without Cloud for Shopping Centers.**
Objectives:	To design an effective **offline smart parking system** where all real-time parking data is processed locally within the mall's infrastructure.
Proposed Solution:	The system uses **ultrasonic sensors** for parking space detection and **local microcontrollers** to process data. A **centralized control panel** located within the mall receives data from all sensors, calculates available spaces, and displays this information on digital signage and mobile applications.
Results:	The parking space utilization rate improved by 30%, with a reduction in user search time by 25%. Data processing directly at the mall's network improved the speed of space allocation and decreased the risk of system failures.
Advantages:	Eliminates dependence on external cloud services, ensuring reliability and constant data availability. Real-time information is processed quickly with localized systems.
Limitations:	The system faces challenges in expanding to other malls without a standardized, scalable solution. Additionally, the local data processing might require more maintenance and hardware upgrades as parking demand grows.

Reference 3:	**Edge Computing-Based Smart Parking System Without Cloud for Malls**
Objectives:	To reduce latency and improve efficiency in parking systems by using **edge computing** (i.e., local processing) for real-time data management and decision-making in mall parking lots.
Proposed Solution:	Parking spaces are equipped with **magnetic sensors** and **infrared sensors** for occupancy detection. Data from these sensors is processed by **local edge devices** (such as edge servers or IoT gateways), which then update the parking availability directly to mobile apps and digital signs.
Results:	The system showed a 20% increase in parking efficiency and reduced search times by 35%. Edge computing provided a reliable, real-time response to drivers without delays that could arise from relying on remote cloud servers.
Advantages:	Fast and efficient decision-making at the local level. The system is highly reliable since it doesn't depend on external networks or cloud connectivity. Users experience near-instant updates for parking availability.
Limitations:	More hardware is required for local processing, and the maintenance of edge devices can add to the operational costs. Scaling the solution for larger malls with multiple floors or high parking space counts requires significant infrastructure investment.

Reference 4:	**Autonomous Parking Space Management System Using Localized IoT**
Objectives:	To manage and allocate parking spaces in shopping malls by using **IoT-based sensors** without cloud infrastructure. The focus is on creating a robust, efficient system that relies entirely on **local data processing** for managing parking spaces.
Proposed Solution:	The system employs **license plate recognition (LPR)** cameras combined with **magnetic and ultrasonic sensors** installed at each parking spot. Data is processed through **local servers** within the mall's building, allowing users to receive real-time updates and spot reservation information.
Results:	The system demonstrated a 40% reduction in parking search time and optimized space utilization. Additionally, it improved operational efficiency by reducing the need for manual monitoring.
Advantages:	Reduces reliance on external servers, ensuring system availability even during internet disruptions. All data processing is done locally, offering faster responses.
Limitations:	The local processing capability can be limited by the hardware used (such as local servers or microcontrollers). Expanding the system to larger malls requires upgrading or adding more edge devices for processing.

BLOCK DIAGRAM:

1. Sensors: Detect vehicle presence and occupancy status.

2. Microcontroller: Processes sensor data and controls the system.

3. Communication Module: Transmits data to a central server or mobile app.

4. Display: Shows parking availability and guidance.

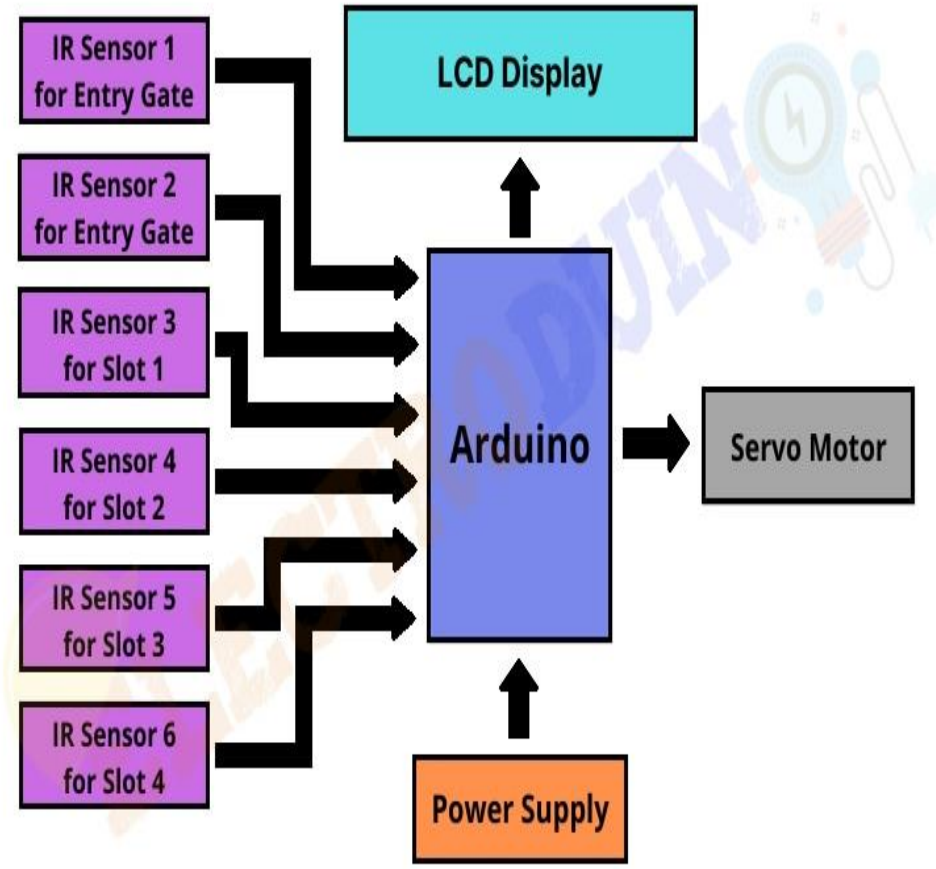

Fig:1

COMPONENTS LIST AND SPECIFICATION

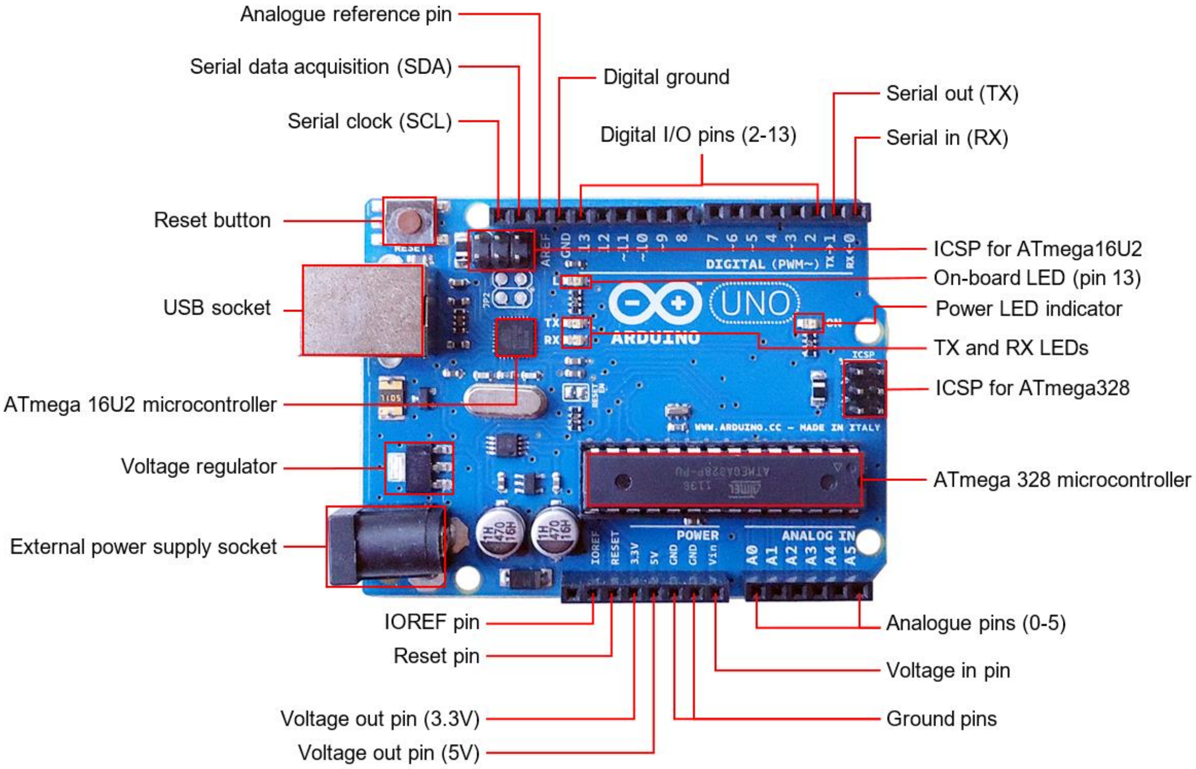

Fig:2

Arduino Uno Board

The Arduino Uno 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.[1] 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. [4] It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is similar to the Arduino Nano and Leonardo.[5][6] The hardware reference design is distributed under a Creative Commons Attribution Share-Alike 2.5 license and is available on the Arduino website. Layout and production files for some versions of the hardware are also available

Infrared Sensor :

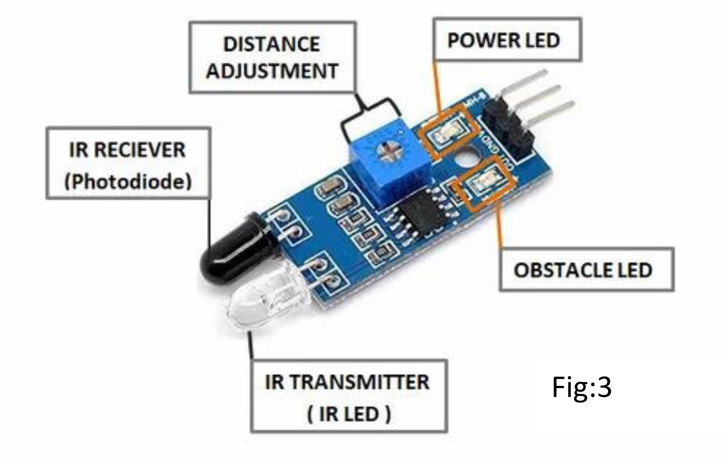

Fig:3

An infrared sensor (PIR sensor) is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. They are most often used in PIR-based motion detectors. PIR sensors are commonly used in security alarms and automatic lighting applications. PIR sensors detect general movement, but do not give information on who or what moved. For that purpose, an imaging IR sensor is required. PIR sensors are commonly called simply "PIR", or sometimes "PID", for "passive infrared detector". The term passive refers to the fact that PIR devices do not radiate energy for detection purposes. They work entirely by detecting infrared radiation (radiant heat) emitted by or reflected from objects.

Jumper Wire

A jumper wire is a short length of wire used to connect two points on a circuit board or breadboard.

Uses:

1. Prototyping: Jumper wires are often used in prototyping and testing electronic circuits.

2. Breadboarding: Jumper wires are used to connect components on a breadboard.

3. Circuit Debugging: Jumper wires can be used to test and debug circuits.

Types:

1. Male-to-Male: Jumper wires with male connectors on both ends.

Fig:4

2.Male-to-Female: Jumper wires with a male connector on one end and a female connector on the other.

Fig:5

3. Female-to-Female: Jumper wires with female connectors on both ends.

Fig:6

Breadboard:

A breadboard is a rectangular board with rows and columns of holes that allow users to easily connect and prototype electronic circuits.

Features:

1. Holes and Rows: Breadboards have rows and columns of holes that accept wires and component leads.

2. Internal Connections: The holes in each row are connected internally, allowing users to create circuits.

3. Power Rails: Many breadboards have power rails along the sides for connecting power sources.

Uses:

1. Prototyping: Breadboards are ideal for building and testing electronic circuits.

2. Circuit Development: Breadboards allow users to develop and refine circuit designs.

3. Education: Breadboards are often used in educational settings to teach electronics and circuit design.

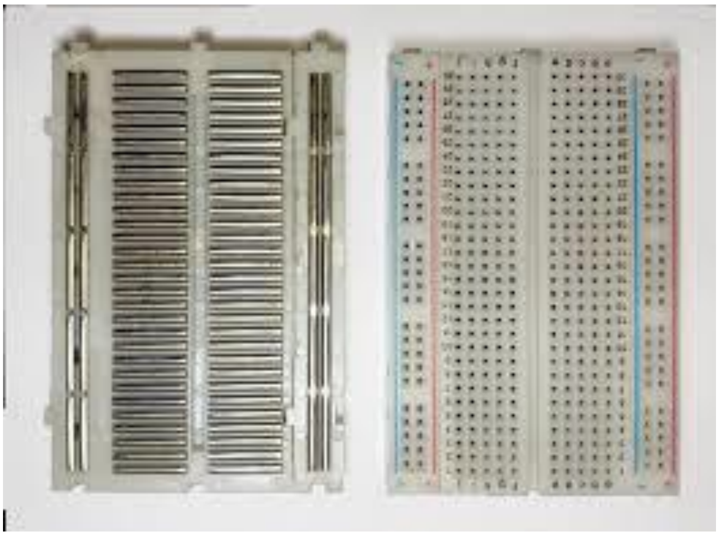

Fig:7

SERVO MOTORS

A servomotor (or servo motor) **is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration.** It consists of a suitable motor coupled to a sensor for position feedback.

In this project we use servo motors to open the gate of the parking slot when the vehicle is detected at the entrance.

When the car is leaving the parking slots the servo motors helps to lift the gate and helps the car to leave the parking slots.

Fig:8

I2C Display

Fig:9

Pinout and Information

Pinout:
A standard I2C display module typically has 4-6 pins:

1. VCC (Power): Supplies power to the display module.
2. GND (Ground): Ground connection for the display module.
3. SDA (Serial Data): Carries data between the microcontroller and display module.
4. SCL (Serial Clock): Provides the clock signal for I2C communication.

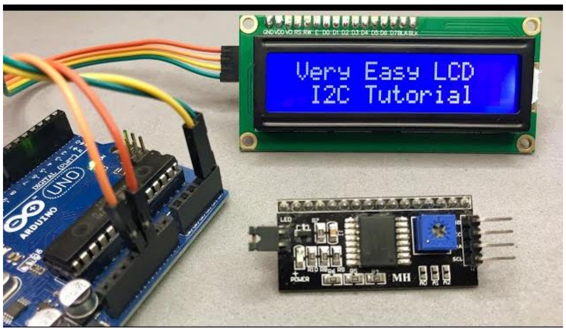

Fig:10

Optional Pins:
Some I2C display modules may have additional pins:

1. Backlight Control: Allows control of the display's backlight.
2. Reset: Resets the display module.

I2C Display Information:
1. Address: Each I2C display module has a unique address (e.g., 0x27 or 0x3F).
2. Resolution: The display's resolution (e.g., 16x2 or 20x4 characters).
3. Display Type: The type of display (e.g., LCD or OLED).
4. Communication Protocol: I2C protocol is used for communication.

Buck Converters (Step-Down Converter):

The buck converter, also referred to as a step-down converter, is a popular topology in power electronics that converts a higher input voltage to a lower output voltage. It is crucial in various applications, from portable devices to automotive systems, where specific components or subsystems require a lower voltage level to operate. The primary advantage of the buck converter is its simplicity, which enables efficient voltage conversion using a relatively small number of components.

The operating principle of the buck converter involves controlled energy transfer from the input to the output through switches, an inductor, and a capacitor. A high-side switch (usually a MOSFET) and a low-side switch (typically a diode) are employed in the buck converter to control the current flow through the inductor. By adjusting the duty cycle of the high-side switch, the average output voltage can be regulated proportionally to the input voltage.

When the high-side switch of a buck converter is switched on, it allows current to flow through the inductor, which stores energy in its magnetic field. This stored energy is then transferred to the output, charging the output capacitor and powering the load. When the high-side switch is turned off and the low-side switch is turned on, the inductor's magnetic field collapses, releasing the stored energy and maintaining the current flow to the load. The buck converter is designed to operate within a closed-loop control system, where a feedback mechanism continuously compares the output voltage to a reference voltage to ensure that the output voltage remains stable and regulated, regardless of changes in input voltage or load conditions.

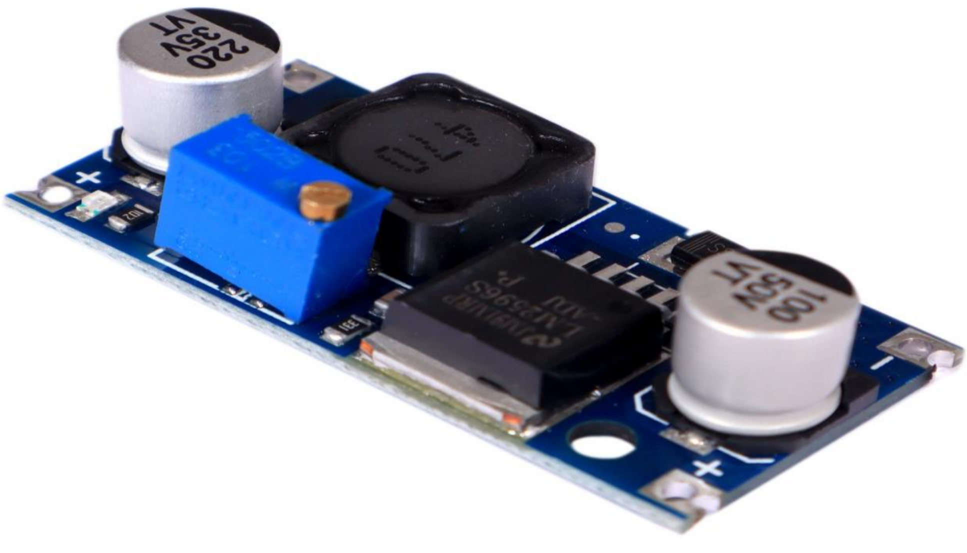

Fig:11

Simple **SMPS (Switch-Mode Power Supply)** 220V AC to 12V DC

A Switch-Mode Power Supply (SMPS) is a type of power supply that converts AC power from the mains to DC power for electronic devices. Here's an overview of a 220V AC to 12V DC SMPS:

Components:

1. Input Filter: EMI filter to reduce electromagnetic interference.
2. Bridge Rectifier: Converts AC to DC.
3. Capacitor Filter: Smooths the DC output.
4. Switching Transistor: High-frequency switching device (e.g., MOSFET).
5. Transformer: Steps down the voltage and provides isolation.
6. Output Rectifier: Converts the transformed AC to DC.
7. Output Filter: Smooths the DC output.

Working Principle:

1. The input AC voltage (220V) is filtered and rectified to produce a high-voltage DC.
2. The switching transistor chops the DC voltage at high frequency.
3. The transformer steps down the voltage and provides isolation.
4. The output rectifier converts the transformed AC to DC.
5. The output filter smooths the DC output to produce a stable 12V DC.le smps 220 ac to 12 v:

Fig:12

Result of smart Parking Project:

Fig:13

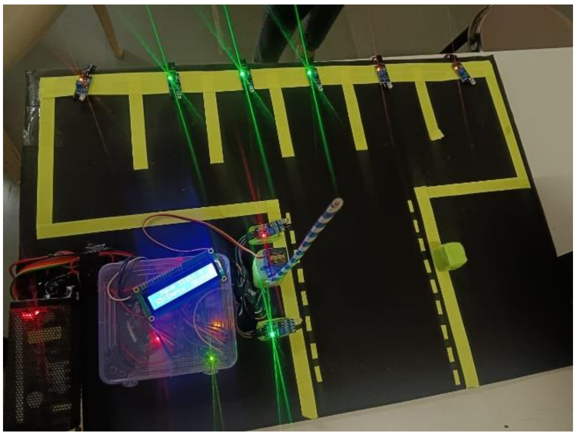

Fig:14

Fig:15

Software:

1 Arduino IDE: The integrated development environment (IDE) used to write, Verify, and upload code to the Arduino Uno board.

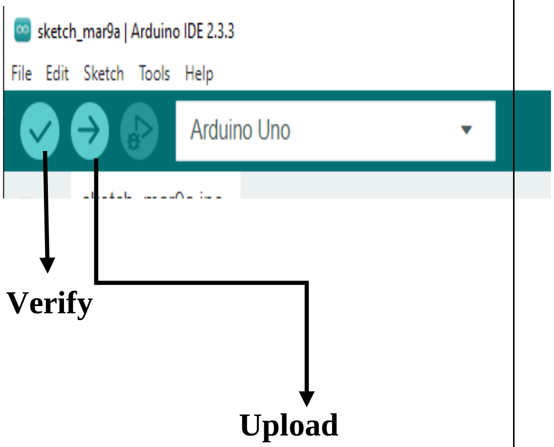

Fig:17

Fig:16

2. Embedded C Programming Language: The language used to write the code for the Arduino Uno board.

3. Arduino Library: e.g –>Liquid Crystal I2C

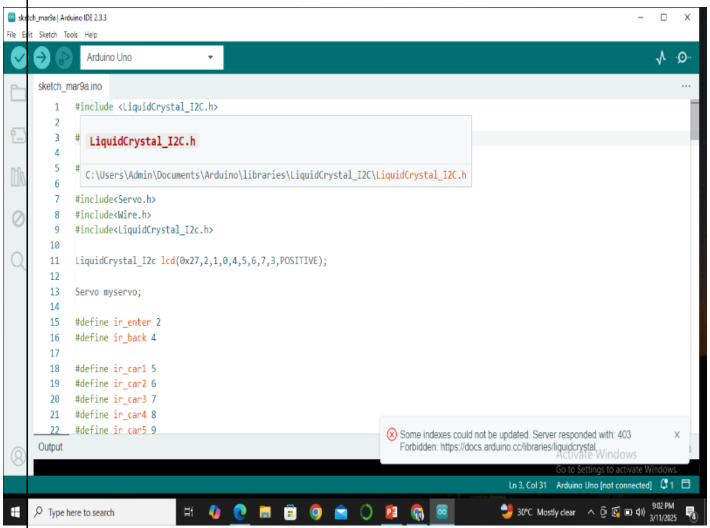

Fig:18

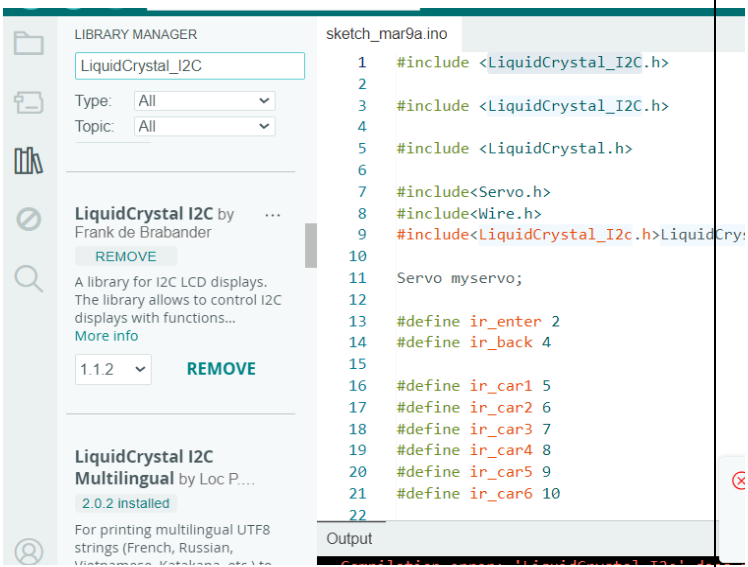

Fig:19

Arduino IDE

The Arduino IDE is an open-source software, which is used to write and upload code to the Arduino boards. The IDE application is suitable for different operating systems such as Windows, Mac OS X, and Linux. It supports the programming languages C and C++. Here, IDE stands for Integrated Development Environment.

The program or code written in the Arduino IDE is often called as sketching. We need to connect the Genuino and Arduino board with the IDE to upload the sketch written in the Arduino IDE software. The sketch is saved with the extension '.ino.'

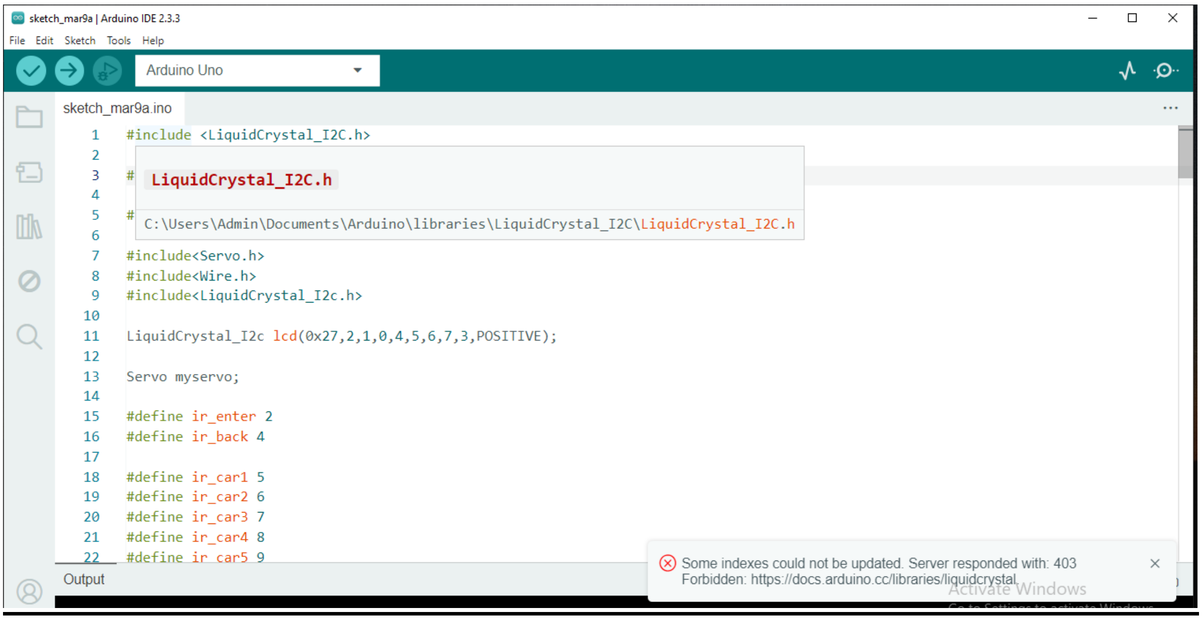

Fig:20

Code :

```
#include <LiquidCrystal_I2C.h>

#include <Servo.h>
#include <Wire.h>

// LCD and Servo setup
LiquidCrystal_I2C lcd(0x27, 16, 2);
Servo myservo;

#define ir_enter 2  // IR sensor for entry
#define ir_back 4   // IR sensor for exit

#define ir_car1 5
#define ir_car2 6
#define ir_car3 7
#define ir_car4 8
#define ir_car5 9
#define ir_car6 10

int S1 = 0, S2 = 0, S3 = 0, S4 = 0, S5 = 0, S6 = 0;
int flag1 = 0;  // Flag to check if a car is inside
int flag2 = 0;  // Flag to check if the gate is already opened
int slot = 6;

void setup()
{
    Serial.begin(9600);
    pinMode(ir_car1, INPUT);
    pinMode(ir_car2, INPUT);
    pinMode(ir_car3, INPUT);
    pinMode(ir_car4, INPUT);
    pinMode(ir_car5, INPUT);
    pinMode(ir_car6, INPUT);
    pinMode(ir_enter, INPUT);
    pinMode(ir_back, INPUT);

    myservo.attach(3);
    myservo.write(90); // Start with the gate closed
    lcd.backlight();
    lcd.begin(16, 2);

    lcd.setCursor(0, 0);
    lcd.print("   Car Parking   ");
    lcd.setCursor(0, 1);
    lcd.print("    System      ");
    delay(1000);
    lcd.clear();
```

```
    Read_Sensor();
    int total = S1 + S2 + S3 + S4 + S5 + S6;
    slot = slot - total;

    lcd.setCursor(0, 0);
    lcd.print("  Have Slot: ");
    lcd.print(slot);
    lcd.print("   ");

    displaySlots();
}

void loop() {
    // Continuously read sensor data and update the display
    Read_Sensor();
    displaySlots();

    // Check for car entry
    if (digitalRead(ir_back) == LOW || flag2 == 0) { // When IR sensor detects
a car
        flag2 = 1; // Set flag to indicate the gate is open
        if (flag1 == 0) {
            myservo.write(180); // Open the gate
            slot++; // Increase slot count
            Serial.println("Car entered"); // Log entry
            delay(2000); // Delay to keep gate open
            myservo.write(90); // Close the gate
            flag1 = 1; // Set flag to indicate a car is now in
        }
    }

    // Check for car exit
    if (digitalRead(ir_enter) == LOW && flag1 == 1) { // When IR sensor
detects a car exiting
        flag1 = 0; // Reset the flag for car exit
        myservo.write(180); // Open the gate
        slot--; // Decrease slot count
        Serial.println("Car exited"); // Log exit
        delay(1000); // Delay to keep gate open
        myservo.write(90); // Close the gate
        flag2 = 0; // Reset flag to indicate the gate is closed
    }

    // Servo control based on IR sensor detection (optional)
    // You can add any additional control here if needed.
}
```

```
void Read_Sensor() {
    S1 = S2 = S3 = S4 = S5 = S6 = 0;

    if (digitalRead(ir_car1) == 0) { S1 = 1; }
    if (digitalRead(ir_car2) == 0) { S2 = 1; }
    if (digitalRead(ir_car3) == 0) { S3 = 1; }
    if (digitalRead(ir_car4) == 0) { S4 = 1; }
    if (digitalRead(ir_car5) == 0) { S5 = 1; }
    if (digitalRead(ir_car6) == 0) { S6 = 1; }
}

void displaySlots() {
    lcd.setCursor(0, 1);
    lcd.print("S1:"); lcd.print(S1 == 1 ? "Fill " : "Empty ");
    lcd.setCursor(10, 1);
    lcd.print("S2:"); lcd.print(S2 == 1 ? "Fill " : "Empty ");
    delay(2000);

    lcd.setCursor(0, 3);
    lcd.print("S3:"); lcd.print(S3 == 1 ? "Fill " : "Empty ");
    lcd.setCursor(10, 3);
    lcd.print("S4:"); lcd.print(S4 == 1 ? "Fill " : "Empty ");
    delay(2000);

    lcd.setCursor(0, 3);
    lcd.print("S5:"); lcd.print(S5 == 1 ? "Fill " : "Empty ");
    lcd.setCursor(10, 3);
    lcd.print("S6:"); lcd.print(S6 == 1 ? "Fill " : "Empty ");
    delay(2000);
}
```

FUTURE SCOPE:

The future of smart parking systems, even those based on Arduino, lies in integrating them with broader city infrastructure, utilizing AI for predictive parking, and incorporating autonomous vehicle features. These advancements promise more efficient parking management, reduced congestion, and improved environmental sustainability.

1. Integration with City Systems:

- **Parking :**
  This concept envisions smart parking solutions working in conjunction with other city applications, like smart street lighting, to optimize resource utilization and potentially lower costs.
- **Data-Driven Optimization:**
  By analyzing parking data and patterns, authorities can optimize space allocation, pricing strategies, and even route planning to minimize congestion.

2. AI-Driven Prediction:

- **Predictive Parking:**
  AI can analyze various factors (events, weather, time of day) to predict parking demand and dynamically adjust pricing or space allocation.
- **Personalized Recommendations:**
  AI could even provide users with personalized parking recommendations based on their travel patterns and preferences.

3. Autonomous Vehicle Integration:

- **Self-Parking:**
  The rise of autonomous vehicles will require smart parking systems to accommodate self-parking features, including specialized parking lots and robotics valets.
- **Robotics and Automation:**
  Robotics can be used for automated parking and retrieval of vehicles, further enhancing efficiency.

4. Enhanced Security and Accessibility:

- **Vehicle Tracking and Identification:**

  Systems can be enhanced with machine learning to store vehicle information (color, design, number plate) for enhanced security.

- **User-Friendly Interfaces:**
  Apps and systems should be designed for accessibility, catering to various user groups (e.g., visually impaired, elderly).

5. Sustainability and Environmental Benefits

- **Reduced Congestion and Emissions:**

  Smart parking systems can help reduce traffic congestion, leading to lower emissions and improved air quality.

- **Optimized Space Utilization:**
  Efficient parking management can lead to smaller parking lots, freeing up valuable urban space and reducing the carbon footprint.

Application of the Smart Parking System Project

In modern urban environments, **vehicle density is increasing**, but parking space remains limited. This leads to:

- Wasted time searching for spots
- Increased **fuel consumption**
- Rising **traffic congestion**
- Driver **frustration**
- Environmental impact due to **CO_2 emissions** from idling vehicles

A **smart parking system** built using Arduino, IR sensors, and an LCD display can help **optimize** parking operations.

Where It Can Be Implemented

1.**Shopping Malls**

- Real-time slot availability shown at the entrance.
- Customers can make quicker decisions, improving the shopping experience.

2. **Office Parking Lots**

- Tracks available spaces for employees.
- Can be combined with ID cards or RFID for employee-only access.

3. Residential Apartments

- Allows flat owners to know which visitor slots are free.
- Prevents unauthorized parking.

4. **Airports**

- Handles large volumes of short-term and long-term parking.
- Can guide drivers directly to available areas through digital signage.

5. **Public Parking Garages**

- Avoids over-crowding.
- Can help in **automated ticketing**, entry, and exit.

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Conclusion :

The Smart Parking System using Arduino is a low-cost and efficient way to manage parking. It uses sensors to find empty spots, gives drivers real-time updates, and can work with mobile apps. This helps reduce traffic, saves time, and makes parking easier in busy cities.

- **Efficiency and Optimization:**

  The system's ability to accurately detect and display available parking spaces leads to optimized parking utilization, minimizing wasted space and driver search time.

- **Reduced Congestion:**

  By guiding drivers to available spots, the system reduces the number of cars circling in search of parking, contributing to smoother traffic flow.

- **Improved Driver Experience:**

  Real-time information on parking availability and potential mobile application integration enhance the overall parking experience for drivers.

- **Cost-Effective Solution:**

  Arduino-based systems are generally less expensive to implement compared to traditional parking systems, making them an attractive option for various parking facilities.

- **Potential for Further Development:**

  The modular design of the system allows for easy expansion and integration with other smart city technologies, such as IoT platforms and cloud computing.

- **Addressing Challenges:**

  The system addresses common parking challenges like finding available spaces and managing peak demand in urban areas.