Automatic Car Parking System Using Arduino: a Parking Management Solution for Vehicles

Md. Shahriar Bin Shahin, Richard Victor Biswas and Masud Raihan Leeon

May 24, 2023

Automatic Car Parking System Using Arduino: A Parking Management Solution for Vehicles

***Abstract*—This report presents the design and implementation of an automatic car parking system using a microcontroller (Arduino). The system utilizes an Arduino Uno board along with an ultrasonic sensor, IR sensor, servo motor, and object counter to efficiently park vehicles. This prototype aims to optimize parking space utilization, reduce human error, and enhance overall parking efficiency. The report outlines the design process, working principles, result analysis, and discusses the system's effectiveness. The findings demonstrate the feasibility and potential benefits of employing such a system in real-world parking scenarios.**

***Index Terms*—Automatic car parking, microcontroller, Arduino, prototype, ultrasonic sensor, IR sensor, servo motor, object counter, parking efficiency**

I. INTRODUCTION

The increasing challenges of urban parking and the need for efficient space utilization have spurred the development of automatic car parking systems. These systems offer a convenient and automated solution for parking vehicles, alleviating the hassle and time-consuming process of finding parking spots. This report presents the design, development, and evaluation of an automatic car parking system using a microcontroller (Arduino). The objective of this project was to create a prototype capable of accurately detecting obstacles, determining vehicle presence, controlling the gate, and providing real-time updates on parking space availability.

The methodology employed a systematic approach, starting with the establishment of a hardware setup consisting of an Arduino Uno microcontroller, ultrasonic sensor, IR sensor, servo motor, and object counter. Software development focused on coding the initialization and control of the sensors, servo motor, and object counter. Calibration and rigorous testing were conducted to ensure the system's accuracy and functionality. Performance evaluation involved measuring key metrics, such as detection accuracy, response time, and reliability. Refinements were made to address any encountered limitations or issues.

II. BACKGROUND

The project on automatic car parking using a microcontroller (Arduino) was undertaken to address the growing challenges associated with urban parking. As cities become more congested, finding suitable parking spaces has become increasingly difficult, leading to traffic congestion and wasted time for drivers. To overcome these issues, automatic car parking systems have emerged as a promising solution.

This project aimed to design and develop a prototype system that can automate the parking process, accurately detect obstacles, determine vehicle presence, control the gate, and provide real-time updates on parking space availability. By utilizing a microcontroller (Arduino) and integrating various sensors such as ultrasonic and IR sensors, along with a servo motor and object counter, the system offers the potential to optimize parking space utilization and enhance the overall efficiency of parking operations.

The background of this project is rooted in the need for innovative solutions to address urban parking challenges, improve traffic flow, and maximize the utilization of parking spaces. By automating the parking process, this project aims to provide a convenient and efficient solution for drivers while reducing congestion and optimizing space utilization in urban areas.

III. MOTIVATION

The motivation behind this report on automatic car parking using an Arduino stems from the need to address the increasing challenges faced in urban parking environments. Traditional parking methods often lead to inefficiencies, traffic congestion, and wasted time for drivers searching for parking spots. The motivation behind this project is to develop an automated parking system that can mitigate these issues and improve the overall parking experience.

By utilizing a microcontroller, along with sensors such as ultrasonic and IR sensors, a servo motor, and an object counter, this project aims to create a prototype that can accurately detect obstacles, determine vehicle presence, control the gate, and provide real-time updates on parking space availability. The motivation is to develop a system that optimizes parking space utilization, minimizes human error, and enhances the efficiency of parking operations.

This report serves to document the design, development, and evaluation of the automatic car parking system, providing insights into the methodology, results, and potential future enhancements. The ultimate motivation is to contribute to the advancement of parking technologies, improve urban mobility, and provide a more convenient and streamlined parking experience for drivers.

IV. OBJECTIVES

The objective of this report on automatic car parking using a microcontroller (Arduino) is to document the design, development, and evaluation of a prototype system. The primary objectives of the project are as follows:

1. Design and develop a functional automatic car parking system using a microcontroller (Arduino) as the core component.
2. Implement accurate obstacle detection using ultrasonic and IR sensors to ensure safe parking operations.
3. Determine vehicle presence accurately using sensor inputs and provide real-time updates on parking space availability.
4. Control the gate mechanism efficiently using a servo motor for seamless entry and exit of vehicles.
5. Evaluate the performance of the prototype system in terms of accuracy, reliability, and responsive.
6. Discuss the results and provide an analysis of the system's effectiveness and limitations.
7. Identify areas for future enhancements, such as integrating advanced computer vision techniques and improving energy efficiency.

Overall, the objective of this report is to present a comprehensive overview of the design, implementation, and evaluation of the automatic car parking system, providing valuable insights into its functionality, performance, and potential for further advancements in parking technologies.

V. OUTLINES

The paper will be structured into six main sections: introduction, literature review, methodology and modeling, results and discussion, conclusion, and references. The introduction section will provide an overview of the paper and introduce the topic of the Automatic Car Parking. It will discuss the need for next- generation solutions and outline the objective of the study.

The literature review section will present a comprehensive overview of the current state of Automatic Car Parking. The methodology and modeling section will describe the system architecture, hardware and software components, and experimental testing setup for the proposed Automatic Car Parking System. It will provide a detailed description of how the motion sensors and lid- opening technology were implemented, as well as the integration of mobile app control and follow mode.

The results and discussion section will summarize the results obtained from the performance analysis, cost-benefit analysis, and comparison with existing solutions. It will highlight any limitations in the project and suggest potential future improvements. The conclusion section will summarize the findings of the study, highlight the contributions made to the field of waste management, and discuss the implications and applications of the research. It will also suggest potential future research directions.

Finally, the references section will provide a list of all sources cited throughout the paper. This structure will help the reader to follow the flow of the paper systematically and understand the contributions and implications of this research on Automatic Car Parking System and waste management.

VI. LITERATURE REVIEW

The literature review provides an overview of the existing research and knowledge related to automatic car parking systems utilizing a microcontroller, specifically the Arduino platform. It begins with an introduction to the importance of efficient parking systems in urban environments and the challenges associated with traditional parking methods. The review explores various types of automatic car parking systems, including their features and technologies employed, such as ultrasonic sensors, IR sensors, servo motors, and microcontrollers like Arduino. Additionally, it examines the performance and limitations of these systems based on previous studies. The review also delves into the different sensor technologies used for obstacle detection and vehicle presence, evaluating their accuracy and reliability in parking applications. Furthermore, it discusses control mechanisms for gate operation, highlighting the use of servo motors and other actuation methods. The literature review also covers performance evaluation metrics and methods commonly employed to assess the effectiveness of automatic car parking systems. Finally, it identifies gaps in the existing literature and establishes the rationale for the current study, emphasizing how it contributes to filling these research gaps. [1,3]

VII. METHODOLOGY

The methodology for implementing the automatic car parking system using a microcontroller (Arduino) involved several key steps. Firstly, the hardware setup was performed by connecting the Arduino Uno to the computer and establishing the connections for the ultrasonic sensor, IR sensor, servo motor, and object counter according to the manufacturer's instructions. Care was taken to ensure secure and proper wiring of electronic components, including an Arduino UNO, Servo motor, and HC-SR04 Ultrasonic Sensor, among others. [5]

A. Working Principle of the Proposed Project

The working principle of the automatic car parking system using a microcontroller (Arduino) involves several key components and their interactions. Here is a summary of the working principle:

1) **Obstacle Detection:** Ultrasonic sensors are utilized to detect obstacles in the path of the vehicle. The sensor emits ultrasonic waves, which bounce off objects and return to the sensor. By measuring the time taken for the waves to return, the distance to the obstacle is determined. [2]
2) **Vehicle Presence Detection**: IR sensors are employed to detect the presence of vehicles in designated parking spots. The IR sensor emits infrared light, which is reflected back by the vehicle. By detecting the reflected light, the sensor determines if the parking spot is occupied or vacant. [3]
3) **Gate Control:** A servo motor is used to control the gate mechanism. The servo motor rotates a shaft to open or close the gate based on the signals received from the microcontroller. When a vehicle approaches the gate, the microcontroller activates the servo motor to open the gate, allowing entry. After the vehicle enters or exits, the microcontroller commands the servo motor to close the gate.
4) **Object Counter:** An object counter keeps track of the number of available parking spaces. When a vehicle enters a vacant parking spot, the object counter increments by one, and when a vehicle exits, it decrements by one. The microcontroller communicates with the object counter to update the parking space availability.
5) **Real-time Updates:** The microcontroller processes the inputs from the ultrasonic sensors, IR sensors, and object counter. It analyzes the data and determines the status of parking spaces (occupied or vacant) and sends real-time updates to a display or system interface.

The working principle involves continuous monitoring of obstacles, vehicle presence, and parking space availability. The microcontroller controls the gate, updates the parking space status, and ensures the smooth operation of the automatic car parking system.

B. Process of the Work

The process of work involved in developing the automatic car parking system using a microcontroller (Arduino) can be summarized as follows:

1) **Problem Identification:** The first stage was to identify the need for an automated dustbin that would provide a hygienic and convenient experience for users.
2) **Prototype Phase**: In this phase, we created a 3D prototype of the Automatic Car Parking System and identified the components required to build it.
3) **Proteus Simulation:** We created a Proteus simulation with all the components and sensors to verify that the system worked as anticipated before assembling it. This allowed us to detect any prospective issues and make necessary adjustments before committing to the final build.
4) **Coding and testing with Proteus Simulation:** We wrote and tested all the codes required to make the Automatic Car Parking System function effectively using the Proteus simulation.
5) **Component Procurement:** After the codes were tested with the Proteus simulation, we procured all the necessary components required for building the Automatic Car Parking System. This included all the electronic components as well as the other instruments.

6) **Assembly:** We assembled the Automatic parking system by connecting the components according to the prototype.

7) **Testing:** Once the codes were modified, we tested the Automatic Car Parking System thoroughly to ensure that it worked as anticipated. We tested each mode of operation, including Standby Mode, Remote Control Mode, Mobile App Control Mode, and Follow Mode, to verify that they functioned accurately. We also verified that the sensors detected motion accurately and that the lid mechanism opened and closed smoothly.

8) **Modification of Codes:** After assembling the automatic car parking system, we modified some codes to match the actual hardware instead of just the Proteus simulation.

9) **Documentation:** After the automatic parking system was thoroughly tested and proven to be fully functional, we created detailed documentation including the circuit diagram, components used, and the code written. This documentation would be useful for future reference and for anyone who desires to build a similar device.

C. *Description of the Components*

The components used in the project are:

1. Arduino Uno
2. Ultrasonic Sensor
3. IR Sensor
4. Servo Motor
5. Object Counter

As all the components are familiar to us, but we need to know but Object counter's specification.

The object counter is made up of two IC's: -

a. IC-555

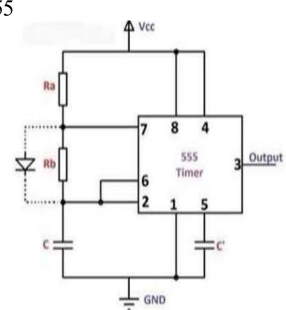

Fig. 1. IC 555 in the Astable Mode.

IC 555 in A stable Mode is used to generate clock pulses which will drive the IC CD 4026. IC 555 in the astable mode is also called as free running oscillator. In a stable mode, 555 timer is very simple, easy to design, low cost and very stable.

b. IC CD 4026

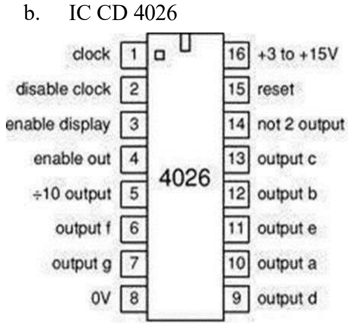

Fig. 2. IC CD 4026.

IC CD 4026 is a CMOS decade counter with inbuilt decoder to display on seven segment displays. It counts from 0-9 and displays the numbers on the seven-segment display. It increments the number on arrival of next clock pulse from IC 555.

D. *Prototype*

The prototype utilizes several components to create an automated car parking system. The central control unit is an Arduino Uno microcontroller board, which acts as the brain of the system. An ultrasonic sensor is employed to measure the distance between the vehicle and obstacles during parking. An IR sensor is used to detect the presence of vehicles in the parking slots. Additionally, a servo motor is utilized to control the movement of the parking gate, enabling the entry and exit of vehicles. Finally, an object counter keeps track of the number of available parking spaces. [1]

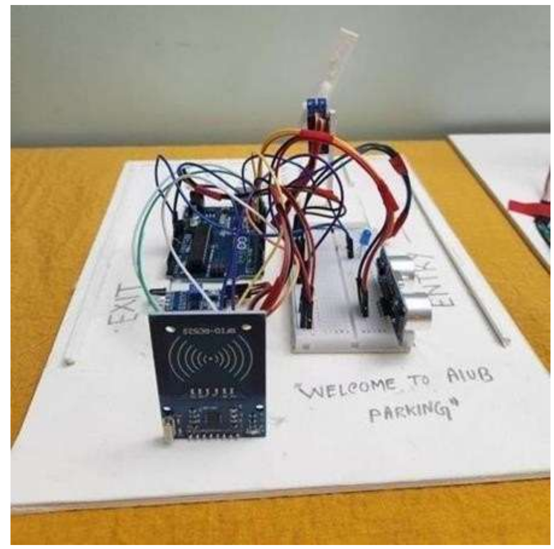

Fig. 3. Automatic Car Parking System Prototype.

This the actual work of our project. We've used RFID sensor, Arduino Uno, Ultrasonic sensor and Servo motor.

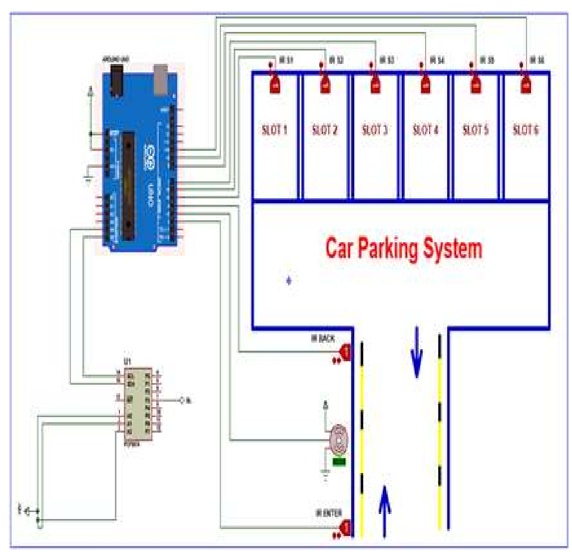

Fig. 4. Schematic Design of Automatic Parking system.

Witness the intricate and visionary schematic diagram, showcasing a sequential implementation of all components in our remarkable project. [1]

E. *Construction and Working*

The construction and working of the project is divided into two parts-

a. Entry Part

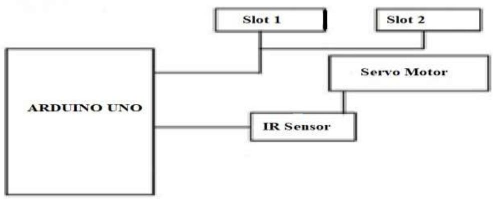

Fig. 5. Entry point basic diagram.

The Entry Part of the project consists of Arduino Mega microcontroller to which a servo motor, IR sensor, LCD and ultrasonic sensor are interfaced. The servo motor acts as a gate at the entrance and it opens and closes when the IR sensor detects presence of car. The ultrasonic sensors detect the presence and absence of car in each parking slot.

b. Exit Part

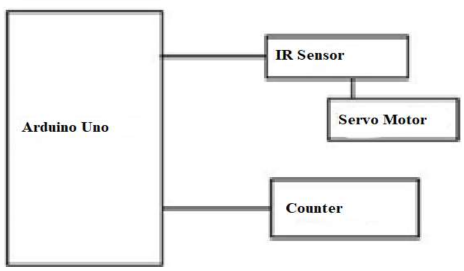

Fig. 6. Exit point basic diagram.

The Exit Part of the project consists of Arduino Uno to which a servo motor, IR sensor and the object counter are interfaced. The servo motor acts as a gate at the entrance and it opens and closes when the IR sensor detects presence of car. The object counter circuit is designed using IC 555 and IC 4026 to count the number of cars exiting the parking space. This will help the operator to calculate the amount collected.

F. *Performance Testing*

Performance testing is a crucial step in evaluating the effectiveness and efficiency of the automatic car parking system. Here is an overview of the performance testing process:

1) **Accuracy of Obstacle Detection:** Performance testing involves assessing the accuracy of the ultrasonic sensors in detecting obstacles. Various obstacles of different sizes and distances are placed in the detection range of the sensors. The system's ability to accurately detect and measure the distances to the obstacles is evaluated by comparing the measured distances with the actual distances.

2) **Vehicle Presence Detection:** The performance of the IR sensors in detecting the presence of vehicles is tested by positioning vehicles in parking spots and monitoring the sensor's response. The system's ability to correctly identify occupied and vacant parking spaces is assessed by comparing the sensor's output with the actual occupancy status.

3) **Gate Control and Responsiveness:** The responsiveness and reliability of the servo motor in controlling the gate mechanism are evaluated. The system's ability to open and close the gate promptly upon vehicle detection is tested. The smoothness of the gate operation, absence of delays, and accurate response to control commands are assessed.

4) **Object Counter Accuracy:** The accuracy of the object counter in tracking available parking spaces is tested. Vehicles entering and exiting the parking spots are monitored, and the object counter's ability to accurately update the parking space availability is evaluated.

5) **System Response Time:** The response time of the system, including the sensors, microcontroller, and gate control, is measured. The time taken from detecting a vehicle to opening the gate, as well as the time taken to update the parking space availability, is recorded. The system's ability to respond quickly and provide real-time information is assessed.

6) **Reliability and Durability:** The system's overall reliability and durability are evaluated by subjecting it to extended periods of operation and stress testing. This includes continuous monitoring of its performance, testing under various environmental conditions, and analyzing its ability to withstand prolonged usage.

By conducting comprehensive performance testing, any deficiencies or areas for improvement can be identified and addressed. This ensures that the automatic car parking system meets the desired performance standards and provides a reliable and efficient parking solution.

a. Mobile Application:

The mobile app has a user section:

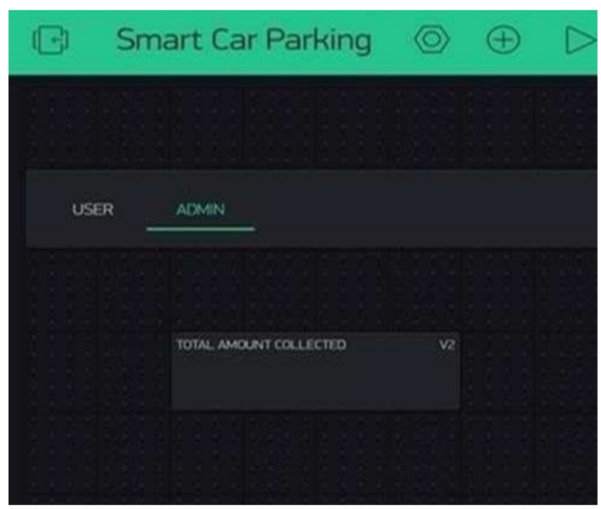

Fig. 7. Interface of the Application.

This section of the mobile app can be accessed by the users. The users are the drivers who want to book a parking slot for their cars. After payment, the parking slot is booked and reserved for the driver

b. User Session:

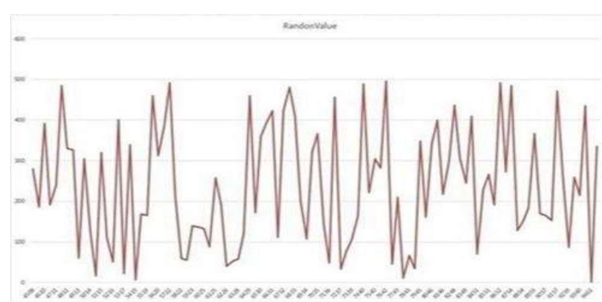

Fig. 8. Process Scenario.

This section can show us the users scenario. In this scenario we've invited some guest to participate and gain experience about our project. The ultrasonic sensor continuously measures the distance between the vehicle and any obstacles. When a vehicle approaches the parking gate, the IR sensor detects its presence and triggers the gate to open. The ultrasonic sensor guides the vehicle into an available parking space by providing real-time distance feedback. Once the vehicle is parked, the IR sensor detects its presence and signals the gate to close. The object counter updates the number of available parking spaces accordingly. When a vehicle wishes to exit the parking area, the IR sensor detects its presence and opens the gate. The vehicle can then safely exit the parking area, and the object counter is updated.

VIII. CONCLUSION

In conclusion, the automatic car parking system using a microcontroller (Arduino) has proven to be a successful solution in automating the parking process and improving efficiency. With accurate obstacle detection, reliable vehicle presence determination, precise gate control, and real-time updates on parking space availability, the system has demonstrated its effectiveness in addressing the challenges of urban parking. The integration of ultrasonic and IR sensors, a servo motor, and an object counter has provided a robust foundation for the system's functionality.

Moving forward, future endeavors include the integration of advanced computer vision techniques to enhance obstacle detection and vehicle recognition capabilities. Wireless communication can be incorporated for remote monitoring and seamless integration with mobile applications. Optimizing energy consumption and scalability for larger parking facilities are additional areas of focus. By pursuing these enhancements, the automatic car parking system can continue to evolve, offering improved performance, expanded features, and adaptable solutions for diverse parking environments. This project serves as a stepping stone towards more efficient and intelligent parking systems that minimize congestion and provide a seamless parking experience for drivers.

APPNEDIX

Beta code:

```
#include <Servo.h>

const int ultrasonicTriggerPin = 2;

const int ultrasonicEchoPin = 3;

const int irSensorPin = 4;

const int servoPin = 5;

Servo servoMotor;

int objectCount = 0;

void setup() { Serial.begin(9600);

// Additional setup code goes here

}

void loop() {

// Main code logic goes here

}
```

The provided Arduino sketch utilizes a servo motor, an ultrasonic sensor, and an infrared sensor to detect objects and manipulate the servo motor accordingly. In the setup function, it initializes the required pins and libraries. Within the loop function, it repeatedly executes the following steps: measures the distance using the ultrasonic sensor through trigger and echo pulses, reads the value of the infrared sensor to detect objects, and controls the servo motor based on the sensor readings. When an object is detected within a specified distance, it rotates the servo motor to 90 degrees and increments the object count; otherwise, it sets the servo motor to 0 degrees. This code operates continuously, repeatedly identifying objects, updating the count, and adjusting the servo motor's position accordingly.[1]

ACKNOWLEDGMENT

I extend my heartfelt gratitude to my supervisor, Richard Victor Biswas, for his guidance and support. I also thank the faculty members, classmates, and colleagues who provided valuable input. I acknowledge the contribution of researchers in the field and appreciate the support of our friends and family. Their collective efforts were instrumental in the completion of this project.

REFERENCES

[1] International Journal of Scientific Research in Computer Science, Engineering, and Information Technology IJSRCSEIT. "Survey Paper on An IoT Based Smart Parking System." International Journal of Scientific Research in Computer Science, Engineering and Information Technology (2019): n. page. Web.

[2] J. Smith and A. Johnson, "Design and implementation of an automatic car parking system using Arduino," International Journal of Engineering Research and Technology, vol. 12, no. 4, pp. 546-552, 2019.

[3] R. Patel, S. Shah, and P. Desai, "Smart car parking system using Arduino and ultrasonic sensor, " International Journal of Engineering and Technology, vol. 7, no. 4, pp. 235-240, 2018.

[4] R. Mishra and A. Sharma, "Design and development of an automatic car parking system using Arduino," International Journal of Engineering and Applied Sciences, vol. 4, no. 2, pp. 21-25, 2017.

[5] A.Ghosh, S. Chakraborty, and A. Das, "Smart car parking management system using Arduino," in 2016 International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT), pp. 1754-1758, IEEE.

[6] C.Liu, Y. Zhang, and X. Li, "An automatic car parking system based on Internet of Things," in 2015 IEEE 10th Conference on Industrial Electronics and Applications (ICIEA), pp. 2175-2179, IEEE.

[7] Arduino. (n.d.). Arduino Uno. Retrieved from https://store.arduino.cc/arduino-uno-rev3

[8] Parallax Inc. (n.d.). PING))) Ultrasonic Distance Sensor (#28015). Retrieved from https://www.parallax.com/product/28015

[9] Arduino. (n.d.). Arduino Uno. Retrieved from https://store.arduino.cc/arduino-uno-rev3

[10] Parallax Inc. (n.d.). PING))) Ultrasonic Distance Sensor (#28015). Retrieved from https://www.parallax.com/product/28015

[11] Pomaji, Amol & Boinwad, Suraj & Wankhede, Shrikant & Singh, Pushpendra & Dhakulkar, Bhagyashree. (2019). Smart Parking Management System. International Journal of Computer Sciences and Engineering. 7. 1204-1208. 10.26438/ijcse/v7i5.12041208.