CAR PARKING SYSTEM USING ARDUINO UNO

A

MAJOR PROJECT-II REPORT

Submitted in partial fulfillment of the requirements for the

degree of

BACHELOR OF TECHNOLOGY

in

COMPUTER SCIENCE & ENGINEERING

By

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CERTIFICATE

We hereby certify that the work which is being presented in the B.Tech. Major Project-I Report entitled **CAR PARKING SYSTEM,** in partial fulfillment of the requirements for the award of the degree of ***Bachelor of Technology,*** submitted to the Department of **Computer Science & Engineering**, Sagar Institute of Science & Technology (SISTec)**,**Bhopal (M.P.) is an authentic record of our own work carried out during the period from Jul-2024 to Dec-2024 under the supervision of **Prof. Shweta Singh**

The content presented in this project has not been submitted by us for the award of any other degree elsewhere.

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ABSTRACT

This project presents an efficient, IoT-enabled car parking system designed to optimize parking management in areas with limited space. The system uses an Arduino Uno microcontroller integrated with sensors and a MQTT Dashboard for real-time monitoring. An ultrasonic sensor detects incoming cars, and IR sensors monitor the occupancy of each parking slot. If a parking spot is available, the system automatically allows entry by controlling a servo motor barrier and updates the LED panel to show slot status. The ESP8266 Wi-Fi module enables data communication with the MQTT Dashboard, allowing users to view real-time parking availability remotely. This solution aims to simplify the parking process, reduce congestion, and improve parking space utilization through automation and IoT integration.

LIST OF ABBREVIATIONS

ACRONYM	FULL FORM
IOT	Internet of Things
MQTT	Message Queuing Telemetry Transport
IR	Infrared
LED	Light Emitting Diode
IDE	Integrated Development Environment
HTTP	Hypertext Transfer Protocol
CoAP	Constrained Application Protocol
AMQP	Advanced Message Queuing Protocol
SSL/TLS	Secure Sockets Layer and Transport Layer Security

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CHAPTER 1
INTRODUCTION

In today's rapidly urbanizing world, the demand for smart solutions to everyday challenges has increased significantly. Parking management, especially in urban areas, has become a pressing issue due to the surge in vehicle numbers, coupled with limited space availability. Drivers frequently struggle to locate vacant parking spots, leading to wasted time, increased frustration, higher fuel consumption, and elevated levels of emissions. These challenges underscore the need for efficient, real-time parking management solutions that can offer an organized and sustainable approach.

Our project, an IoT-Based Car Parking System, addresses these challenges by combining hardware and software components to create a comprehensive solution. This system leverages the Internet of Things (IoT), a technological approach that enables devices to communicate and share data in real-time, thereby optimizing processes that were previously handled manually. The IoT-based parking system we aim to develop will detect parking slot availability through ultrasonic sensors, control entry and exit via servo motors, and enable remote monitoring through an MQTT dashboard. The system provides real-time updates on parking space availability to users, offering a seamless and automated experience from the moment a vehicle approaches the parking entrance to when it exits.

The project is motivated by the need to reduce the time drivers spend in finding parking, alleviate traffic congestion, and lower fuel consumption and emissions. Traditional parking systems require drivers to check each slot manually, which is inefficient and can often result in occupied spaces being mistaken for free ones, leading to further frustration. By automating the process and providing real-time data on the dashboard, our system solves these issues by offering a reliable, easy-to-use, and eco-friendly solution. With this system, drivers can identify available parking slots at a glance and make quick decisions on whether to park or search elsewhere.

The IoT-based car parking system is also a step toward supporting smart city infrastructure. With the expansion of IoT in various urban applications, this parking system represents a small but impactful advancement in the digital transformation of city services. The project's objectives include enabling real-time parking slot monitoring, automating entry and exit, ensuring remote monitoring, and providing convenient, accurate parking information to users and administrators alike. The system's design emphasizes usability, reliability, and scalability,

making it suitable for various applications, from small parking lots to large commercial complexes.

1.1 ABOUT PROJECT

This IoT-based car parking system project addresses the need for efficient and automated parking management, especially in areas with limited space. Using an Arduino Uno as the central controller, the system integrates multiple sensors, including ultrasonic and IR sensors, to detect cars entering the parking area and monitor individual parking slot occupancy. When a car arrives, the ultrasonic sensor detects its presence and triggers the system to check for available slots. The IR sensors, placed at each parking space, continuously update the status of each slot, indicating whether it is occupied or vacant. This information is displayed on an LED panel, making it visible for users on-site.

Additionally, the system leverages an ESP8266 Wi-Fi module to connect to an MQTT Dashboard, which enables real-time remote monitoring of parking availability. The MQTT protocol allows seamless communication between the Arduino and the MQTT broker, efficiently transferring data about slot availability to the dashboard. This setup provides users with instant access to parking information, making it easier for them to check for open spaces before arriving. By automating data updates, the system minimizes the need for human intervention in parking management.

Through its design, this project aims to enhance user convenience and optimize the use of limited parking spaces. The system controls a servo motor barrier that automatically opens when a slot is available, reducing wait times and improving the overall parking experience. The automated monitoring and control functions provide a streamlined and user-friendly solution to parking congestion, demonstrating the power of IoT technology in simplifying everyday tasks.

1.2 PROJECT OBJECTIVES

The objective of this IoT-based car parking system project is to create a scalable, automated, and accessible parking solution that addresses parking challenges in high-demand areas. The system utilizes an Arduino Uno as its core controller, integrating ultrasonic and IR sensors to detect vehicle presence and manage parking slot availability with precision and reliability. By incorporating an ESP8266 Wi-Fi module, the system aims to provide seamless real-time data exchange with an MQTT Dashboard, enabling remote monitoring and reducing the need for manual oversight.

1.2.1 KEY GOALS OF THIS PROJECT INCLUDE

1.2.1.1 AUTOMATE AND SIMPLFY PARKING MANAGEMENT

Eliminate the need for human intervention by automating slot detection and gate control, providing a smoother parking experience.

1.2.1.2 FACILITATE REAL-TIME MONITORING AND ALERTS

Offer real-time updates on parking slot status to users and attendants via the MQTT Dashboard, allowing for proactive management and communication when slots are full.

1.2.1.3 ENHANCE SECURITY AND CONTROL

Use controlled access to prevent unauthorized parking and ensure each slot is used efficiently, adding a layer of security to the parking area.

1.2.1.4 OPTIMIZE LIMITED PARKING SPACE

Effectively manage space in compact parking lots by enabling only available slots to be accessed, reducing waiting times and maximizing utilization.

1.2.1.5 ENABLE SCALABILITY FOR LARGER SYSTEMS

Design the system to be easily adaptable for larger parking facilities by allowing additional sensors and dashboards as needed.

1.2.1.6 MINIMIZE ENVIRONMENTAL IMPACT

Reduce congestion and idling times in parking areas, contributing to decreased emissions and more sustainable parking practices.

Overall, this project aims to streamline parking management through advanced IoT integration, creating a smart, efficient, and scalable system for modern urban and commercial environments.

Our solution consists of essential hardware components, including the Arduino Uno, ultrasonic sensors, IR sensors, and servo motors. These components work in conjunction to detect and manage parking space occupancy. By combining these hardware components with an MQTT-based dashboard, our system allows both drivers and administrators to remotely monitor the parking status, ensuring seamless and efficient parking management.

CHAPTER 2
SOFTWARE & HARDWARE REQUIREMENTS

2.1 SOFTWARE REQUIREMENTS

Software requirements refer to the specific needs, capabilities, and constraints that a software system must fulfill to meet user expectations and achieve its intended purpose. They define the features, functionalities, and operations the system should perform, such as processing data or interacting with users. These requirements are categorized into functional requirements, which describe what the system should do, and non-functional requirements, which outline performance, security, and usability criteria. Clear software requirements serve as a foundation for design, development, and testing, ensuring the software meets both technical and user demands. Properly documented requirements help minimize errors, align team efforts, and deliver a successful software product.

2.1.1 ARDUINO IDE

For programming the Arduino Uno with the necessary code to handle sensors and MQTT communication.

2.1.2 MQTTLIBRARY FOR ARDUINO

For integrating MQTT protocol into your Arduino project. Libraries like PubSubClient are commonly used for this purpose.

2.1.3 MQTT BROKER

An MQTT broker is required to handle message routing between your Arduino and the MQTT Dashboard app. You can use public brokers or set up your own broker on a server.

2.1.4 MQTT DASHBOARD APP

For visualizing and monitoring the parking space data. Ensure it’s set up to connect to your MQTT broker.

2.1.5 MOBILE APP OR WEB INTERFACE

Depending on how you want to integrate or display additional features, you may develop or use a web interface or app.

2.2 HARDWARE REQUIREMENTS

Hardware requirements refer to the specific physical components, devices, and specifications needed for a system to function effectively. They outline the essential hardware resources, such as processors, memory, storage, sensors, or peripherals, required to support the software and meet the system's performance needs. These requirements are

categorized based on minimum and recommended configurations to ensure compatibility and optimal functionality. Clear hardware requirements help in designing, assembling, and testing systems while ensuring that all components work together seamlessly. Properly defined requirements reduce the risk of hardware-software conflicts and improve system reliability and efficiency.

2.2.1 ARDUINO UNO

Acts as the central microcontroller for processing data and controlling the system.

2.2.2 ULTRASONIC DISTANCE SENSORS

Used to detect the presence of a car and measure the distance to determine if a parking space is occupied.

2.2.3 BLUETOOTH MODULE

(e.g., HC-05) or Wi-Fi Module (e.g., ESP8266) Enables wireless communication between the Arduino and the mobile app or server for real-time updates.

2.2.4 LED INDICATORS

Provides visual feedback on the availability of parking spaces to users or operators.

2.2.5 RELAY MODULE

Controls the activation of alarms or indicators based on sensor input.

2.2.6 IR SENSORS

Detects the presence of cars in each parking slot.

2.2.7 SERVO MOTOR

Controls the barrier gate, allowing cars to enter and exit the parking lot.

2.2.8 CONNECTING WIRES AND BREADBOARD

For connecting the sensors, modules, and Arduino

CHAPTER 3
PROBLEM DESCRIPTION

3.1 CURRENT PARKING CHALLENGES

In densely populated urban areas, finding parking has become a significant daily struggle. Traditional parking systems often do not provide accurate, real-time information about parking availability, requiring drivers to physically search for available spots. This process wastes time and adds to traffic congestion, especially in multi-story or large parking complexes where checking each spot is impractical. For urban planners and facility managers, the inability to provide effective parking management leads to dissatisfaction among residents and visitors, as well as financial loss due to inefficient use of available spaces.

3.2 LACK OF REAL-TIME MONITORING

Without real-time monitoring, it is challenging to optimize the use of parking spaces. Drivers who cannot identify empty spots quickly may resort to parking illegally or leaving the area altogether, causing unnecessary frustration. For larger parking facilities, manually tracking occupied slots is impractical, as it requires continuous human effort and is prone to error. An automated parking management system, in this context, offers a solution that reduces manual effort, provides accurate availability information, and allows for more organized space utilization.

3.3 NEED FOR AUTOMATED PARKING MANAGEMENT

Automating parking management can greatly alleviate the need for constant human monitoring, reduce errors, and ensure that parking facilities are utilized to their full potential. Additionally, automation helps improve traffic flow by reducing the time vehicles spend searching for parking, contributing to lower emissions and a more sustainable urban environment.

3.4 SCALABILITY AND ADAPTIBILITY ISSUES

Current parking management systems often lack scalability and adaptability, limiting their effectiveness in growing urban environments. As vehicle numbers increase and parking demands fluctuate, traditional systems struggle to expand efficiently to accommodate new parking lots or changing space requirements. Without flexible, modular designs, these systems

are not easily adjustable for various facility sizes, from small lots to multi-level parking complexes. Implementing a scalable, IoT-based solution addresses this limitation by allowing easy addition of sensors and remote management capabilities, which ensure the system can adapt to future growth and different types of parking environments.

CHAPTER 4
LITERATURE SURVEY

From [1], John et al. (2018) examined IoT-based parking systems designed to reduce traffic congestion and optimize parking space utilization. The study highlighted the use of ultrasonic sensors for accurate vehicle detection and real-time monitoring. By integrating IoT technologies, these systems provided automated solutions to improve efficiency in urban parking. This aligns with the project's objective of using sensors to detect vehicle presence and communicate availability through a dashboard. Their findings also showcased the potential for reducing manual intervention and errors in parking management. The study emphasizes cost-effective solutions, which reflect the use of Arduino and ESP8266 in this project. Real-world applications demonstrated significant improvements in reducing waiting times for parking users. Such systems also contributed to better urban planning by optimizing land use. This project's design builds upon these principles to offer a scalable and efficient solution for parking management.

From [2], Patel et al. (2019) explored the MQTT protocol, emphasizing its lightweight and efficient design for IoT communication. The study highlighted MQTT's ability to handle low bandwidth and power requirements, making it ideal for devices like Arduino and ESP8266. Their research detailed how MQTT enables seamless real-time data transfer between IoT devices and dashboards, which is critical in parking systems. The project benefits from this protocol by using it to transmit parking slot status to a monitoring dashboard. MQTT's publish/subscribe model was praised for its simplicity and scalability in managing IoT device networks. The researchers also demonstrated its reliability under varying network conditions, ensuring consistent performance. This aligns with the project's goal of real-time updates to users. By reducing latency, MQTT enhances user experience and operational efficiency. Its adoption ensures a robust foundation for IoT-based applications like smart parking.

From [3], Kumar and Singh (2020) studied the role of IoT technologies in creating smart city infrastructures, particularly focusing on traffic and parking management. The study proposed simple yet scalable IoT models that integrate real-time monitoring and automation. These findings mirror this project's design, which uses a two-tier architecture with Arduino, ESP8266, and MQTT for efficient parking management. They emphasized the role of sensors in creating data-driven solutions for urban challenges, aligning with the use of ultrasonic and IR sensors in this project. The integration of dashboards for user-friendly interfaces was also

highlighted as a critical success factor. Their research noted that smart parking systems improve traffic flow and reduce pollution by minimizing unnecessary vehicle movement. This project adopts similar principles to contribute to sustainable urban development. By focusing on cost-effective and easy-to-deploy solutions, the study provided a blueprint for scalable IoT applications.

From [4], Gupta et al. (2017) focused on using IR and ultrasonic sensors for vehicle detection and parking slot monitoring. Their study validated these sensors as cost-effective and reliable solutions for real-time parking systems. The research showcased their accuracy in detecting vehicle presence, which directly aligns with this project's design. Ultrasonic sensors were praised for their ability to monitor distance and identify occupancy, while IR sensors ensured precise entry and exit detection. The combination of these sensors creates a robust framework for parking automation, reducing manual errors. Their findings supported the use of low-cost hardware like Arduino for sensor integration. The study also emphasized how sensor-driven systems can enhance operational efficiency. This project builds upon these insights by implementing real-time monitoring through these sensors. By integrating with IoT dashboards, the system offers a seamless user experience. Such sensor technologies are critical in creating modern, automated parking solutions.

From [5], Sharma and Verma (2021) investigated the importance of energy efficiency in IoT applications, particularly for systems with continuous operations. They highlighted the advantages of using low-power components like ESP8266, which ensures reliable communication without excessive energy consumption. Their findings align with this project's goal of creating a sustainable smart parking system. The research detailed strategies for optimizing hardware and software to reduce energy usage. The MQTT protocol, used in this project, was recognized for its low resource requirements. The study also discussed battery management and power-saving modes in IoT devices. By ensuring energy efficiency, such systems can achieve long-term operational reliability. This project adopts these principles by using energy-efficient components and lightweight protocols. The research reinforced the importance of sustainability in IoT-based applications, making it a key consideration in design. This ensures that the project remains both cost-effective and environmentally friendly.

From [6], Rao et al. (2020) explored the synergy between IoT systems and cloud computing, focusing on data storage and real-time processing capabilities. Their study highlighted the benefits of using cloud platforms for large-scale IoT implementations, emphasizing data accessibility and reliability. For smart parking systems, this integration ensures centralized data

management and easy scalability. Although this project uses MQTT for direct communication, the cloud can be incorporated to store historical parking data and enhance analytics. The study also discussed how cloud platforms support multiple devices simultaneously, which aligns with the project's potential expansion to manage more parking slots or locations. The security features of cloud platforms were emphasized, ensuring data integrity and user privacy. By leveraging cloud services, IoT systems can offer advanced visualization tools and predictive analytics, which may be future enhancements for this project. The combination of IoT and cloud creates a robust framework for real-time and long-term applications.

From [7], Williams et al. (2019) emphasized the role of automation in addressing urban traffic issues, especially those caused by inefficient parking systems. Their study illustrated how automated parking solutions reduce search times for vacant spots, decreasing congestion and emissions. The project aligns with this research by providing automated parking slot detection and monitoring through sensors and MQTT. The researchers also highlighted the role of real-time data in enabling dynamic parking management, a feature integrated into this project through the dashboard. Automation was shown to improve user convenience and operational accuracy by minimizing human intervention. Their findings demonstrated how systems like these could adapt to changing parking demands, offering flexibility and scalability. This project's focus on real-time updates and barrier automation reflects these principles. By reducing manual errors and delays, the project enhances overall parking efficiency. The study validated that automation is a key driver for modernizing urban traffic systems.

From [8], Yadav and Roy (2018) explored how real-time monitoring enhances the usability and effectiveness of parking systems. Their study focused on the role of IoT dashboards in displaying live updates of parking slot availability, enabling users to make informed decisions. This aligns with the project's use of an MQTT dashboard to provide instant updates on slot occupancy. The researchers highlighted how real-time data reduces the time spent searching for parking spaces, improving user satisfaction. They also noted the importance of accurate sensor data to ensure reliable system performance. The study emphasized the need for intuitive interfaces, ensuring that users and administrators can access data effortlessly. This project implements these insights by offering a simple and accessible MQTT-based dashboard. By integrating real-time updates, the system supports efficient parking operations and user convenience. The research underlines the importance of real-time feedback in creating impactful IoT applications.

From Websites [1], MQTT (Message Queuing Telemetry Transport) is a lightweight and efficient messaging protocol tailored for IoT communication. It operates on a publish/subscribe model, which decouples the sender and receiver, allowing scalability and flexibility in large networks. This protocol is ideal for resource-constrained devices, supporting low bandwidth and high latency networks with robust messaging reliability. Key features include three Quality of Service (QoS) levels, retained messages for last-known state delivery, and persistent client sessions that ensure no data is lost during intermittent connections. Additionally, MQTT's "Last Will and Testament" feature ensures devices can signal their offline status, crucial for mission-critical applications. Its simplicity and minimal overhead make it the preferred choice for IoT solutions, including smart homes, industrial IoT, and connected vehicles.

From Websites [2], The Arduino Uno Rev3 is a versatile microcontroller board based on the ATmega327P, designed for a broad range of applications. It features 14 digital input/output pins, including 6 capable of PWM output, 6 analog inputs, a USB connection for programming, and an external power jack. The board supports input power ranging from 7-12V, making it adaptable to various project requirements. With its user-friendly design, replaceable ATmega327P chip, and a 16 MHz ceramic resonator, it offers robustness and reliability for both beginners and professionals. The Uno includes 1KB EEPROM for data storage and is compatible with numerous sensors and actuators, making it suitable for diverse applications like robotics and IoT. Comprehensive online documentation, including tutorials, example codes, and schematics, enables users to prototype and troubleshoot with ease.

CHAPTER 5
SOFTWARE REQUIREMENTS SPECIFICATION

5.1 FUNCTIONAL REQUIREMENTS

5.1.1 PARKING SLOT DETECTION

Ultrasonic sensors detect occupancy status of each slot and relay it to the dashboard.

5.1.2 VEHICLE ENTRY/EXIT DETECTION

IR sensors detect vehicle movement at entry/exit to update slot availability.

5.1.3 BARRIER CONTROL

Servo motor opens/closes the barrier based on slot availability.

5.1.4 REAL-TIME DATA COMMUNICATION

ESP8266 transmits slot data to an MQTT broker for dashboard display.

5.1.5 DASHBOARD DISPLAY

Shows real-time parking slot status for remote monitoring.

5.1.6 ERROR NOTIFICATION

System alerts when a sensor or component encounters an error.

5.2 NON-FUNCTIONAL REQUIREMENTS

5.2.1 RELIABILITY

Ensures at least 99% uptime for uninterrupted monitoring.

5.2.2 USABILITY

Simple and clear dashboard interface for easy status monitoring.

5.2.3 SCALABILITY

Supports the addition of extra slots by adding more sensors.

5.2.4 SECURITY

Ensures secure, encrypted data communication.

5.2.5 MAINTAINABILITY

Modular hardware and software design for easy updates and repairs.

5.2.6 AVAILABILITY

System is operational 24/7 to track and display real-time parking data.

5.3 PERFORMANCE

5.3.1 RESPONSE TIME

Slot status is updated within 2 seconds of any change.

5.3.2 DATA TRANSMISSION SPEED

Dashboard updates occur within 1 second of data transmission.

5.3.3 SYSTEM LATENCY

Low latency in data processing and dashboard refresh to ensure real-time accuracy.

5.3.4 ERROR RECOVERY

Automatic recovery and alerts in case of connection or hardware errors.

5.3.5 DATA REFRESH RATE

Dashboard displays refresh every few seconds to reflect accurate status.

5.3.6 NETWORK RELIABILITY

Stable connection with MQTT broker for uninterrupted data flow.

5.4 SECURITY

The IoT-Based Car Parking Management System is designed with robust security features to protect data and ensure system integrity. Given that the system transmits real-time data on parking availability and access control over a network, it is crucial to maintain data privacy and prevent unauthorized access.

5.4.1 DATA ENCRYPTION

All data transmitted between the system components (e.g., sensors, Arduino, ESP8266) and the MQTT broker is encrypted to prevent interception by unauthorized parties. This ensures that data remains confidential and secure.

5.4.2 ACCESS CONTROL

Only authorized users can access the MQTT dashboard to monitor parking slot status. This feature prevents unauthorized individuals from viewing or manipulating the system data.

5.4.3 AUTHENTICATION AND AUTHORIZATION

The system requires login credentials for users accessing the MQTT dashboard, ensuring that only verified individuals can access parking data and control features.

5.3.4 NETWORK SECURITY

To prevent network attacks, the system utilizes secure Wi-Fi protocols for communication through the ESP8266 module. This minimizes vulnerabilities that could be exploited by attackers to disrupt system operations.

5.3.5 SYSTEM RESILIENCE

The system is designed to withstand hardware or network failures with minimal data loss, using automatic reconnection protocols to maintain system continuity in case of temporary disconnections.

5.5 USABILITY

The IoT-Based Car Parking Management System prioritizes user-friendliness to ensure that both end-users (drivers) and system administrators can efficiently interact with the system. The goal is to make parking status information accessible and easy to understand, while simplifying system operation and monitoring.

5.5.1 SIMPLE DASHBOARD INTERFACE

The MQTT dashboard presents data in a clear and intuitive format, with visible indicators showing the status of each parking slot (e.g., occupied, vacant). This visual clarity makes it easy for users to understand the current parking availability at a glance.

5.5.2 REAL-TIME UPDATES

The dashboard displays real-time status updates on slot availability, reducing delays and allowing for immediate action by users looking for parking or by administrators monitoring the system.

5.5.3 USER NOTIFICATIONS

The system provides instant notifications for key events, such as when all parking slots are full, or when a slot becomes available, allowing users to make quick decisions.

5.5.4 ACCESSIBILITY

The dashboard can be accessed on multiple devices, including smartphones, tablets, and computers, making it convenient for remote monitoring.

5.5.5 LOW-LATENCY PERFORMANCE

The system is designed to respond quickly to sensor inputs, updating slot status with minimal delay. This enhances the user experience by ensuring that information on the dashboard is always current.

By focusing on both security and usability, this project aims to provide a safe and user-friendly experience that meets the needs of both drivers and administrators.

CHAPTER 6
SOFTWARE AND HARDWARE DESIGN

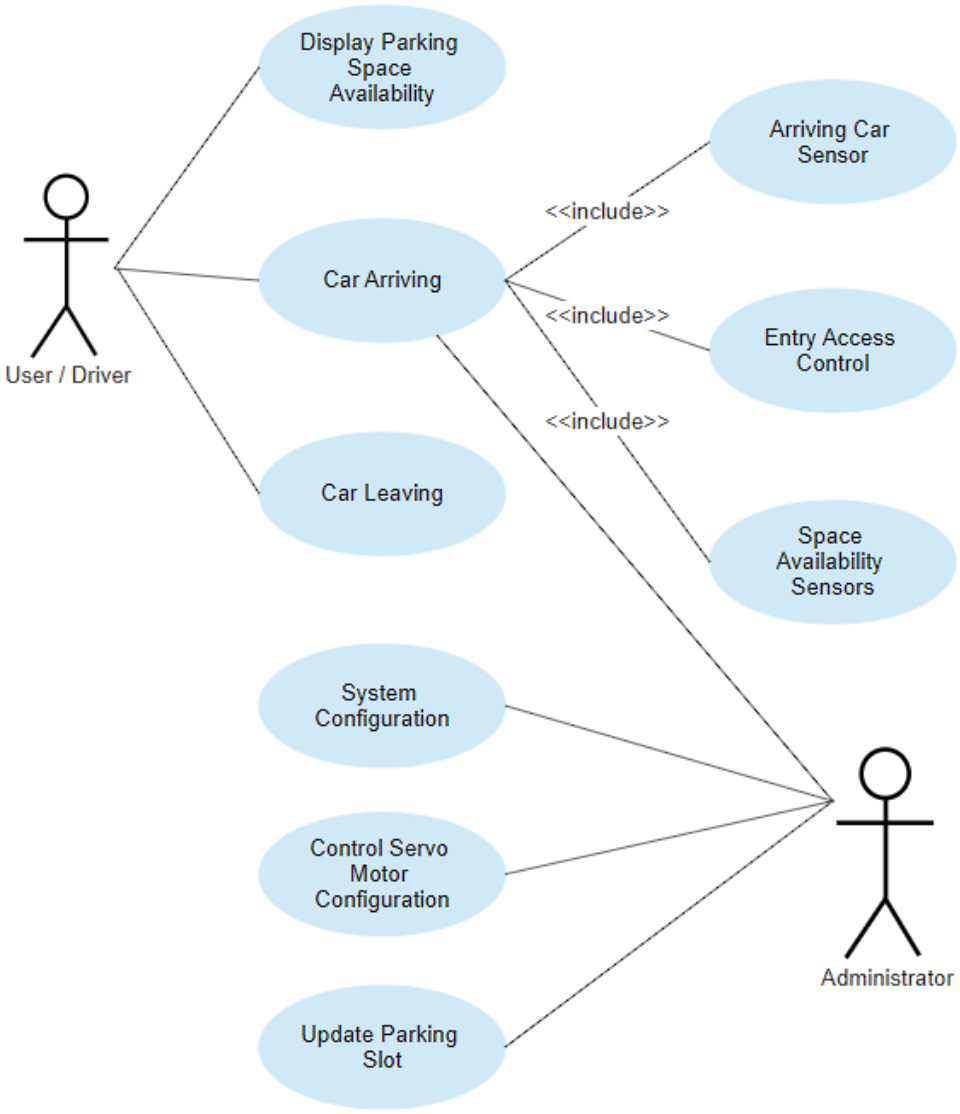

Figure 6.1: Use Case Diagram

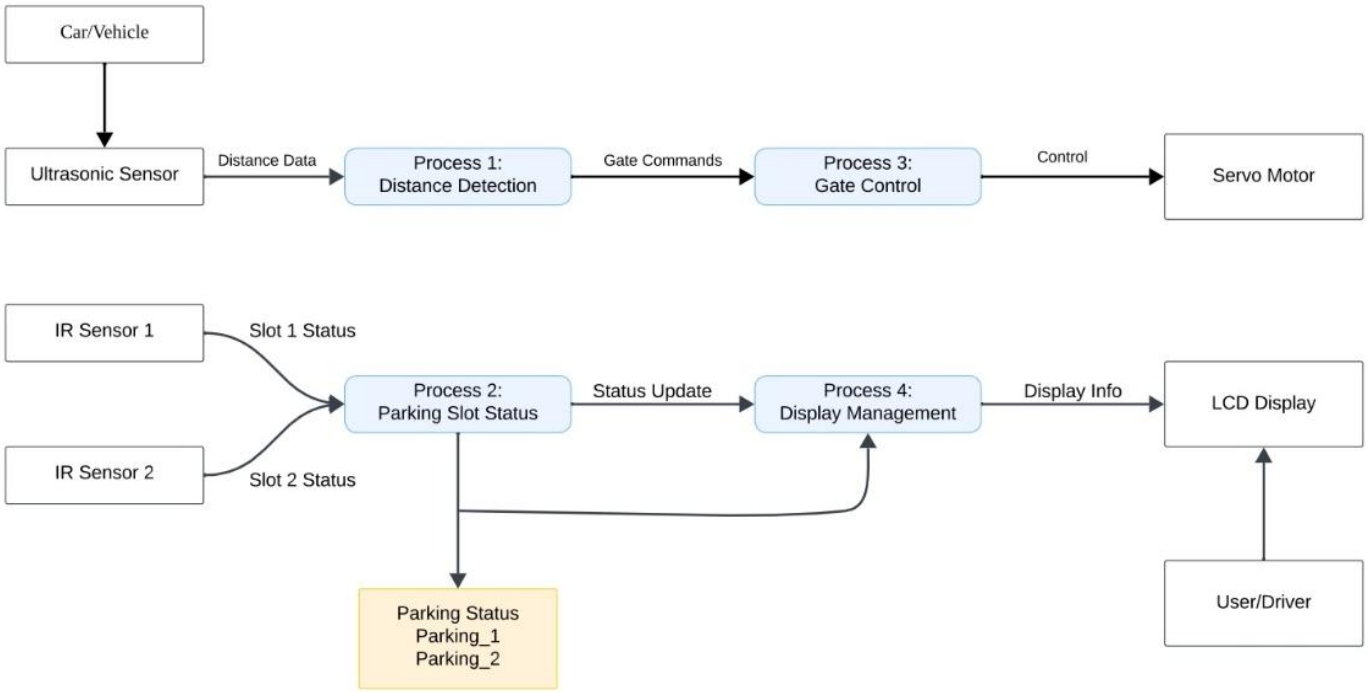

Figure 6.2: Data Flow Diagram

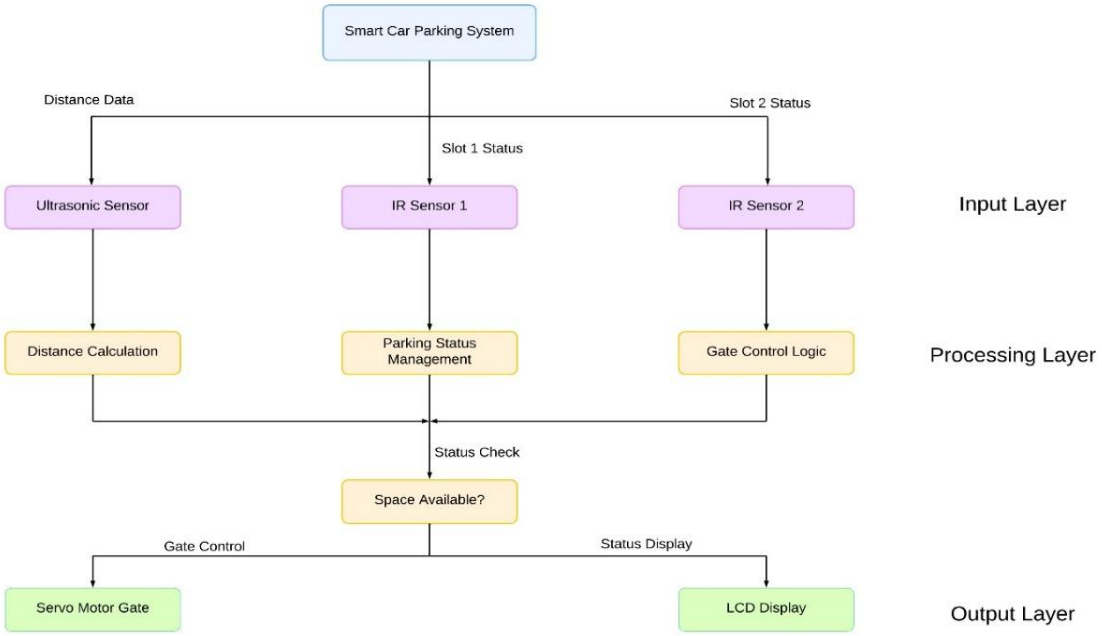

Figure 6.3: Architecture

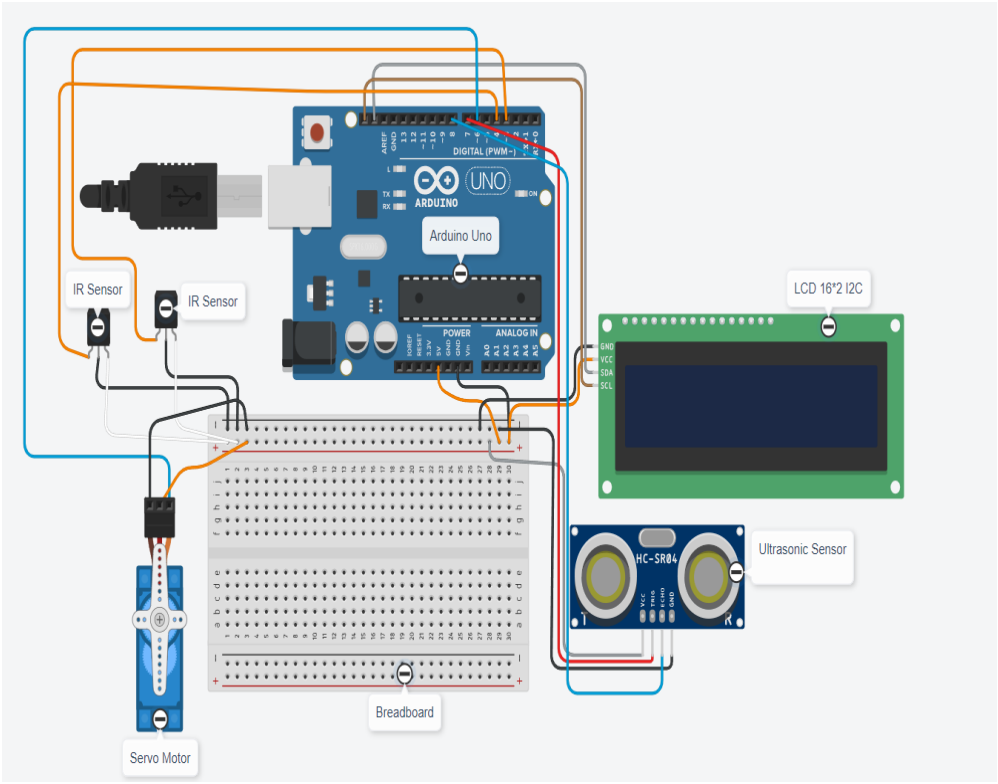

Figure 6.4: Circuit Diagram

6.5 COMPONENTS

Figure 6.5.1: Arduino Uno

Figure 6.5.2: IR Sensor

Figure 6.5.3: Servo Motor

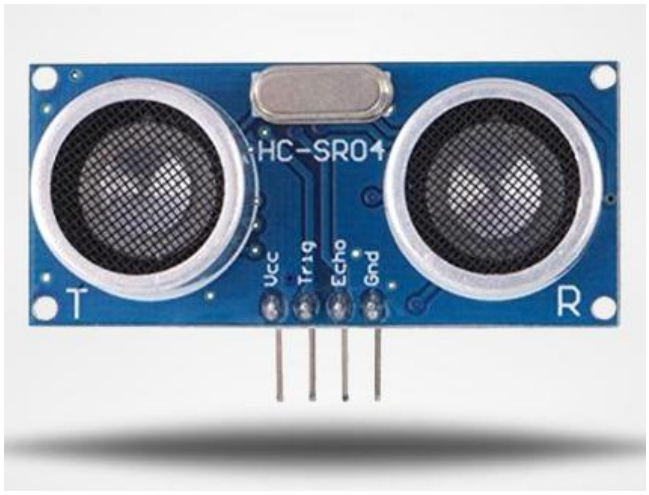

Figure 6.5.4: Ultrasonic Sensor

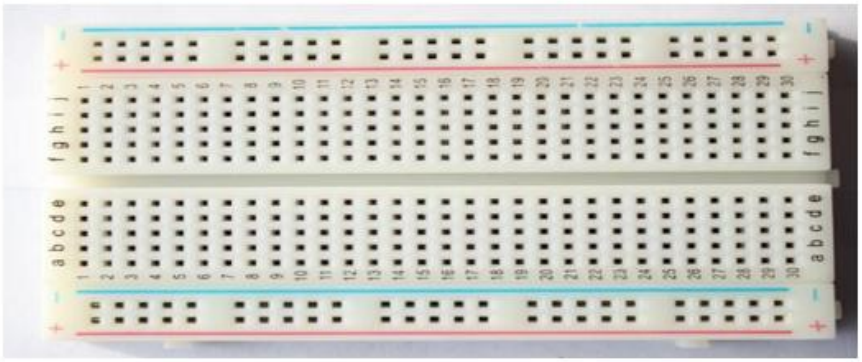

Figure 6.5.5: Bread Board

Figure 6.5.6: Jumper Wire

CHAPTER 7
IOT MODULE

The integration of the Internet of Things (IoT) into modern systems has dramatically enhanced the efficiency of various operations, and one prominent example is the IoT-based parking management system. This technology allows for the automation of parking space management by connecting physical devices such as sensors, controllers, and actuators to a centralized network for real-time monitoring and control. In the context of parking management, the IoT module is a crucial element that ensures smooth operation by automating the detection of available parking spaces and communicating this information to users and administrators.

The **IoT-based Parking Management System** involves the use of multiple sensors, including **ultrasonic and infrared (IR) sensors**, to detect the presence of vehicles in parking spaces. These sensors are connected to an **Arduino microcontroller**, which processes the data and sends the information to the cloud via a **Wi-Fi module (ESP8266)**. The real-time data is then displayed on a cloud-based dashboard, allowing users to check the availability of parking spaces from their mobile devices or computers. The system continuously updates the status of each parking spot, providing an intuitive and user-friendly interface for both drivers and parking lot managers.

The IoT module plays an essential role in ensuring that the parking system operates efficiently. It begins with **pre-processing steps**, where the raw sensor data is validated and cleaned to remove noise or erroneous readings. This ensures that the system operates based on accurate and reliable information. Once validated, the data is sent to a cloud-based platform where it is visualized in real-time. This **data visualization** process allows users to monitor parking space availability, enabling them to make informed decisions about where to park.

A key feature of the IoT module is its ability to facilitate **real-time communication** between the parking system and the cloud using MQTT (Message Queuing Telemetry Transport). This lightweight communication protocol ensures fast and reliable data transmission, allowing the system to update the parking space status promptly and without delay. Additionally, the **result analysis** of collected data can provide valuable insights into parking patterns, peak times, and the efficiency of space utilization, further optimizing the management process.

Overall, the IoT module in the parking management system significantly enhances user convenience, reduces the need for human intervention, and contributes to a more efficient use of

available parking spaces. It transforms traditional parking systems into smart, automated solutions that are essential for modern urban environments and smart cities.

7.1 PRE-PROCESSING STEPS

7.1.1 DATA COLLECTION

Data collection is a critical initial step in the parking management system. Sensors
installed in the parking lot continuously gather data that serves as the foundation for the entire system.

waves. When these waves encounter an object (like a car), they bounce back to the sensor, and the time taken for the waves to return is used to calculate the distance. This measurement is then interpreted by the system to check whether a parking space is occupied.

The IR sensors, typically placed at the entrances and exits, monitor the movement of vehicles. When a vehicle passes through the sensor's infrared beam, it disrupts the signal, alerting the system to the vehicle's presence.

These sensors are essential for capturing real-time data about the parking lot. This information is crucial in maintaining accurate availability status on the MQTT dashboard, which is used to inform the users about parking space occupancy.

The Arduino Uno is responsible for gathering data from these sensors and performing the initial processing. It's vital that the system reads this data frequently and accurately to ensure that parking availability is updated in real-time.

Once data is collected, it is then prepared for transmission to the MQTT broker. This is a continuous process, where sensor data is periodically checked and updated based on the sensor readings.

7.1.2 NOISE FILTERING

Noise filtering plays a crucial role in maintaining the accuracy of the sensor data. Environmental conditions, sensor imperfections, and interference from nearby objects can affect sensor readings, leading to inaccuracies in the data.

For example, ultrasonic sensors can be affected by objects in the environment, such as walls or parked cars, which can cause erroneous readings. The algorithm needs to filter out these false readings to maintain accurate data.

Digital signal processing (DSP) techniques can be implemented to smooth out sudden spikes or drops in sensor data. This technique averages data points over time, ensuring that only the most reliable readings are used.

A threshold-based method can be used for noise filtering. If the sensor reading is beyond a specified threshold (either too high or too low), the reading is discarded as noise and does not contribute to the status update of the parking space.

The Arduino code incorporates error-detection algorithms that verify if the data collected from the sensors is consistent with the expected values. If any discrepancies are found, the erroneous data is rejected and does not affect the overall operation.

Additionally, Kalman filtering can be applied to smooth sensor data and eliminate jitter, leading to more stable measurements.

Once noise has been filtered out, the processed data is ready for further analysis or visualization, allowing the system to maintain an accurate representation of the parking lot's occupancy.

7.1.3 DATA TRANSFORMATION & AGGREGATION

After noise filtering, the data undergoes transformation into a useful format that can be used to make decisions regarding the status of each parking space.

The ultrasonic sensor provides continuous distance measurements, but these values need to be converted into a more intuitive binary format occupied or vacant. If the distance is smaller than the predefined threshold (indicating a car is present), the parking space is marked as occupied. If the distance exceeds this threshold, the parking space is marked as vacant.

Similarly, data from the IR sensors is straightforward a 1 indicates a vehicle has passed through the sensor's beam, while a 0 means no vehicle is present.

The next step is data aggregation. This step combines the data from multiple sensors into a coherent status report. For example, if the IR sensor at the parking entrance detects a car, and the ultrasonic sensor confirms that the parking space is full, the data is aggregated to show that the parking lot has reached full capacity.

The data from various sensors are aggregated on the Arduino Uno, which calculates the overall status of the parking lot, including the availability of each individual parking space. This information is formatted into a message that can be sent to the MQTT broker for further transmission.

After aggregation, the system may use algorithms to predict parking space availability for the next few hours or detect patterns based on historical data. This step allows the system to provide more informed insights to users about peak parking hours.

The transformed and aggregated data is then transmitted via the ESP8266 Wi-Fi module, ensuring seamless communication with the cloud platform for real-time monitoring.

7.2 DATA VISUALIZATION

7.2.1 DASHBOARD OVERVIEW

The **cloud-based dashboard** is the user-facing interface that visualizes parking lot occupancy in real-time. It provides users with a clear and concise view of available and occupied parking spaces.

The dashboard displays the **parking lot layout** in a graphical format, where each parking space is represented by an icon that changes color based on its status green for available and red for occupied.

The layout may also include **zoomable maps**, allowing users to view a specific section of the parking lot if it's large. This feature enables users to navigate through the parking lot visually and make better parking decisions.

The **MQTT protocol** ensures that data sent from the sensors to the cloud is published and updated on the dashboard with minimal latency. The dashboard interface communicates with the MQTT broker, allowing it to dynamically receive and display the real-time status of each parking spot.

Users can interact with the dashboard, clicking on individual parking spaces for detailed information. For example, users might click on a specific spot to see when it was last occupied or to view usage statistics over time.

In addition to real-time updates, the dashboard may also display the **occupancy rate** of the parking lot, helping users understand the overall parking situation, including how many spaces are currently available and the likelihood of finding an empty spot.

7.2.2 REAL-TIME UPDATES

The **real-time update feature** is one of the most critical aspects of the dashboard. It ensures that users have access to up-to-date information regarding parking availability without needing to refresh or reload the page.

When the **Arduino Uno** receives updated data from the sensors, it sends the information via the **ESP8266 module** to the MQTT broker, which in turn pushes the data to the dashboard.

The **MQTT broker** is responsible for handling the message queuing process. It ensures that messages are delivered in a timely and reliable manner, ensuring that the dashboard always displays the correct parking space status.

The real-time feature minimizes waiting times for users, as they can make quick decisions based on the current availability of parking spaces. This also reduces the time spent searching for

parking, which is a common frustration for drivers in crowded lots.

The dashboard automatically refreshes the status of each parking space at regular intervals or when new data is received, ensuring that the information is always accurate.

If a parking spot becomes available (e.g., when a car leaves), the system instantly updates the dashboard, making the space available for another user to park. This continuous loop of data communication ensures that the parking management system operates smoothly.

7.2.3 USER INTERFACE AND ACCESSIBILITY

The **user interface (UI)** of the dashboard is designed with ease of use in mind. It is intuitive, clean, and user-friendly, ensuring that all users—whether tech-savvy or not—can navigate and use the dashboard effectively.

Key UI elements include **color-coded icons**, buttons for real-time refresh, and clickable parking spaces that provide more detailed information. Each parking space can be color-coded based on its status, such as green for available, red for occupied, or yellow for pending (e.g., when a car is moving in or out).

The dashboard is optimized for different **devices**, including desktops, tablets, and smartphones. This makes it accessible to a wide range of users, ensuring that people on the go or in the parking lot itself can easily check parking availability.

In addition to basic functionality, the dashboard also features **search filters** or sorting options, allowing users to find available parking spaces based on criteria like proximity to the entrance or their current location.

Accessibility features include **high contrast modes**, larger text options, and voice commands for people with disabilities, making the system inclusive and usable for a broader audience.

The interface also supports **multi-language options**, allowing people who speak different languages to access and navigate the system without barriers.

The real-time nature of the updates means that users do not need to manually refresh the page—data updates automatically, keeping users informed without additional effort.

7.3 IOT MODEL DESCRIPTION

The integration of the IoT module allows for efficient real-time decision-making by parking system administrators and users. By automating the process of detecting available parking spaces and managing the entrance and exit of vehicles, the system minimizes human error and reduces operational overhead. As a result, it can handle large volumes of cars in busy urban areas while maintaining an organized and streamlined operation.

The real-time monitoring aspect provided by the IoT system is one of its most significant benefits. Since the data is sent to the cloud, it is accessible from anywhere and at any time, using mobile apps or web dashboards. This not only helps drivers find available parking more easily, but also assists parking lot operators in tracking space usage, optimizing parking lot design, and managing traffic flow efficiently.

Another significant aspect of the IoT-based parking system is its scalability. As cities grow and parking demand increases, the system can easily accommodate additional sensors or parking spots without requiring a major overhaul. The modular design ensures that parking spaces can be added incrementally, making it suitable for both small parking areas and large multi-level parking structures.

The sustainability of the IoT system is another key benefit. By reducing the amount of time drivers spend searching for parking spaces, the system helps lower fuel consumption and emissions. In addition, it optimizes the usage of parking spaces, ensuring that no space is underutilized and that the entire parking lot is used as efficiently as possible.

Furthermore, the integration of security features within the IoT module ensures that only authorized users can access parking spaces. By leveraging technologies like RFID tags, license plate recognition, or user authentication through mobile apps, the system adds an extra layer of security to prevent unauthorized parking and improve the overall safety of the facility.

In summary, the IoT module within a parking management system provides not just convenience but also significant operational advantages. By automating data collection, processing, and transmission, it ensures smooth and efficient parking lot management, allowing for smarter cities and better experiences for both users and operators. This technological framework sets the stage for further innovation and optimization, positioning IoT-based parking systems as a cornerstone of modern urban infrastructure.

7.4 RESULT ANALYSIS

The result analysis of the IoT-based parking system is a crucial aspect that enables ongoing optimization and ensures that the system performs effectively. Once data is collected from the various sensors, processed, and visualized in real-time, it is analysed to evaluate the system’s overall performance and identify areas for improvement. The system's effectiveness is not only measured by its ability to provide real-time parking space availability but also by its efficiency in space utilization, its accuracy in sensor readings, and the quality of its communication protocols.

By analysing the sensor data, such as the occupancy patterns of parking spaces, peak usage times, and vehicle entry/exit trends, valuable insights can be derived. These insights can help in improving the management of parking facilities by enabling administrators to predict high-demand periods and take proactive actions to manage traffic flow. For instance, if the analysis reveals that certain parking spaces are consistently underutilized, the system can be reconfigured to ensure that the parking layout is optimized for better utilization.

Additionally, traffic analysis from the data can highlight bottlenecks or congested areas in the parking lot, helping managers reconfigure entry and exit points or modify the layout for better traffic flow. This helps avoid gridlocks and reduces the time it takes for users to enter and exit the parking lot.

Result analysis also plays a key role in long-term system improvement. As the system continuously collects and processes data, it becomes more intelligent over time, allowing it to make better predictions about parking space availability and optimize parking lot operations. The system can learn from past trends and adjust to evolving parking behaviours, ensuring that it remains efficient and responsive to users' needs.

In conclusion, the result analysis in an IoT-based parking management system is not just about tracking current performance; it’s also about continuously refining the system to make it more efficient, user-friendly, and responsive to the changing dynamics of parking management. The insights gathered from result analysis are instrumental in ensuring the system’s sustained success and its adaptability to future demands.

CHAPTER 8
CODING

```
#include <LiquidCrystal_I2C.h>
#include <Servo.h>
// LCD and Servo configurations
LiquidCrystal_I2C lcd(0x27, 20, 4); // set the LCD address for a 16 chars and 2-line display
Servo myservo;                      // create servo object to control a servo
// Pin definitions
const int IR_PIN_1 = 4;
const int IR_PIN_2 = 5;
const int servo_pin = 6;
const int trigPin = 7;
const int echoPin = 8;

// Variables
int distance;
int pos = 0;        // variable to store the servo position
int IT_State_1;
int IT_State_2;
String Parking_1;
String Parking_2;

void setup() {
   pinMode(trigPin, OUTPUT);
```

```
  pinMode(echoPin, INPUT);
  pinMode(IR_PIN_1, INPUT);
  pinMode(IR_PIN_2, INPUT);

  Serial.begin(9600); // Initialize serial communication


  lcd.init();
  lcd.backlight();


  // Servo calibration
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Motor Calibration");
  lcd.setCursor(0, 1);
  lcd.print("started");
  delay(1000);


  myservo.attach(servo_pin);
  for (pos = 15; pos <= 160; pos += 1) {
    myservo.write(pos);
    delay(15);
  }
  for (pos = 160; pos >= 13; pos -= 1) {
    myservo.write(pos);
    delay(15);
```

```
    }
    myservo.detach();

    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Motor Calibration");
    lcd.setCursor(0, 1);
    lcd.print("Done");
    delay(1000);

    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Car");
    lcd.setCursor(0, 1);
    lcd.print("Parking System");
    delay(2000);
}



void loop() {
    distance = ultra();

    // Check if parking space is available
    if ((distance < 10) && ((Parking_1 == "EMPTY") || (Parking_2 == "EMPTY"))) {
        myservo.attach(servo_pin);
```

```
    for (pos = 5; pos <= 160; pos += 1) {
      myservo.write(pos);
      delay(15);
    }
    for (pos = 160; pos >= 5; pos -= 1) {
      myservo.write(pos);
      delay(15);
    }
    myservo.detach();
  }

  // Read IR sensors to determine slot occupancy
  IT_State_1 = digitalRead(IR_PIN_1);
  Parking_1 = (IT_State_1 == LOW) ? "FULL"  "EMPTY";

  IT_State_2 = digitalRead(IR_PIN_2);
  Parking_2 = (IT_State_2 == LOW) ? "FULL"  "EMPTY";

// Update LCD display with parking slot statuses
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Slot One =" + Parking_1);
  lcd.setCursor(0, 1);
  lcd.print("Slot Two =" + Parking_2);
  delay(1000);
```

```
}

// Function to get distance from ultrasonic sensor
int ultra() {
    int result = 0;
    unsigned long duration, distanceSum = 0;

    for (int i = 0; i < 3; i++) {
        digitalWrite(trigPin, LOW);
        delayMicroseconds(2);

        digitalWrite(trigPin, HIGH);
        delayMicroseconds(10);
        digitalWrite(trigPin, LOW);

        duration = pulseIn(echoPin, HIGH);
        distanceSum += duration / 58.2;
        delay(10);
    }
    result = distanceSum / 3;
    return result;
}
```

CHAPTER 9
RESULT AND OUTPUT SCREENS

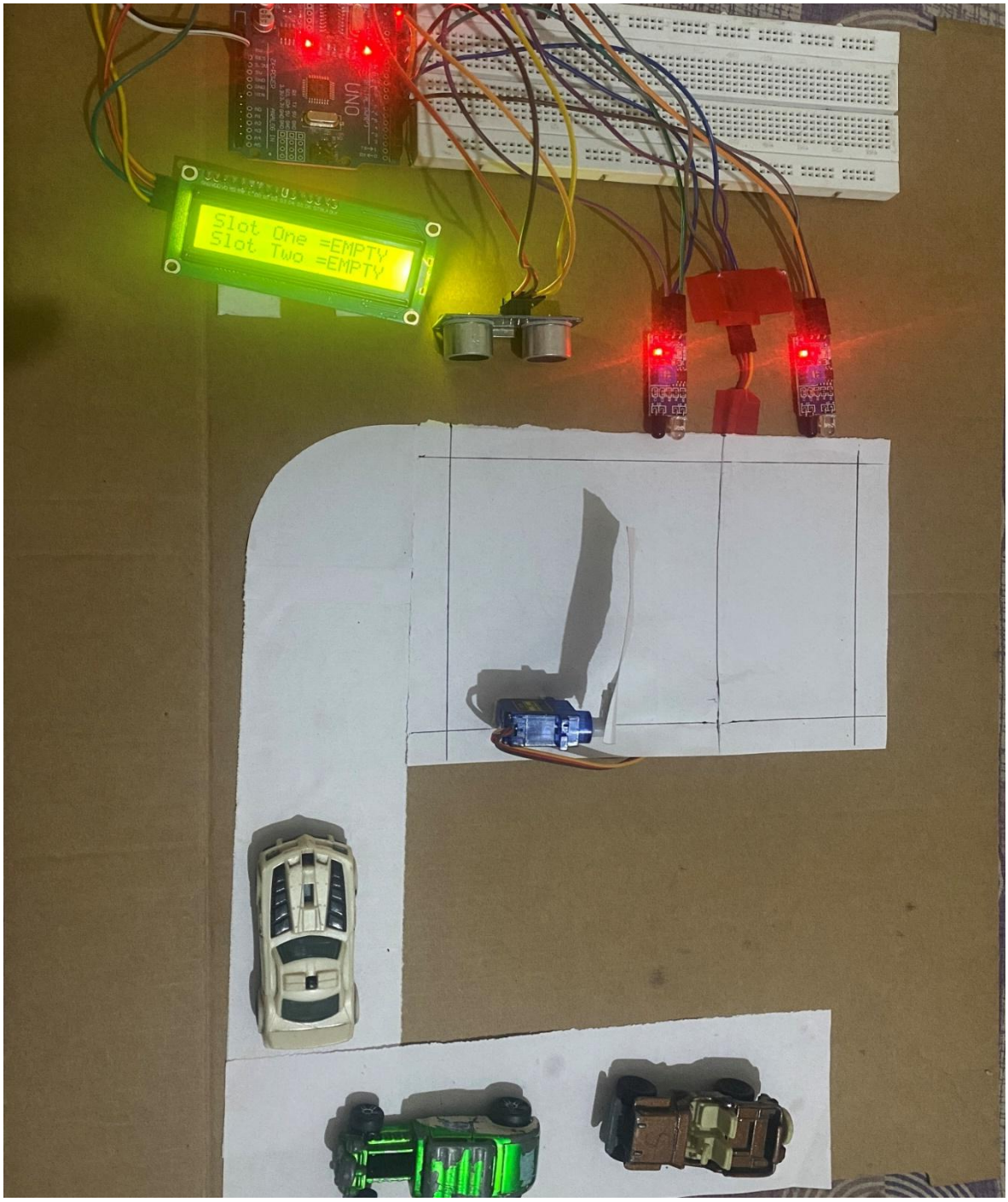

Figure 9.1: Both Slots Are Empty

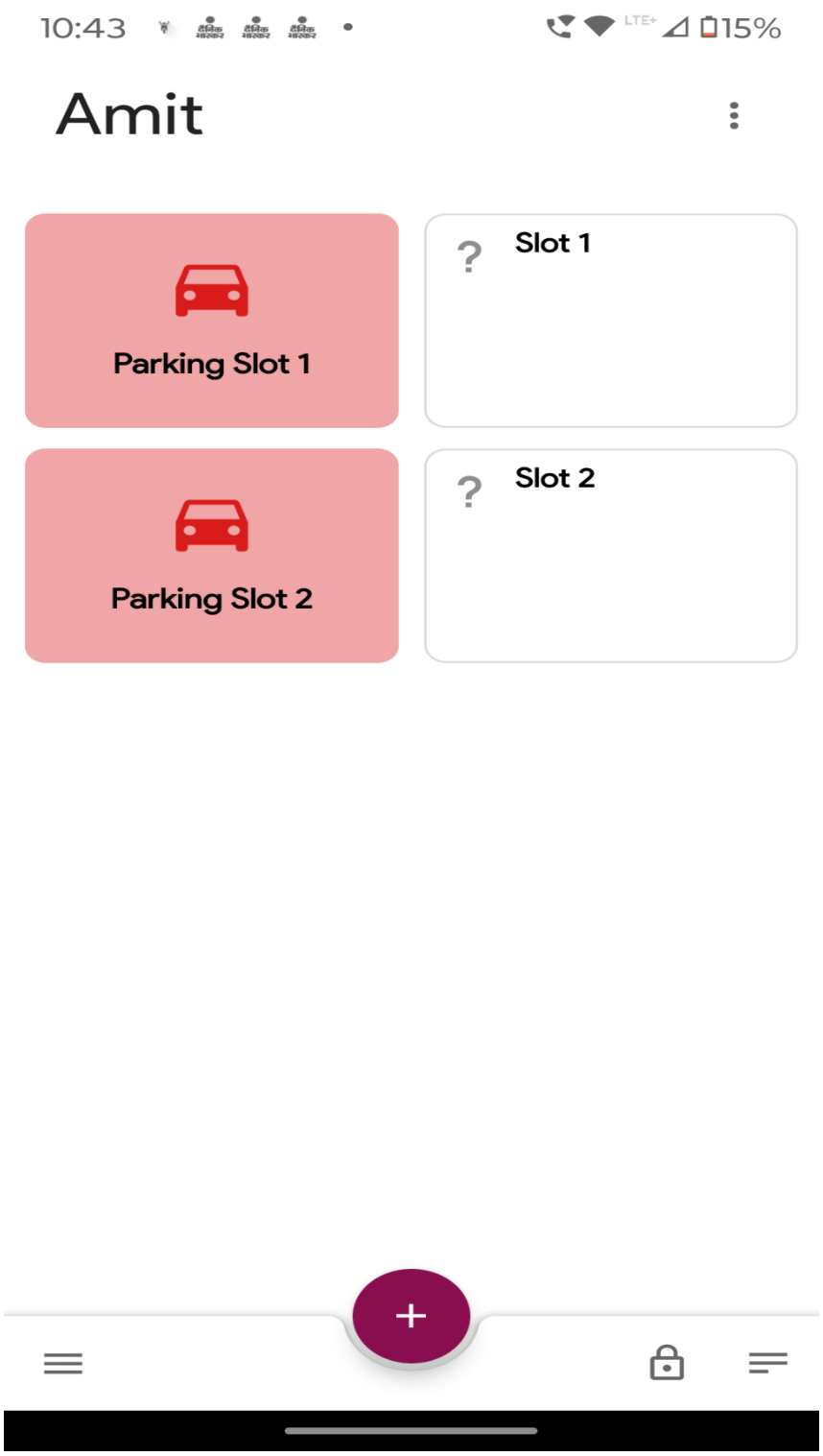

Figure 9.2: Both Slots Empty Showing On Mobile App

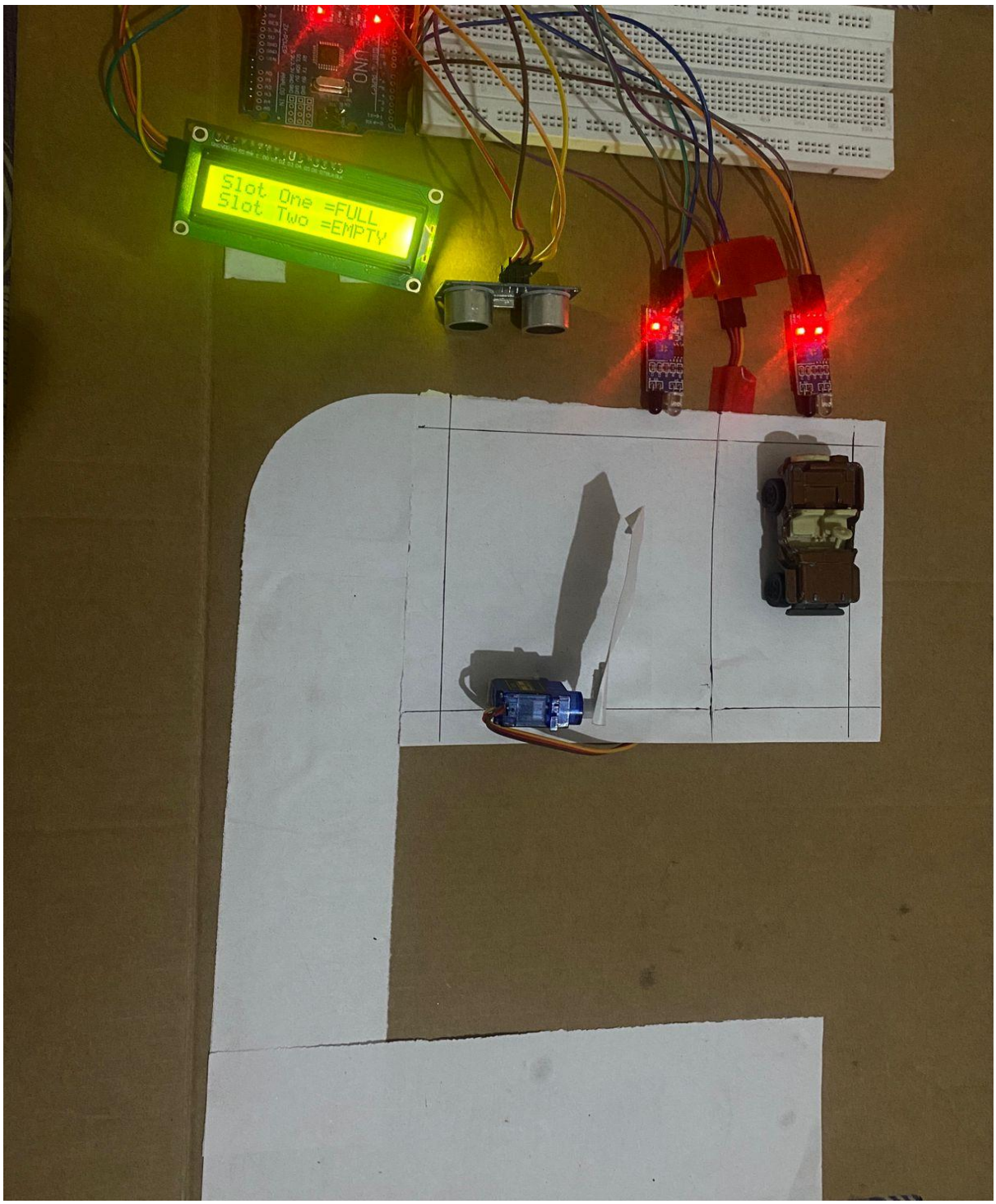

Figure 9.3: Slot 1 Full & Slot 2 Empty

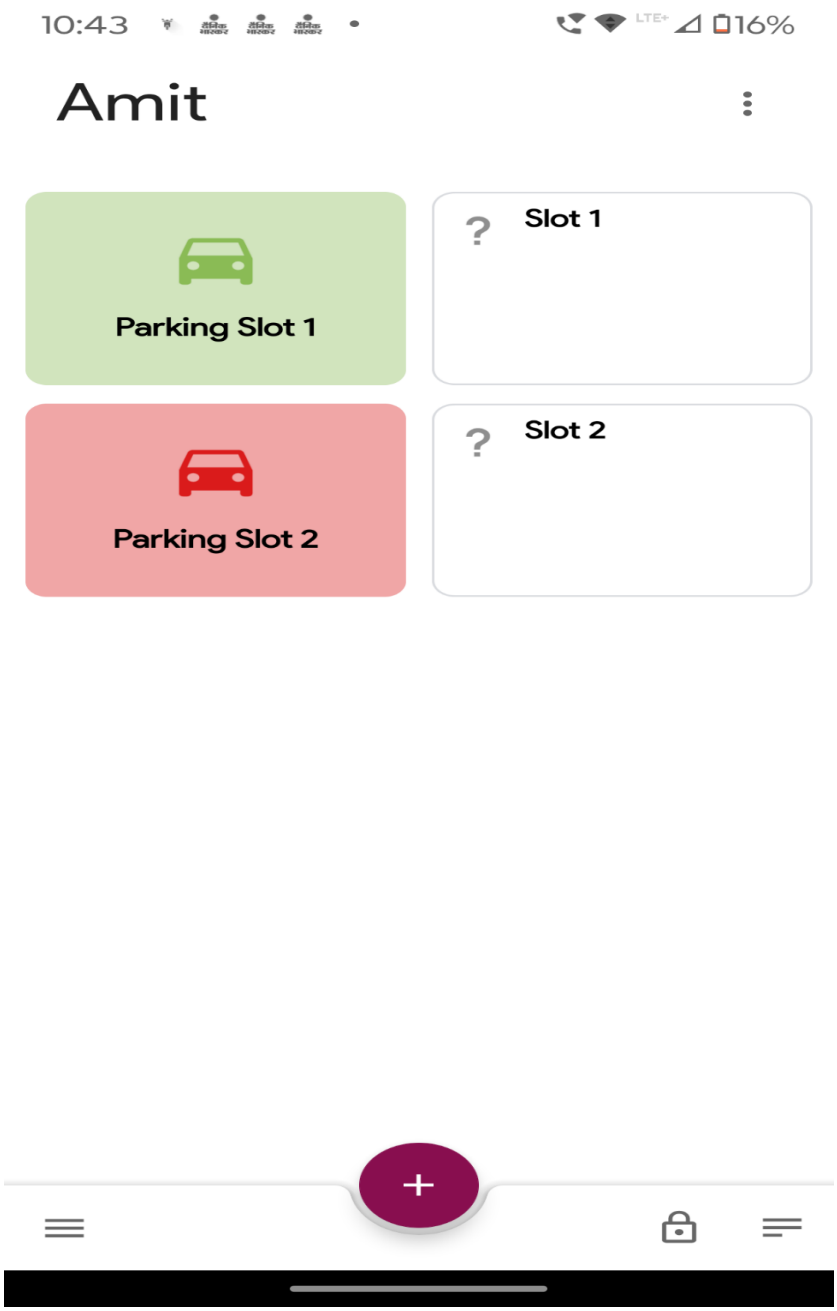

Figure 9.4: Slot 1 Full & Slot 2 Empty Showing On Mobile App

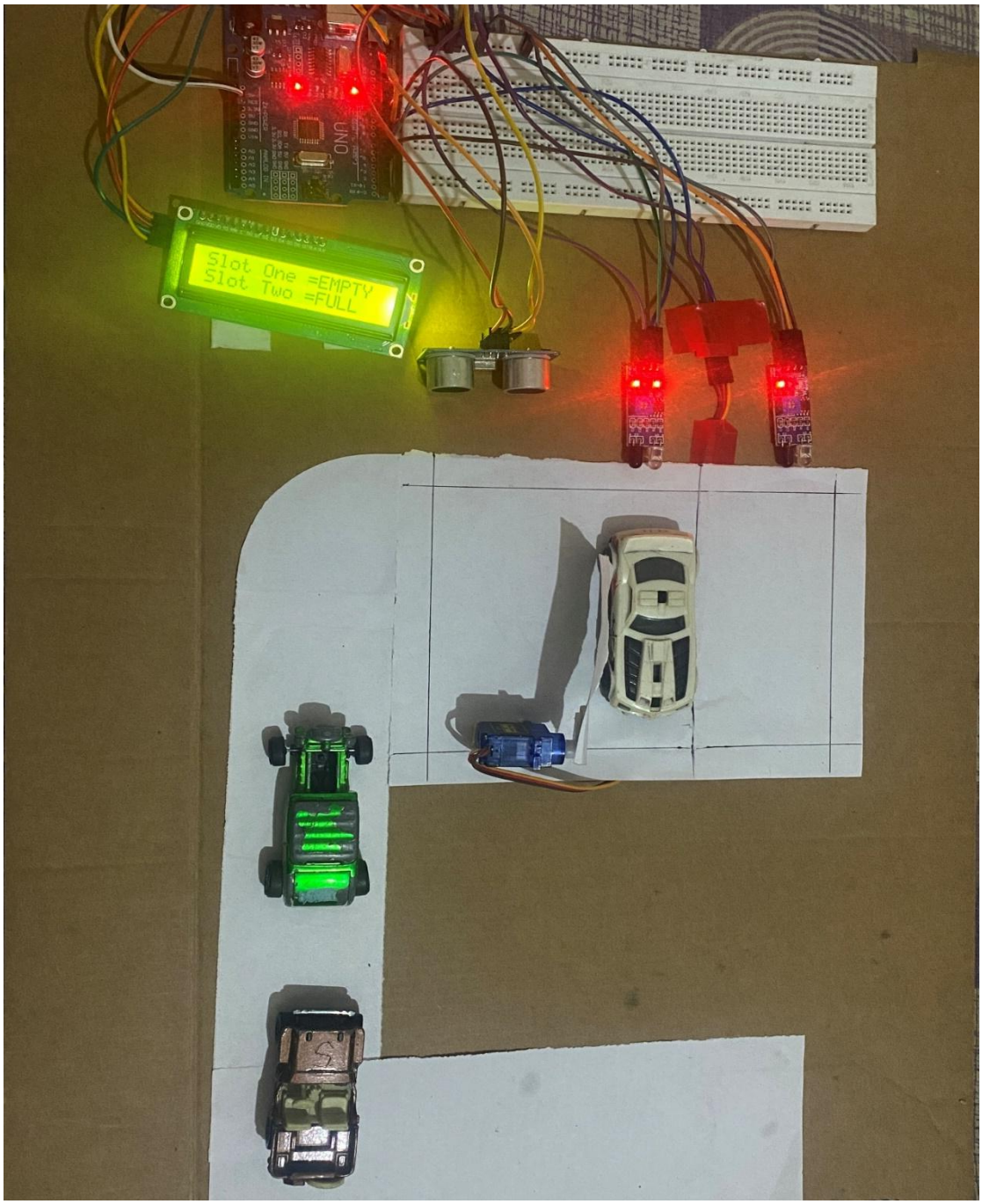

Figure 9.5: Slot 1 Empty & Slot 2 Full

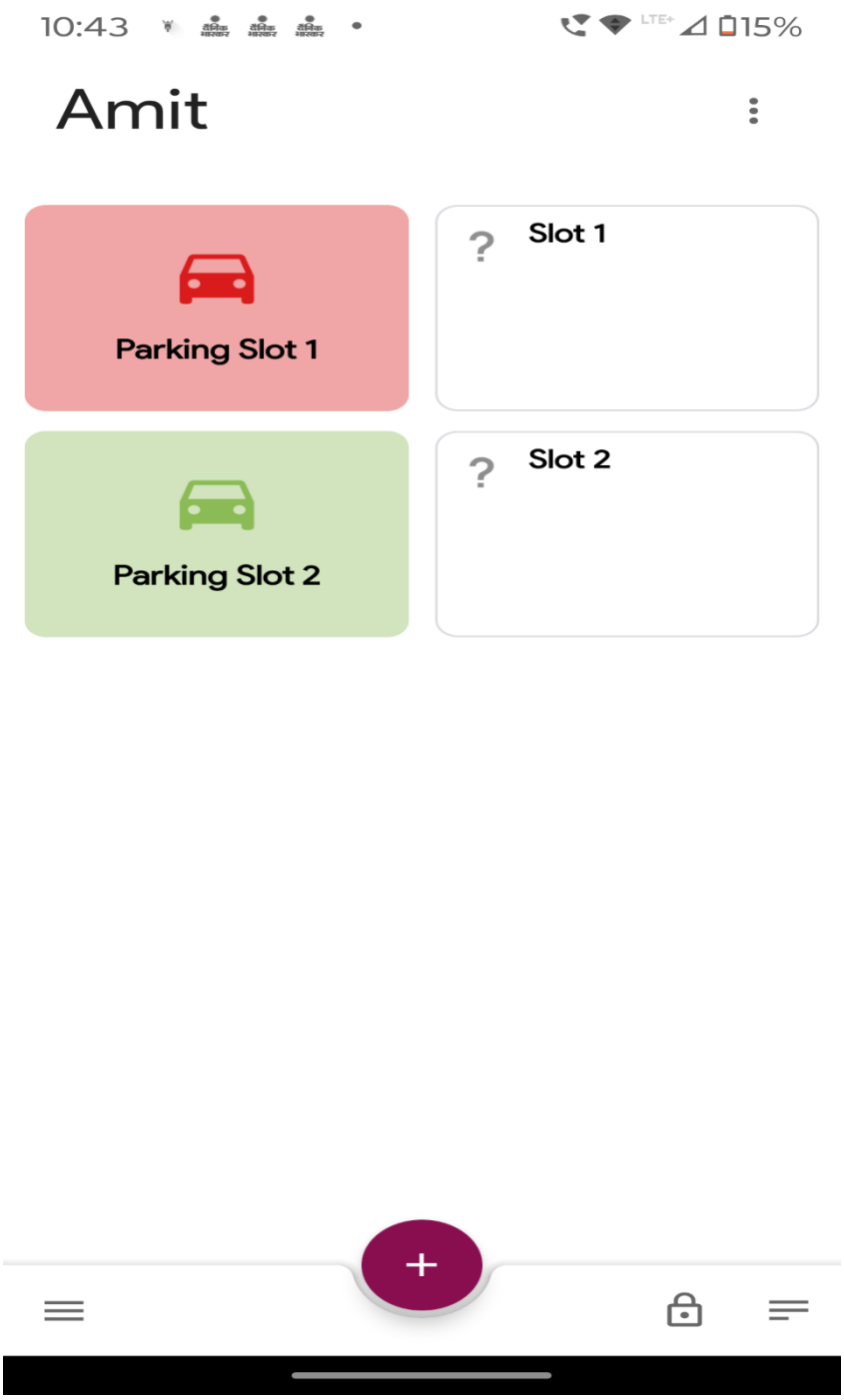

Figure 9.6: Slot 1 Empty & Slot 2 Full Showing On Mobile App

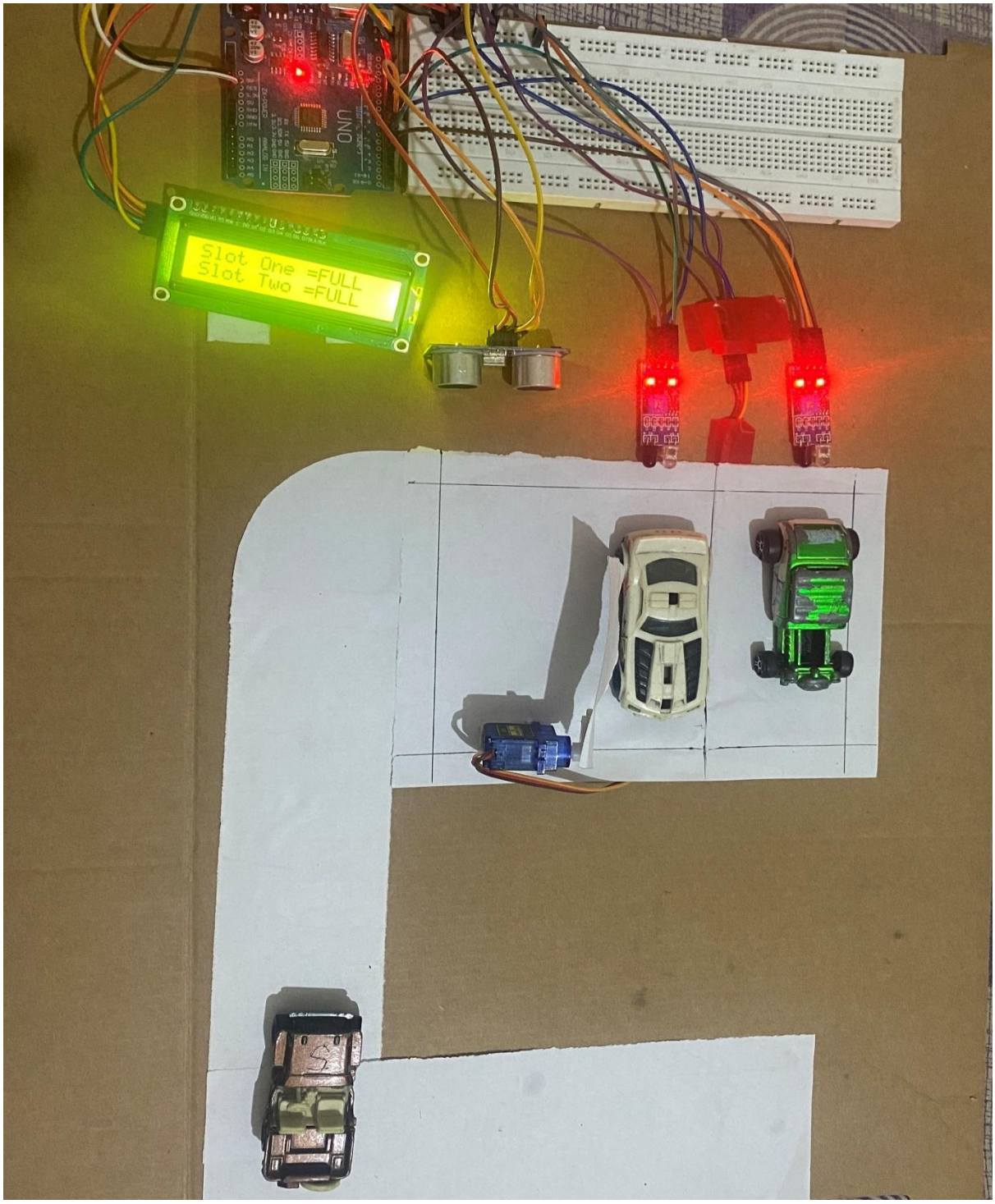

Figure 9.7: Both Slots Full

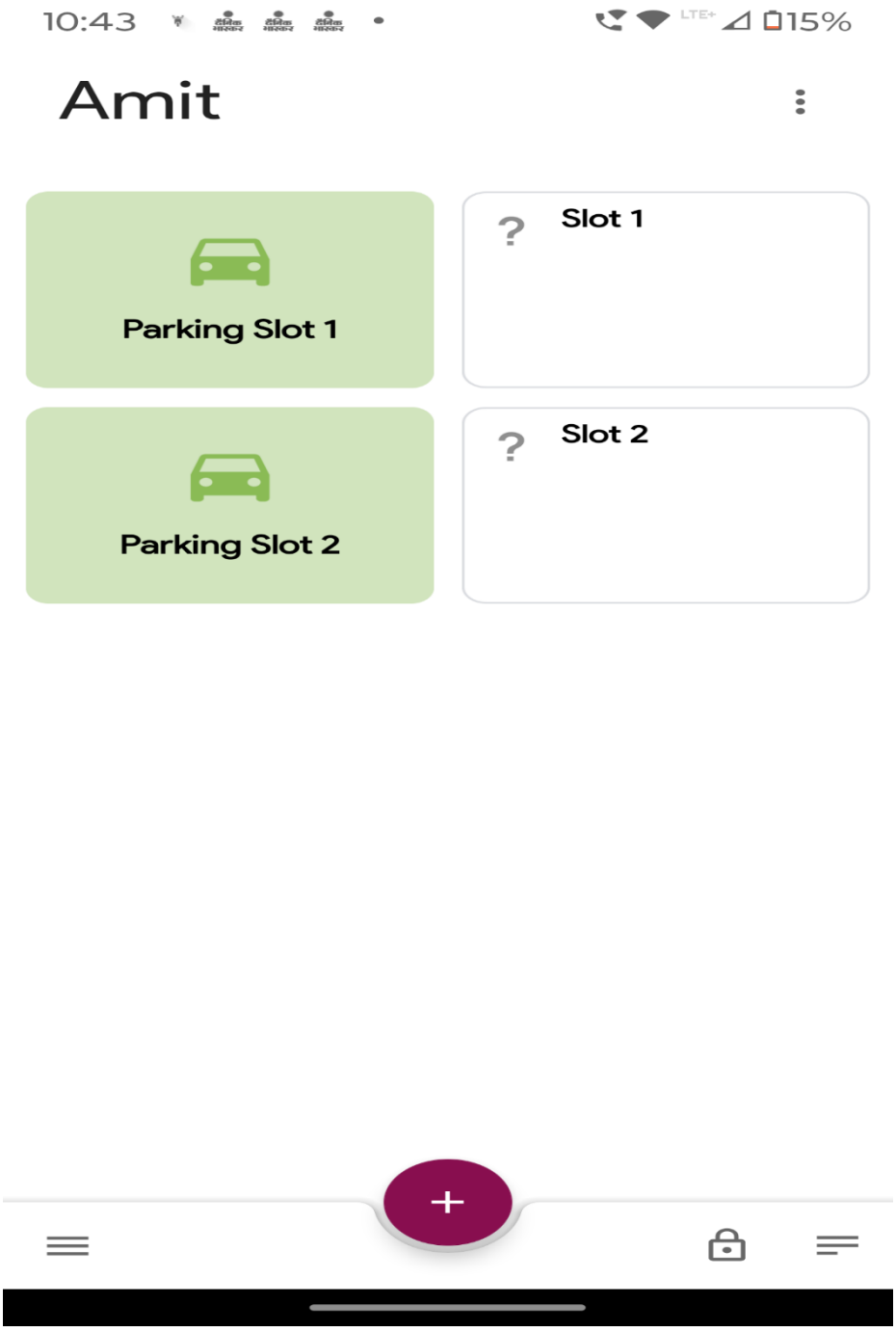

Figure 9.8: Both Slots Full Showing On Mobile App

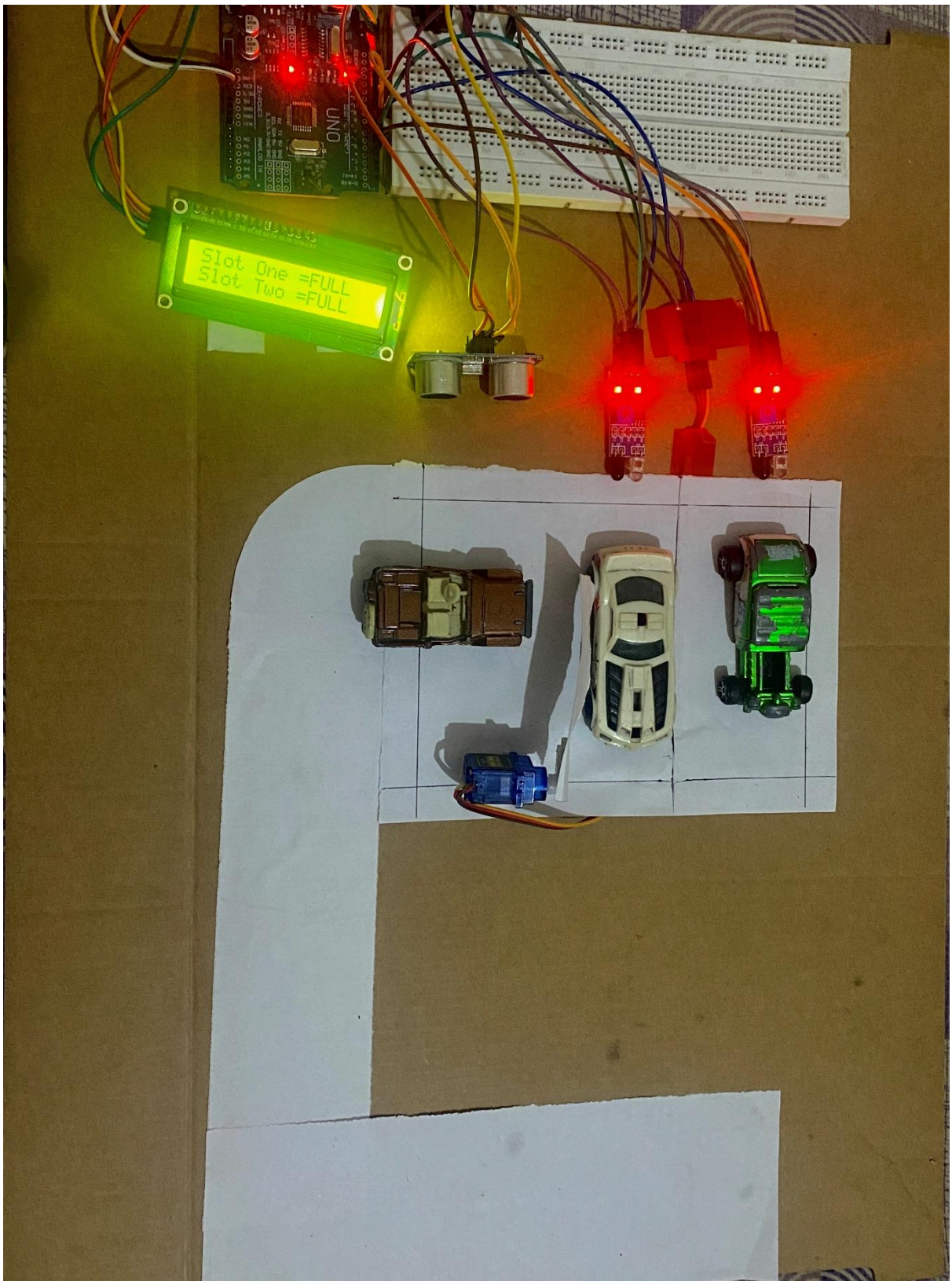

Figure 9.9: Parking Gate Not Opening Due To Both Slots Are Full

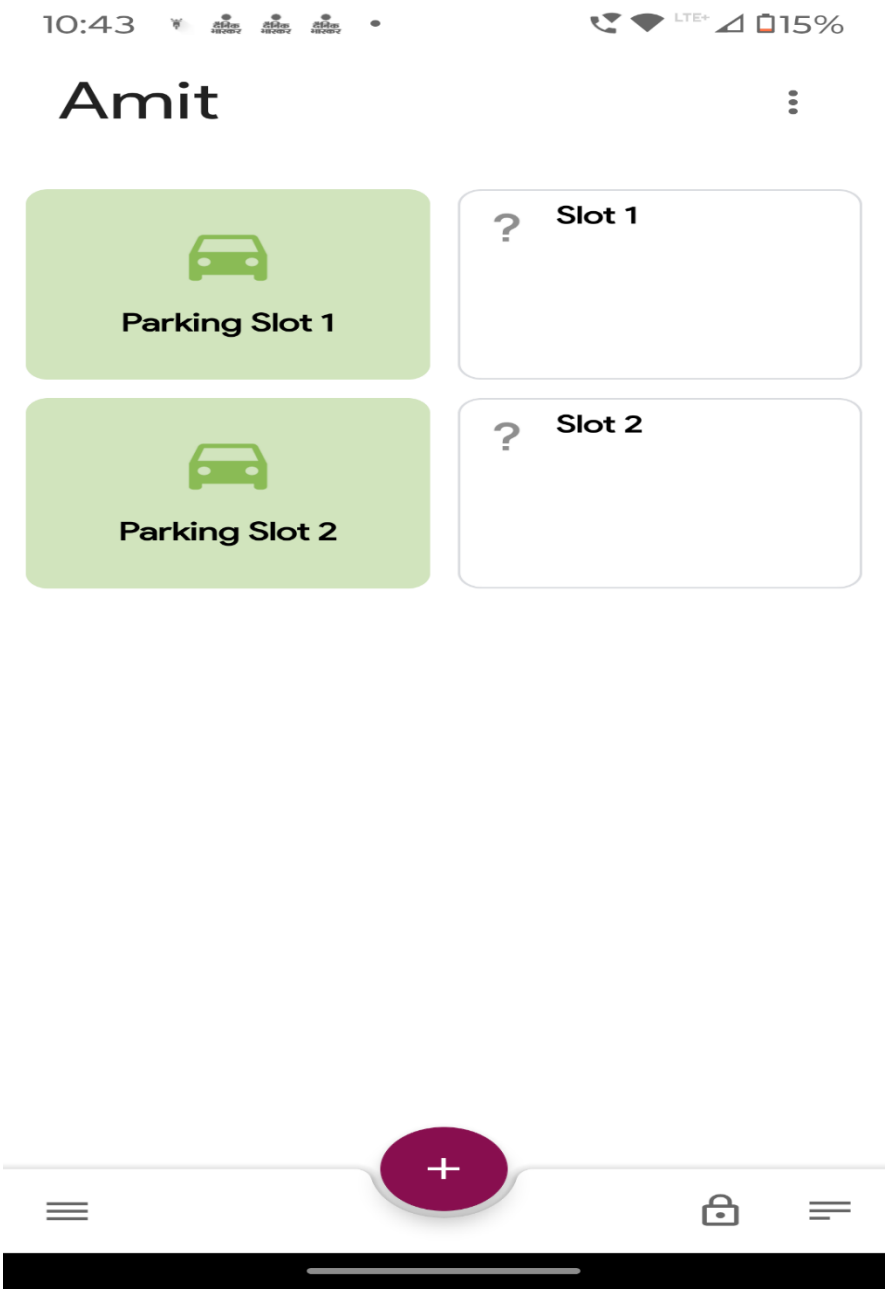

Figure 9.10: Both Slots Showing Full

CHAPTER 10
CONCLUSION AND FUTURE WORK

10.1 CONCLUSION

Our project detects the empty slots and helps the drivers to find parking space in unfamiliar city. The average waiting time of users for parking their vehicles is effectively reduced in this system. The optimal solution is provided by the proposed system, where most of the vehicles find a free parking space successfully. Our preliminary test results show that the performance of the Arduino UNO based system can effectively satisfy the needs and requirements of existing car parking hassles thereby minimizing the time consumed to find vacant parking lot and real time information rendering. This smart parking system provides better performance, low cost and efficient large scale parking system. When car enters the parking area, the driver will park the car in the nearest empty slot when slot is occupied the LED light glows and when slot is empty LED lights are turned off chromatically indicating that the parking slot is empty to be occupied. It also eliminates unnecessary travelling of vehicles across the filled parking slots in a city. Smart Parking solutions are designed to provide drivers an ultimate solution on their journey from the beginning to end without searching for parking, cost, travel time etc. This advantage comes by paying marginal fees to the smart parking service providers. To change a culture which has been existing for several centuries is a humongous task. Parking has always been an at the moment affair with direct cash exchange. The inclusion of technology in this method is a change in culture which will take the time to establish. Smart Parking is one of the most adopted and fastest growing smart city solutions across the world. Airports, universities, shopping centers and city garages are just a few entities that have begun to realize the significant benefits of automated parking technology.

In this study, the various types of smart parking system and has been presented. From the various examples of the implementation of the smart parking system being presented, its efficiency in alleviating the traffic problem that arises especially in the city area where traffic congestion and the insufficient parking spaces are undeniable. It does so by directing patrons and optimizing the use of parking spaces. With the study on all the sensor technologies used in detecting vehicles, which are one of the most crucial parts of the smart parking system, the pros and cons of each sensor technologies can be analyzed. Although, there are certain disadvantages in the implementation of visual based system in vehicle detection as described earlier, the advantages far outweigh its disadvantages.

10.2 FUTURE WORK

In some of the parking areas are lacking such facilities and hence fail all the security norms necessary to park a vehicle. By looking such a huge concern, it is highly required that each and every parking area should be well equipped with high tech parking control systems, that nevertheless lasts the best. These innovative parking control systems not only make a bright choice but also allow you to pay the right price without getting any worry. parking control system has been generated in such a way that it is filled with many secure devices such as barricades, swing gates, slide gates, parking control gates, toll gates, time and attendance machine, car counting system etc. These features are hereby very necessary nowadays to secure your car and also to evaluate the fee structure for every vehicle's entry and exit. Nowadays parking is very important and hence it is necessary for every vehicle owner to park his or her car in a secure designated parking slot available. To escalate this particular system various parking owners have integrated themselves with sophisticated parking control systems, which are high tech and offers full-fledged parking services.

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WEBSITES

1. https://www.hivemq.com/mqtt-essentials/

2. https://docs.arduino.cc/hardware/uno-rev3/

PROJECT SUMMARY

About Project

Title of the project	Car Parking System using Arduino uno
Semester	8th
Members	4 members
Team Leader	Ashutosh Rathore
Describe role of every member in the project	Aman Raj (Coding) Abhishek Lodhi (Reference, Presentation) Dipesh Amode. (Documentation) Bharat Pal (Model Creation)
What is the motivation for selecting this project?	This project addresses the rising demand for efficient parking systems in congested urban areas. It aims to reduce time wastage and traffic by providing real-time parking updates using IoT. Automating parking processes improves space utilization and user convenience. The solution is scalable, cost-effective, and aligns with smart city goals.
Project Type (Desktop Application, Web Application, Mobile App, Web)	IoT-based Embedded System Application

Tools &Technologies

Programming language used	C++
Compiler used (with version)	Arduino Uno
IDE used (with version)	Arduino IDE
Front End Technologies (with version, wherever Applicable)	
Back End Technologies (with version, wherever applicable)	
Database used (with version)	

Software Design& Coding

Is prototype of the software developed?	Yes
SDLC model followed (Waterfall, Agile, Spiral etc.)	Waterfall
Why above SDLC model is followed?	The Waterfall Model is chosen because the project has well-defined requirements and follows a sequential process. It ensures proper integration of hardware and software components by completing each phase before moving to the next. This approach minimizes risks and provides clarity at every stage.
Justify that the SDLC model mentioned above is followed in the project.	The Waterfall SDLC model is followed as the project progresses through defined, sequential phases. Each phase, from **requirements** to **design** and **implementation**, is completed before moving to the next. This approach suits the project's clear objectives and ensures systematic development with minimal changes.
Software Design approach followed (Functional or Object Oriented)	The **Object-Oriented Design (OOD)** approach is followed, organizing the system into objects representing entities like sensors and controllers. This ensures modularity, reusability, and efficient interaction between components while maintaining scalability.
Name the diagrams developed (According to the Design approach followed)	Use Case Diagram, Data Flow Diagram, Circuit Diagram, Architecture Diagram
In case Object Oriented approach is followed, which of the OOPS principles are covered in design?	
No. of Tiers (example 3-tier)	1
Total no. of front-end pages	1
Total no. of tables in database	
Database in which Normal Form?	
Are the entries in database encrypted?	
Front end validations applied (Yes / No)	No
Session management done (in case of web applications)	
Is application browser compatible (in case of web applications)	
Exception handling done (Yes / No)	No

Commenting done in code (Yes / No)	Yes
Naming convention followed (Yes / No)	
What difficulties faced during deployment of project?	Connection of ESP8266-01 Wi-Fi module
Total no. of Use-cases	
Give titles of Use-cases	

Project Requirements

MVC architecture followed (Yes / No)	No
If yes, write the name of MVC architecture followed (MVC-1, MVC-2)	
Design Pattern used (Yes / No)	
If yes, write the name of Design Pattern used	
Interface type (CLI / GUI)	
No. of Actors	2
Name of Actors	User 1, User 2
Total no. of Functional Requirements	6
List few important non-Functional Requirements	Reliability, Usability, Scalability, Security, Maintainability, Availability

Testing

Which testing is performed? (Manual or Automation)	Yes
Is Beta testing done for this project?	Yes

Write project narrative covering above mentioned points

The project uses a **1-tier architecture**, consisting of a **Frontend (Client-side)**. The **Frontend**, through the **MQTT dashboard** or mobile app, provides real-time updates on parking space availability and allows users to interact with the system. It communicates with the backend via the MQTT protocol.

This architecture offers a clear division of responsibilities, with the frontend focused on user interaction and the backend handling sensor processing and hardware control. It ensures an efficient, scalable, and easy-to-maintain system suitable for smart parking management.

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GLOSSARY OF TERMS

APPENDIX-1

A

Arduino IDE The Arduino IDE is an opensource program for writing and uploading code to Arduino boards. The IDE program is compatible with a variety of operating systems, including Windows, Mac OS X, and Linux. C and C++ are supported programming languages. IDE stands for Integrated Development Environment in this case. Sketching refers to the process of writing a program or code in the Arduino IDE. To upload the sketch written in the Arduino IDE software, we must connect the Genuine and Arduino boards to the IDE. The '.ino' extension is used to save the sketches.

Arduino Library The Library is considered as the advanced feature, which extends the capabilities of the Arduino IDE. It means that the libraries provide extra functionality to the programming platform of Arduino. The libraries in Arduino are written in C or C++ These libraries allow us to manipulate data and work with the hardware. To implement any Library in the Arduino IDE, go to the Sketch -> Import Library. There are several libraries available for download. We can also create our own library.

S

Servo-Motor A servomotor 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. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors.

Schematic Capture Schematic capture or schematic entry is a step in the design cycle of electronic design automation (EDA) at which the electronic diagram, or electronic schematic of the designed electronic circuit is created by a designer. This is done interactively with the help of a schematic capture tool also known as schematic capture.

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