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IOT Based Parking Lot for Smart City

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Abstract: This project presents an intelligent parking lot system using infrared sensors to detect available parking spaces in real-time. The system improves user convenience and reduces traffic congestion by providing accurate parking availability data. Infrared sensors, chosen for their reliability and low power consumption, are installed in each parking slot. The sensor data is processed centrally and shared via thingspeak website and digital displays.

The system will be piloted in a section of the parking lot, with calibration ensuring accuracy. Results show reduced time searching for parking and decreased congestion. The system's scalability, energy efficiency, and real-time capabilities enhance user experience and optimize parking operations. Future developments include predictive analytics and expansion to other high-traffic areas.

Keywords: infrared sensors, Arduino esp8266, ThingSpeak website, Parking availability, Parking management, Realtime detection, User convenience.

I. INTRODUCTION

Finding a place to park in cities is becoming a bigger issue, particularly in busy spots like shopping centers, business hubs, and public areas [1][8]. As city populations grow and the number of cars on the road increases, the demand for managing traffic has reached an all-time high. The current transportation systems often fall short in handling this demand, leading to delays and inefficiencies. Drivers frequently have to walk through parking lots in search of vacant spots, which not only annoys users but also leads to more traffic and higher carbon emissions. Research indicates that a large portion of city traffic is due to drivers looking for parking spots, creating a cycle of congestion and environmental harm [2]. Moreover, the absence of up-to-date information on parking availability makes it difficult for drivers to choose the best parking spots. Poor parking management can also hurt businesses in busy areas, as some customers may choose to avoid places known for their limited parking space [3]. As cities continue to grow, the need for creative solutions to make parking more efficient becomes more critical [5]. To tackle these significant issues, this project introduces a smart parking lot system that uses infrared sensors for instant detection of available parking spaces. By linking these sensors to ThingSpeak to show parking status in real-time, the system offers users precise, up-to-the-minute information, making parking more convenient and improving the flow of traffic inside the mall. This method enhances the dependability and low energy use of infrared sensors and ensures the system runs smoothly [6]. In the end, the system marks a major advancement in contemporary parking solutions, offering a flexible and economical way to address the urban parking challenge while supporting a greener city environment.

II. METHODOLOGY/EXPERIMENTAL

A. Theory

The intelligent parking system was designed to optimize parking management in cities [4], especially in high traffic areas such as shopping malls. This system uses infrared sensors with an Arduino microcontroller and ESP8266 Wi-Fi module to detect the availability of parking spaces in real time and provide accurate and timely information to users to improve their car experience.

This section describes the methods used to design, develop and implement a smart parking system incorporating infrared sensors, Arduino, ESP8266 and real-time data visualization [7]. The method is divided into several main parts, each of which contributes to the success of the project.

B. Components Used

1) *Infrared Sensor Nodes:* Each parking lot is equipped with infrared sensors that detect the presence or absence of vehicles. These sensors are reliable and efficient [6] and can operate continuously with reduced power consumption.
2) *Arduino Microcontroller:* The data collected from the infrared sensors is processed using the Arduino microcontroller. The Arduino is responsible for reading the sensor inputs, processing the data and determining the status of the parking spaces in real time.

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3) *ESP8266 Wi-Fi Module:* The ESP8266 Wi-Fi module allows for seamless communication between the Arduino and the cloud-based platform, ThingSpeak. This module transmits the parking availability data to ThingSpeak, enabling users to access real-time information remotely [7].
4) *Boom Barrier:* The system includes a boom barrier that automatically opens only when a parking space is available in the lot. This feature enhances security and ensures that only authorized vehicles can access the parking area.
5) *LCD Screen:* An LCD screen is integrated into the system to display the status of each parking slot, indicating whether it is empty or full. This provides drivers with immediate visual feedback, helping them locate available spaces more efficiently.
6) *Data Visualization:* Integration with ThingSpeak displays available information in real time. Users can access this information through digital display boards placed at strategic points in the parking lot and the thingspeak console, which allows them to make parking decisions before they arrive.
7) *User Interfaces:* User-friendly interfaces, including the thingspeak and digital displays, provide intuitive access to parking information. These interfaces ensure that users can easily find available slots, reducing search time and improving overall user satisfaction.

C. *Circuit Diagram*

The connections of Esp8266 to Arduino Uno is shown (Fig 1), These connections are important to establish a valid connection through esp8266 to Thingspeak website for data transfer.

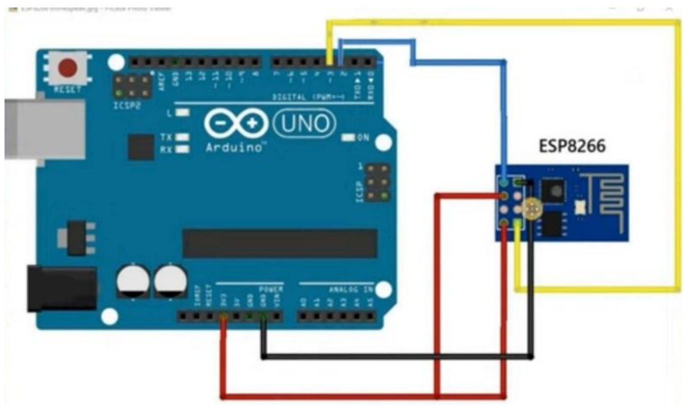

Fig2.1:Wifi Module circuit

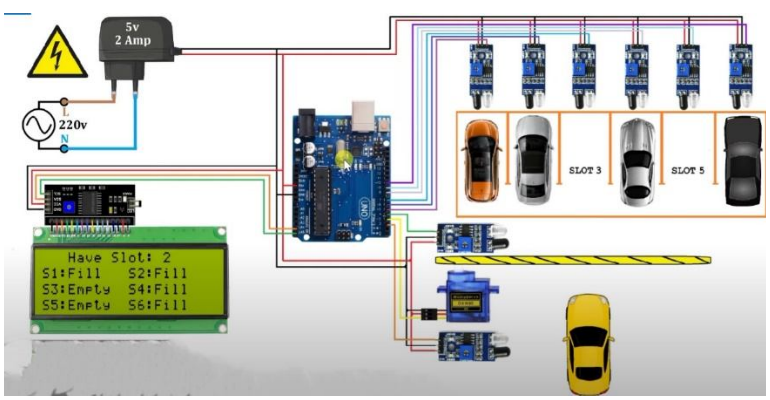

Fig2.2:Parking lot circuit

D. *Implementation*

The intelligent parking lot system is designed to enhance the management and monitoring of parking spaces by integrating several key components, including the ESP8266 microcontroller, infrared sensors, an LCD display, and a boom barrier. Each parking slot is equipped with infrared sensors that detect the presence of a vehicle, sending corresponding signals to the ESP8266 microcontroller. These signals are processed in real-time to determine whether a parking slot is occupied or available. The status of each slot is then displayed on the LCD screen, with "Full" (0) indicating that the slot is occupied and "Empty" (1) signalling availability.

To further improve the efficiency of the system, the ESP8266 is configured to communicate with ThingSpeak, a cloud-based IoT platform, where all parking data is stored and visualized in real time (Fig 3(a) & Fig 3(b)). This cloud integration allows for remote monitoring of the parking lot, enabling operators or users to access live updates on parking availability from anywhere via the internet. The system's ability to store historical data on ThingSpeak also offers opportunities for advanced data analysis, such as identifying patterns in parking usage and optimizing space management based on demand trends.

The boom barrier plays a crucial role in controlling entry to the parking facility. It is connected to the ESP8266 and operates based on real-time parking availability. If all slots are full, the boom barrier will remain closed, preventing further entry, while an available slot triggers the barrier to open, allowing the vehicle to park. This automated access control not only reduces congestion but also ensures efficient use of available parking spaces.

By providing immediate and accurate parking status updates, automating the entry process, and enabling remote monitoring, the system significantly enhances parking management operations. Its ability to streamline parking operations in real time contributes to reduced driver frustration, minimized congestion, and a more organized parking facility, making it particularly useful in high-traffic environments such as shopping malls, airports, and urban centers.

Figure 3(a): Status Of Parking Space "S1"

Figure 3(b). Status Of Parking Space "S3"

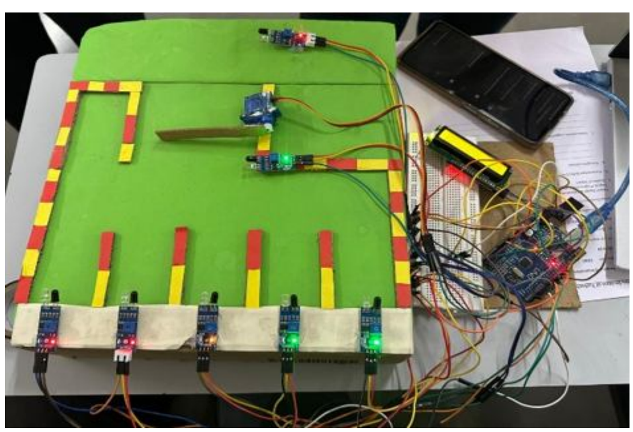

Fig 4: Real Life Implementation

The LCD screen has 6 specified abbreviations S1, S2, S3, S4, S5 (Parking Slot Numbers) and SA (Slot Availability. (Fig 5) The LCD screen displays the total amount of slots available as "SA:5", meaning there are currently 5 available spaces in the parking lot. This is followed by the status of every space with the letters "E" or "F" for showing empty or full spaces.

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This inclusion of the LCD screen in the parking lot system offers several benefits that enhance user experience and operational efficiency. It provides real-time visual feedback on parking status, clearly indicating whether slots are empty or full. This immediate display of information helps drivers make quick decisions, reducing the time spent searching for parking and minimizing congestion in the lot.

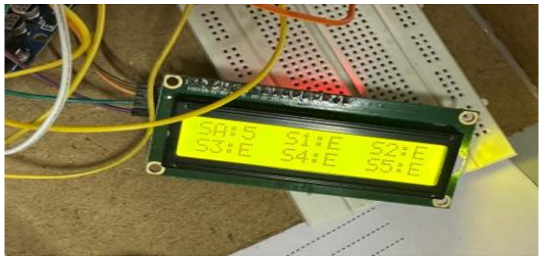
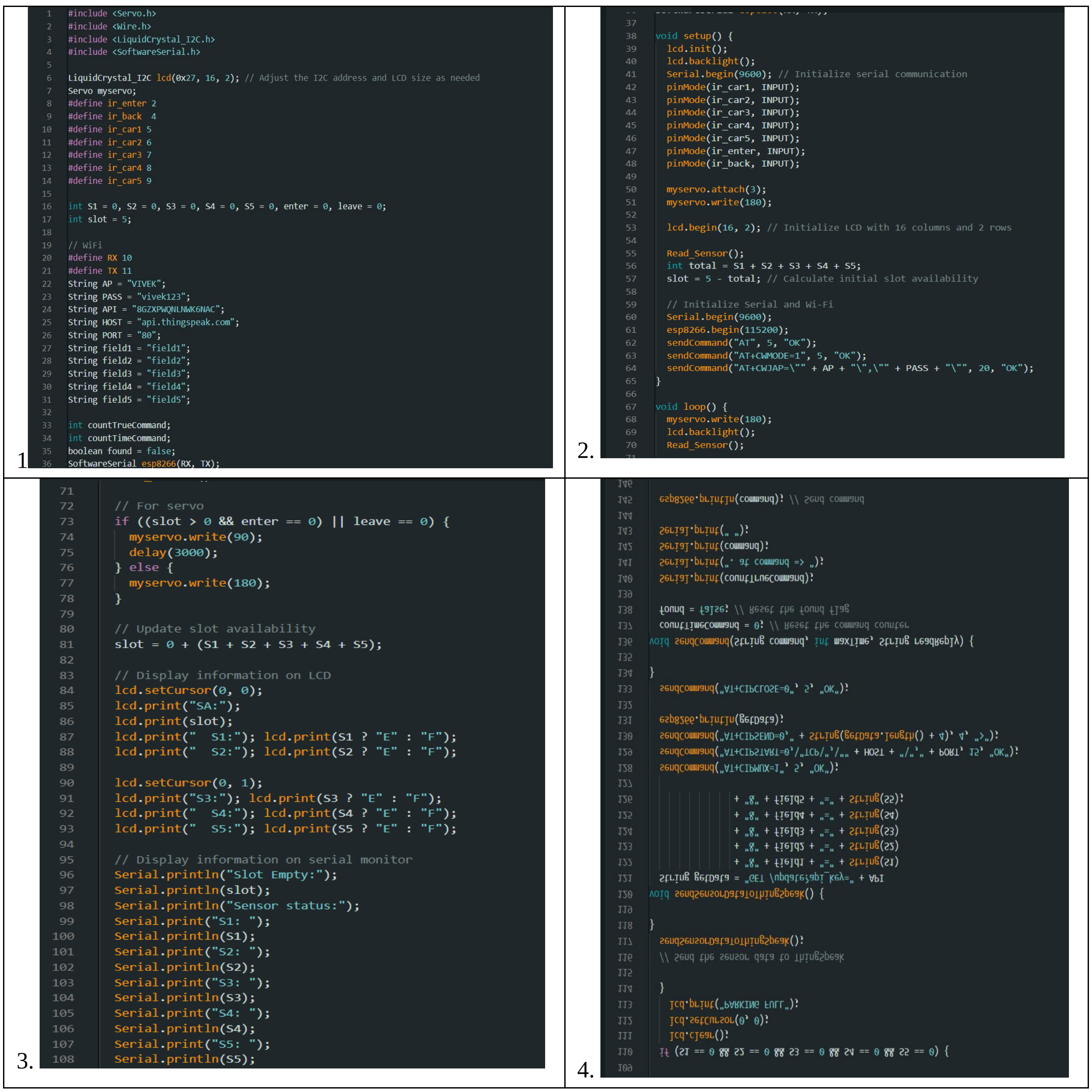


Fig 5: LCD Screen With Status Of Each Slot

E. Code



1.
```cpp
#include <Servo.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <SoftwareSerial.h>

LiquidCrystal_I2C lcd(0x27, 16, 2); // Adjust the I2C address and LCD size as needed
Servo myservo;
#define ir_enter 2
#define ir_back  4
#define ir_car1 5
#define ir_car2 6
#define ir_car3 7
#define ir_car4 8
#define ir_car5 9

int S1 = 0, S2 = 0, S3 = 0, S4 = 0, S5 = 0, enter = 0, leave = 0;
int slot = 5;

// WiFi
#define RX 10
#define TX 11
String AP = "VIVEK";
String PASS = "vivek123";
String API = "8GZXPWQNLNWK6NAC";
String HOST = "api.thingspeak.com";
String PORT = "80";
String field1 = "field1";
String field2 = "field2";
String field3 = "field3";
String field4 = "field4";
String field5 = "field5";

int countTrueCommand;
int countTimeCommand;
boolean found = false;
SoftwareSerial esp8266(RX, TX);
```

2.
```cpp

void setup() {
  lcd.init();
  lcd.backlight();
  Serial.begin(9600); // Initialize serial communication
  pinMode(ir_car1, INPUT);
  pinMode(ir_car2, INPUT);
  pinMode(ir_car3, INPUT);
  pinMode(ir_car4, INPUT);
  pinMode(ir_car5, INPUT);
  pinMode(ir_enter, INPUT);
  pinMode(ir_back, INPUT);

  myservo.attach(3);
  myservo.write(180);

  lcd.begin(16, 2); // Initialize LCD with 16 columns and 2 rows

  Read_Sensor();
  int total = S1 + S2 + S3 + S4 + S5;
  slot = 5 - total; // Calculate initial slot availability

  // Initialize Serial and Wi-Fi
  Serial.begin(9600);
  esp8266.begin(115200);
  sendCommand("AT", 5, "OK");
  sendCommand("AT+CWMODE=1", 5, "OK");
  sendCommand("AT+CWJAP=\"" + AP + "\",\"" + PASS + "\"", 20, "OK");
}

void loop() {
  myservo.write(180);
  lcd.backlight();
  Read_Sensor();
```

3.
```cpp

  // For servo
  if ((slot > 0 && enter == 0) || leave == 0) {
    myservo.write(90);
    delay(3000);
  } else {
    myservo.write(180);
  }

  // Update slot availability
  slot = 0 + (S1 + S2 + S3 + S4 + S5);

  // Display information on LCD
  lcd.setCursor(0, 0);
  lcd.print("SA:");
  lcd.print(slot);
  lcd.print("  S1:"); lcd.print(S1 ? "E" : "F");
  lcd.print("  S2:"); lcd.print(S2 ? "E" : "F");

  lcd.setCursor(0, 1);
  lcd.print("S3:"); lcd.print(S3 ? "E" : "F");
  lcd.print("  S4:"); lcd.print(S4 ? "E" : "F");
  lcd.print("  S5:"); lcd.print(S5 ? "E" : "F");

  // Display information on serial monitor
  Serial.println("Slot Empty:");
  Serial.println(slot);
  Serial.println("Sensor status:");
  Serial.print("S1: ");
  Serial.println(S1);
  Serial.print("S2: ");
  Serial.println(S2);
  Serial.print("S3: ");
  Serial.println(S3);
  Serial.print("S4: ");
  Serial.println(S4);
  Serial.print("S5: ");
  Serial.println(S5);
```

4.
```cpp

  if (S1 == 0 && S2 == 0 && S3 == 0 && S4 == 0 && S5 == 0) {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("PARKING FULL");
  }

  // Send the sensor data to ThingSpeak
  sendSensorDataToThingSpeak();
}

void sendSensorDataToThingSpeak() {
  String getData = "GET /update?api_key=" + API
                 + "&" + field1 + "=" + String(S1)
                 + "&" + field2 + "=" + String(S2)
                 + "&" + field3 + "=" + String(S3)
                 + "&" + field4 + "=" + String(S4)
                 + "&" + field5 + "=" + String(S5);

  sendCommand("AT+CIPMUX=1", 5, "OK");
  sendCommand("AT+CIPSTART=0,\"TCP\",\"" + HOST + "\"," + PORT, 15, "OK");
  sendCommand("AT+CIPSEND=0," + String(getData.length() + 4), 4, ">");
  esp8266.println(getData);

  sendCommand("AT+CIPCLOSE=0", 5, "OK");
}

void sendCommand(String command, int maxTime, String readReply) {
  countTimeCommand = 0; // Reset the command counter
  found = false; // Reset the found flag

  Serial.print(countTrueCommand);
  Serial.print(". at command => ");
  Serial.print(command);
  Serial.print(" ");

  esp8266.println(command); // Send command

```

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5.
```
  unsigned long startTime = millis();

  while ((millis() - startTime) < (maxTime * 1000)) { // Timeout loop
    while (esp8266.available()) {
      char c = esp8266.read();
      if (c == readReply.charAt(0)) {
        unsigned long timeout = millis() + 1000; // Timeout for remaining characters in the reply
        size_t i = 1;
        while (i < readReply.length()) {
          if (timeout < millis()) break; // Timeout
          if (esp8266.available()) {
            if (esp8266.read() == readReply.charAt(i)) {
              i++;
            } else {
              break; // Mismatch
            }
          }
        }
        if (i == readReply.length()) {
          found = true;
          break;
        }
      }
    }
    if (found) break;
  }

  if (found) {
    Serial.println("OYI");
    countTrueCommand++;
  } else {
    Serial.println("Fail");
    countTrueCommand = 0;
  }
}
```

6.
```
void Read_Sensor() {
  S1 = digitalRead(ir_car1);
  S2 = digitalRead(ir_car2);
  S3 = digitalRead(ir_car3);
  S4 = digitalRead(ir_car4);
  S5 = digitalRead(ir_car5);
  enter = digitalRead(ir_enter);
  leave = digitalRead(ir_back);
}
```

III. RESULTS AND DISCUSSIONS

A. Results

The implementation of the intelligent parking lot system delivered notable results in both operational efficiency and user experience, demonstrating the potential of IoT technology in modern parking management. The system's use of infrared sensors proved highly effective in detecting the presence of vehicles, achieving a consistently high detection rate with minimal false positives or negatives. This accuracy ensured that the LCD display could provide users with real-time, reliable status updates, indicating whether each parking slot was occupied (0) or available (1), significantly improving the decision-making process for drivers (Fig 6). This immediate and clear feedback helped reduce confusion and minimize the time spent searching for available slots, contributing to a smoother flow of vehicles within the parking area.

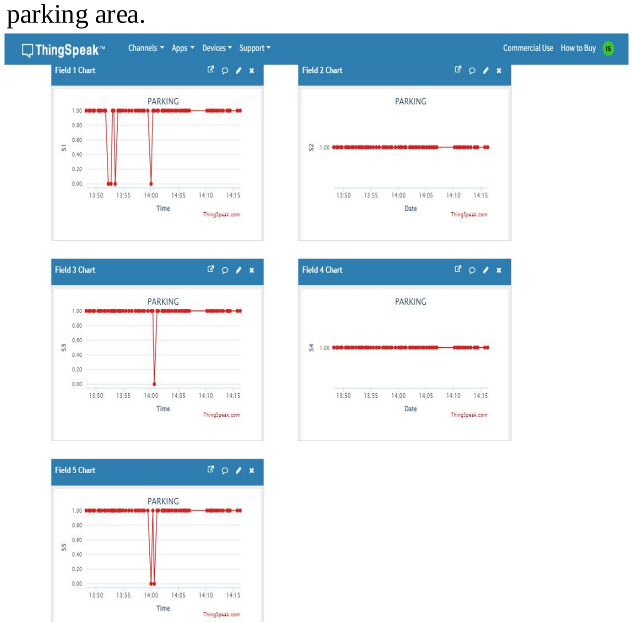

Fig 6: Dashboard of Thingspeak Showing Status Of Slots

The incorporation of the ESP8266 microcontroller was crucial for the system's operation, as it facilitated smooth and uninterrupted communication among the different parts of the parking lot system and the ThingSpeak platform. This connection allowed for the real-time transmission of data on the status of each parking space, whether it was in use or vacant, to ThingSpeak, where it was safely stored and visually represented. This information was not only available through ThingSpeak's online portal but also made compatible with potential future mobile applications, offering a highly engaging and user-friendly interface.

For visitors, the capability to check parking availability from a distance was immensely beneficial. Before arriving at the site, they could assess the status of parking spots, avoiding the hassle of searching for a space in a busy lot. This feature helped to reduce delays related to parking and lessened congestion, particularly during busy periods. Furthermore, the system's precision in detecting the presence of vehicles using infrared sensors ensured the reliability of the displayed parking status, boosting user confidence and satisfaction.

For those managing the parking lot, the ESP8266's function in linking to ThingSpeak offered an effective method for overseeing parking resources. Managers could keep an eye on the lot in real-time, pinpointed the busiest times, and collect data for later analysis. This data could be utilized to refine the allocation of parking spaces, spot patterns, and enhance the efficiency of operations. Moreover, the automation of the boom barrier based on the availability of parking spaces led to a more orderly and efficient parking process, ensuring that only vehicles could enter when spaces were vacant.

In conclusion, the combination of the ESP8266 with ThingSpeak significantly enhanced both the experience for users and the management of operations, establishing the system as a scalable solution for larger parking areas.

B. Discussion

The intelligent parking lot system presented in this study effectively addresses the issue of parking space management through the integration of IoT technologies. The use of infrared sensors, the ESP8266 microcontroller, and real-time communication with ThingSpeak has demonstrated significant improvements in parking efficiency by automating the process of detecting vehicle presence and controlling access through the boom barrier

One key advantage of this system is its real-time monitoring capability, which ensures that users are always aware of the availability of parking spaces. This reduces congestion and improves the overall user experience, particularly in high-traffic environments like airports and malls. The system's integration with a mobile app, as proposed for future work, would further enhance this by allowing users to check slot availability remotely, reserve parking spaces in advance, and even automate payments.

However, the system is not without limitations. The current implementation relies on infrared sensors, which may be affected by environmental factors such as light and weather conditions. Exploring alternative sensing technologies, such as ultrasonic or camera-based solutions, could improve the accuracy and robustness of the system in future iterations.

Moreover, while the communication with ThingSpeak provides basic cloud functionality, integrating more advanced data analytics platforms could allow for predictive analysis, identifying patterns in parking usage over time. This would enable parking lot operators to anticipate demand and optimize space management, potentially reducing operational costs.

In terms of scalability, while the system works well for small to medium-sized parking lots, expanding it to larger facilities could pose challenges related to network bandwidth and data processing. Addressing these issues would be critical for future deployments in larger urban centers.

Overall, the system presents a solid foundation for smart parking solutions, with numerous opportunities for enhancement and broader implementation.

IV. CONCLUSIONS

In conclusion, the intelligent parking lot system demonstrates a successful application of modern technology to address common parking challenges, particularly in high-traffic environments such as airports and shopping malls. By integrating components such as the ESP8266, infrared sensors, an LCD display, and a boom barrier, the system effectively monitors parking availability and provides real-time updates to users.

This capability is especially beneficial in busy settings, where drivers often face long wait times searching for parking spaces. With the LCD displaying occupancy status, travelers can quickly ascertain available slots, significantly reducing congestion and enhancing the overall experience. Additionally, the automated control of the boom barrier ensures that only vehicles with confirmed parking can enter, further streamlining access and improving security.

The ability to communicate with ThingSpeak facilitates remote monitoring and data analysis, allowing fleet managers to track usage patterns and optimize space management . This compatibility not only increases operational efficiency, but also supports strategic planning for future developments or changes. Overall, this project demonstrates the potential of IoT solutions to transform traditional fleet management into a better and more user-friendly experience and sets the stage for future developments in in smart car technologies can improve user satisfaction in airport and shopping areas.

V. ACKNOWLEDGMENT

We would like to express our heartfelt gratitude to everyone who contributed to the development of the intelligent parking lot system. Special thanks to our academic advisors for their invaluable guidance and support throughout the project. We also appreciate our peers for their constructive feedback and collaboration, which greatly enhanced our work. Additionally, we are grateful to our families and friends for their unwavering encouragement and belief in our capabilities. This project would not have been possible without the collective efforts of all involved, and we sincerely thank you for your contributions.

VI. FUTURE SCOPE

The future scope of the parking lot system includes the implementation of a camera system that can enhance vehicle monitoring and fee collection, along with a mobile app to provide users with real-time status updates and data analytics.

1) Camera System Integration: By incorporating a camera system equipped with license plate recognition technology, the system can automatically record vehicle entries and exits. This would facilitate automated fee collection based on parking duration, reducing the need for physical payment stations and streamlining the entire process. Additionally, this system can enhance security by monitoring vehicle movements and preventing unauthorized access.
2) Mobile Application Development: A dedicated mobile app would allow users to view real-time parking availability, reserve slots, and receive notifications on their smartphones. The app could also provide a user-friendly interface for managing payments and accessing transaction histories, further enhancing convenience.
3) Data Science Analytics: Leveraging data science techniques to analyze parking patterns and user behavior can yield valuable insights. Predictive analytics could forecast peak parking times, enabling better space allocation and management. Additionally, data visualization tools could present historical usage trends, aiding parking lot operators in decision-making and operational improvements.
4) User Feedback and Engagement: The mobile app can incorporate a feedback mechanism to gather user input on their parking experience, helping to identify areas for improvement and enhance customer satisfaction. Engaging users through loyalty programs or rewards for frequent parking could also encourage repeated use and foster a sense of community.
5) Integration with Smart City Initiatives: Aligning the parking system with broader smart city initiatives could enhance urban mobility. Collaborating with local transportation agencies to provide information on public transport options near the parking facility would offer users alternative travel solutions, reducing reliance on personal vehicles.
6) Environmental Impact Monitoring: Implementing sensors to monitor emissions and air quality in and around the parking facility could support sustainability goals. Providing users with information on the environmental impact of their parking habits could encourage eco-friendly choices.

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