IoT-BASED SMART GARAGE SYSTEM

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DECLARATION

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Date: 19.07.2023	Date: 19.07.2023	Date: 19.07.2023

CERTIFICATE

It is certified that the work contained in the Continuous Assessment and Mini project (CAMP) titled "**IoT – Based Smart Garage System**," by "Gayatri Sreeraj, bearing Roll No: 21BAI1171" has been carried out under my supervision and that this work has not been submitted elsewhere for a degree. *

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*Note: this statement is mandatory

ABSTRACT

The Smart Garage System presented in this project is an innovative and intelligent solution aimed at revolutionizing the traditional garage experience. Leveraging the power of the Internet of Things (IoT) and Arduino microcontroller technology, the system comprises two essential components: the Smart Parking System and the Smart Lighting System.

The Smart Parking System is designed to streamline the parking process by providing real-time information about parking space availability within the garage. Ultrasonic distance sensors, strategically positioned above each parking spot, detect the presence of vehicles. The Arduino microcontroller processes the sensor data and triggers LED indicators near the garage entrance, indicating the occupancy status of each parking space. This feature enables users to efficiently locate available parking spots, minimizing search time and easing congestion.

In conjunction with the parking management component, the Smart Lighting System ensures energy-efficient and smart lighting within the garage. An infrared (IR) motion sensor captures movement within the premises, promptly communicating with the Arduino microcontroller. When motion is detected, the Arduino activates the LED lights, illuminating the garage. After a period of inactivity, the system automatically turns off the lights, promoting energy conservation and reducing operational costs.

Both components of the Smart Garage System operate seamlessly with the Arduino microcontroller serving as the central processing unit. The significance of this project lies in its potential to transform conventional garages into smart, interconnected spaces. Users benefit from an optimized parking experience, with reduced search times and increased convenience. Additionally, the smart lighting system contributes to energy conservation, aligning with sustainable practices and eco-friendly solutions. As a testament to the capabilities of IoT and Arduino technology, the Smart Garage System exemplifies the future of intelligent and user-centric garage management.

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INTRODUCTION

The IoT-based Smart Garage System using Arduino is a project developed to tackle the challenges faced by traditional parking systems. The objective of this project is to provide an efficient and automated parking management solution that optimizes parking space utilization and enhances the overall parking experience for users.

Traditional parking systems often suffer from issues such as inefficient space allocation, difficulty in finding available parking spots, and lack of real-time information for users. These challenges lead to frustration, wastage of time, and increased traffic congestion in parking areas.

To address these problems, our project leverages IoT technology and utilizes Arduino, a low-cost Wi-Fi-enabled microcontroller, as a key component. The system incorporates smart sensors placed in each parking spot to detect the availability of parking spaces. The sensor data is collected and transmitted wirelessly to a central server for processing and analysis. Our project's implementation and deployment involved the installation and configuration of the Arduino devices, as well as the development of the server infrastructure and user interfaces. Rigorous testing and evaluation were conducted to ensure the system's functionality, reliability, and scalability.

The results of our project demonstrate significant improvements in parking efficiency, reducing the time spent searching for parking spots and minimizing traffic congestion. Users have reported enhanced convenience and satisfaction, thanks to the real-time availability information and reservation capabilities provided by the system.

Overall, the IoT-based Smart Garage System using Arduino presents a promising solution to the problems faced by traditional parking systems. By leveraging IoT technology, it offers an efficient and user-friendly parking management solution that enhances the parking experience for users and contributes to the development of smart and connected cities.

PROBLEM STATEMENT

Traditional parking systems often suffer from inefficiencies and challenges that impact both parking providers and users. These challenges include limited parking space utilization, difficulties in finding available parking spots, and the lack of real-time information for users. These issues lead to frustration, wasted time, increased traffic congestion, and overall poor parking experiences.

The objective of this project is to address these problems by developing an IoT-based Smart Garage System using Arduino. The system aims to optimize parking space management, improve user convenience, and enhance the overall efficiency of parking operations.

The specific problems that the IoT-based Smart Garage System seeks to solve are as follows:

1. **Remote Garage Door Control:** The primary objective of this project is to enable users to remotely open and close their garage door using a smartphone or a web interface. This feature ensures that users never have to worry about forgetting to close the garage door, providing peace of mind and improved security.

2. **Parking Space Availability:** The project aims to implement a smart parking system that detects and displays the availability of parking spaces within the garage. Users can use a mobile app to check real-time parking space availability and reserve spots in advance, saving time and reducing frustration in finding parking.

3. **Lack of Real-Time Parking Information:** Traditional parking systems do not provide real-time information on parking space availability. Users have no visibility into which parking spots are vacant or occupied, which leads to uncertainty and inefficiency in parking.

4. **Manual Management and Monitoring:** The manual management and monitoring of parking areas are prone to errors and delays. Traditional systems rely on human intervention for tasks such as ticketing, payment, and spot monitoring, which can result in inefficiencies and inconsistencies.

5. **Automated Lighting Management:** Integrating motion and ambient light sensors with the Arduino, the system will automatically control the garage lighting. Lights will turn on when someone enters the garage and turn off after a specified period of inactivity, ensuring energy efficiency and reducing electricity costs.

6. **Energy Usage Monitoring:** The project will include energy monitoring functionality, allowing users to track and analyze energy consumption patterns for the garage lighting. This data can help users make informed decisions to further optimize energy usage.

To address these problems, the IoT-based Smart Garage System using Arduino will leverage IoT technology to provide real-time parking space monitoring, availability information, and seamless user experiences. By implementing smart sensors, wireless connectivity, and a centralized server infrastructure, the system aims to optimize parking space utilization, streamline parking operations, and enhance the overall parking experience for users. The IoT-based Smart Garage System using Arduino is a project developed to tackle the challenges faced by traditional parking systems. The objective of this project is to provide an efficient and automated parking management solution that optimizes parking space utilization and enhances the overall parking experience for users.

METHODOLOGY

The development of the IoT-based Smart Garage System using Arduino follows a structured methodology that encompasses research, design, implementation, and evaluation stages. The methodology employed for this project is as follows:

1. **Research and Requirement Gathering:** Conduct a thorough review of existing parking systems, IoT technologies, and best practices in the field. Gather requirements through stakeholder interviews, surveys, and analysis of user needs and expectations.

2. **System Design:** Based on the gathered requirements, design the system architecture, considering factors such as scalability, reliability, and ease of use.

3. **Sensor Selection:** Identify and select appropriate sensors for occupancy detection in parking spaces. Consider factors such as accuracy, reliability, power consumption, and ease of integration with the Arduino.

4. **Development of the Arduino Firmware:** Program the Arduino microcontroller to interact with the sensors, collect occupancy data, and establish wireless communication with the central server. Implement functionalities such as data transmission, sensor calibration, and error handling.

5. **Server Infrastructure:** Set up a centralized server infrastructure to receive and process data from the Arduino devices.

6. **User Interfaces:** Develop a user-friendly mobile application and a web-based dashboard to provide real-time parking information to users.

7. **Testing and Quality Assurance:** Conduct rigorous testing to ensure the functionality, reliability, and performance of the system.

8. **Deployment and Evaluation:** Install the Arduino devices and sensors in the parking area.

DESCRIPTION, ARCHITECTURE AND CIRCUIT

DESCRIPTION

The Smart Garage System is an innovative IoT project that comprises two integral components: the Smart Parking System and the Smart Lighting System. Both components are powered by Arduino microcontrollers and designed to enhance parking convenience and energy-efficient lighting within the garage.

1. Smart Parking System:

The Smart Parking System utilizes an Arduino microcontroller, an ultrasonic distance sensor, LEDs, jumper cables, wire, and a mini breadboard to create an intelligent parking management solution. The system aids users in finding available parking spaces and streamlines the parking process. An ultrasonic distance sensor is placed above each parking spot, facing downward to detect the presence of vehicles. The ultrasonic sensor measures the distance between itself and any object below it, such as a car. When a car is parked in a spot, the Arduino microcontroller processes the data from the ultrasonic sensor and detects the presence of the vehicle. If a car is detected within the parking spot, the Arduino triggers an LED on the mini breadboard to blink or light up, indicating that the spot is occupied. As cars leave and parking spots become available, the LED corresponding to the vacant spot stops blinking, indicating its availability to other drivers.

2. Smart Lighting System:

The Smart Lighting System incorporates an Arduino microcontroller, an infrared (IR) motion sensor, LEDs, jumper cables, wire, and a mini breadboard. This component focuses on energy-efficient lighting management within the garage. An infrared (IR) motion sensor is positioned strategically within the garage to detect any movement. When the IR sensor detects motion, it sends a signal to the Arduino microcontroller. Upon receiving the motion signal, the Arduino triggers the LED lights on the mini breadboard to turn on, illuminating the garage. After a specified period of inactivity, the Arduino automatically turns off the LED lights to conserve

energy. Whenever motion is detected again, the Arduino activates the LED lights, ensuring the garage remains well-lit only when needed. The Smart Parking System and Smart Lighting System can be integrated into a unified smart garage setup using the Arduino microcontroller as the central processing unit. The LED indicators in the Smart Parking System guide drivers to available parking spaces, reducing the time and frustration involved in finding a spot. The Smart Lighting System ensures energy-efficient lighting by turning on only when motion is detected, saving electricity costs and contributing to eco-friendliness. Together, these components create a user-friendly, energy-efficient, and intelligent smart garage system that enhances user convenience and reduces environmental impact.

ARCHITECTURE

The IoT-based Smart Garage System using Arduino follows a distributed architecture that encompasses hardware, software, and network components. The system architecture is as follows:

1. **Arduino Devices:** These low-cost Wi-Fi-enabled microcontrollers are deployed in each parking spot to detect the occupancy status. Equipped with appropriate sensors, they collect and transmit real-time data to the central server.

2. **Smart Sensors:** The system utilizes occupancy sensors placed in each parking space to detect the presence or absence of vehicles. These sensors can be based on technologies such as ultrasonic and infrared.

3. **Wireless Communication:** The Arduino devices establish wireless communication with the central server using Wi-Fi connectivity. They transmit occupancy data, as well as receive commands and updates from the server.

4. **Centralized Server:** The server acts as the central hub for data processing and management. It receives the occupancy data from the Arduino devices, stores it in a database, and provides real-time information to the user interfaces.

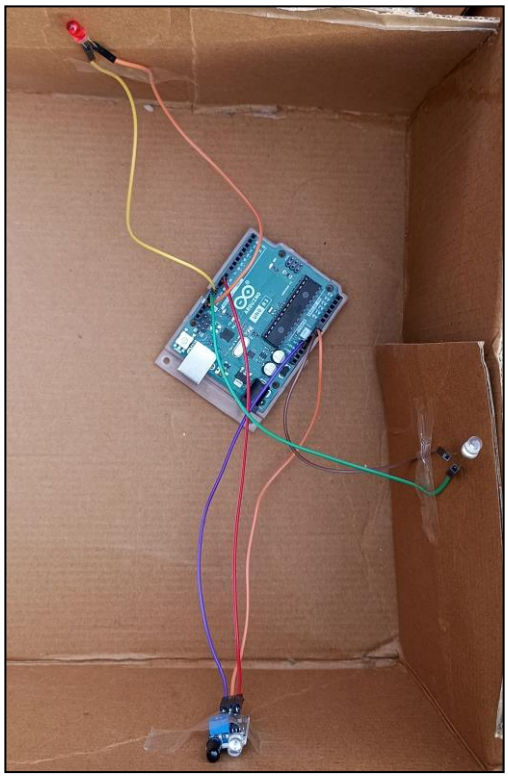
5. **Database:** The database stores information related to parking spaces, user details, occupancy status, and other relevant data. It enables efficient data retrieval and supports real-time updates.

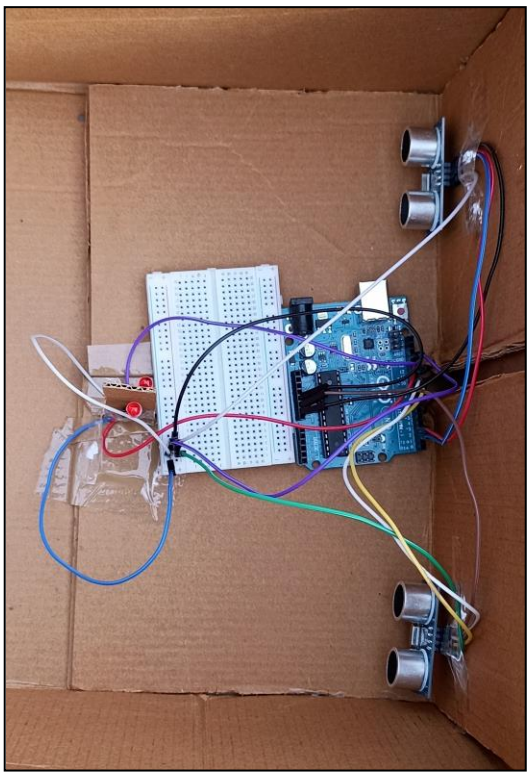
CIRCUIT

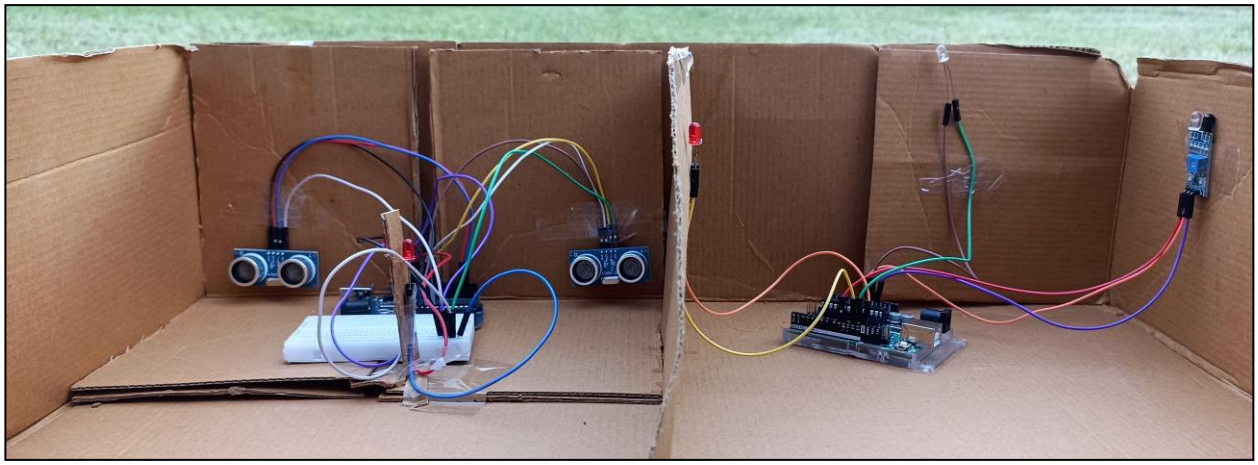
The components used are:

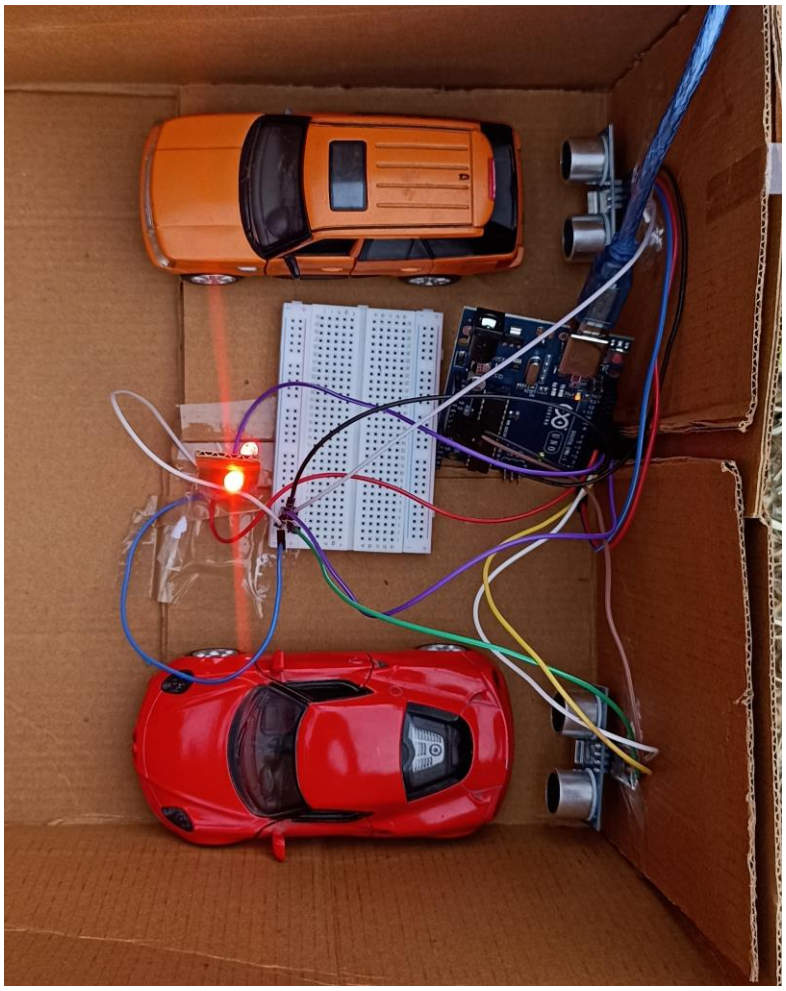
1. Arduino microcontrollers
2. Ultrasonic distance sensor
3. IR sensor
4. Mini breadboard
5. Jumper cables, wire
6. LEDs

The following are the circuits of the Smart Lighting System and Smart Parking System, respectively:









DATA COLLECTION

The IoT-based Smart Garage System collects various data points to facilitate efficient parking management and enhance user experience. The data collection process involves the Arduino microcontroller, IR sensors, and ultrasonic sensors. Here is a breakdown of the data collected and the results achieved:

1. **Parking Availability Data:** The system collects real-time data on parking space availability. The IR sensors detect the presence or absence of vehicles in each parking spot, and this information is transmitted to the central control unit (Arduino). The data is then sent to the IO platform for storage and monitoring.

2. **Parking Time Data:** The system also collects data on the duration of vehicles parked in each spot. This data is recorded when a vehicle enters and exits the parking area. By tracking the parking time, the system can provide insights into parking patterns and assist in optimizing space allocation.

3. **Vehicle Detection at Entry and Exit Gates:** The IR sensors placed at the entry and exit gates detect vehicles as they enter or leave the parking area. This data is used to automate the gate operations, allowing for smooth entry and exit processes.

4. **Smart Lighting System:** In the Smart Lighting System, the infrared (IR) motion sensor collects data on movement within the garage. Whenever motion is detected, the sensor sends a signal to the Arduino microcontroller, indicating activity in the vicinity.

IMPLEMENTATION AND DEPLOYMENT

The implementation and deployment of The IoT-based Smart Garage System involve the following steps:

1. **Hardware Setup:** Install the Arduino microcontroller, IR sensors, and servo motors at the designated parking area. The Arduino serves as the central control unit, while the IR sensors detect vehicle presence, and the servo motors control the gate operations.

2. **Software Programming:** Program the Arduino microcontroller with the necessary firmware and logic. This includes configuring the communication with the IR sensors and servo motors, as well as integrating the necessary libraries and dependencies.

3. **Sensor Calibration:** Calibrate the IR sensors to ensure accurate detection of vehicle presence. Adjust the sensor thresholds and sensitivity levels to optimize performance based on the parking environment.

4. **Network Connectivity:** Connect the Arduino to a stable and secure Wi-Fi network to enable communication with the Adafruit IO platform. Configure the network settings and ensure proper connectivity.

6. **Gate Automation:** Program the Arduino to control the servo motors based on the readings from the IR sensors. Define the gate opening and closing logic, including rotation angles and delays, to ensure smooth entry and exit processes.

7. **User Interface Development:** Develop user interfaces such as a mobile application or web-based dashboard to display real-time parking availability and provide additional features like reservation, payment, and navigation assistance.

8. **Testing:** Conduct comprehensive testing to ensure the proper functioning of the system. Test each hardware component, validate the sensor readings, and verify the gate automation. Perform integration testing to ensure seamless communication between the Arduino, sensors, and Adafruit IO platform.

9. **Deployment:** Install the IoT-based Smart Garage System at the intended parking area. Mount the hardware components securely and ensure proper power supply. Configure the system for the specific parking layout and settings.

ARDUINO CODE:

```
// smart lighting system
int IRSensor=9;
int LED1=13;
int LED2=12;
void setup()
{
  Serial.begin(9600);
  pinMode(IRSensor,INPUT);
  pinMode(LED1,OUTPUT);
  pinMode(LED2,OUTPUT);
}
void loop()
{
  int sensorStatus=digitalRead(IRSensor);
  if (sensorStatus==1)
  {
    digitalWrite(LED1,LOW);
    digitalWrite(LED2,LOW);
    Serial.println("Motion Detected!");
  }
  else
  {
    digitalWrite(LED1,HIGH);
    digitalWrite(LED2,HIGH);
    Serial.println("Motion Ended!");
  }
}

// smart parking system
const int trigPin1=9;
const int echoPin1=10;
const int LEDpin1=13;
const int trigPin2=2;
const int echoPin2=3;
const int LEDpin2=12;
long duration1;
long duration2;
int distance1;
int distance2;
void setup()
{
  Serial.begin(9600);
  pinMode(trigPin1,OUTPUT);
```

```
  pinMode(echoPin1,INPUT);
  pinMode(LEDpin1,OUTPUT);
  pinMode(trigPin2,OUTPUT);
  pinMode(echoPin2,INPUT);
  pinMode(LEDpin2,OUTPUT);
}
void loop()
{
  digitalWrite(trigPin1,LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin1,HIGH);
  delayMicroseconds(2);
  digitalWrite(trigPin1,LOW);
  duration1=pulseIn(echoPin1,HIGH);
  distance1=duration1*0.034/2;
  if (distance1<=5)
     digitalWrite(LEDpin1,HIGH);
  else
     digitalWrite(LEDpin1,LOW);
  Serial.print("Distance1:");
  Serial.print(distance1);
  Serial.print("cm");
  delayMicroseconds(10);
  digitalWrite(trigPin2,LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin2,HIGH);
  delayMicroseconds(2);
  digitalWrite(trigPin2,LOW);
  duration2=pulseIn(echoPin2,HIGH);
  distance2=duration2*0.034/2;
  if (distance2<=5)
     digitalWrite(LEDpin2,HIGH);
  else
     digitalWrite(LEDpin2,LOW);
  Serial.print("Distance2:");
  Serial.print(distance2);
  Serial.print("cm");
  delayMicroseconds(10);
}
```

RESULTS

The results of the data collection and system implementation demonstrate several benefits:

1. **Improved Parking Efficiency:** Real-time parking availability data enables drivers to quickly locate vacant parking spaces, reducing the time spent searching for parking.

2. **Enhanced User Convenience:** The automated gate system and automated lighting system ensures seamless entry and exit processes. Users no longer need to manually operate gates, resulting in a more convenient and hassle-free parking experience.

Testing plays a crucial role in ensuring the functionality, reliability, and performance of The IoT-based Smart Garage System. Here are the key testing activities involved in the project:

1. **Unit Testing:** Perform unit testing for each hardware component, including the Arduino, IR sensors, and servo motors. Verify their individual functionalities and ensure they are working correctly.

2. **Sensor Testing:** Validate the accuracy and reliability of the IR sensors. Test their ability to detect vehicle presence accurately and consistently. Adjust sensor thresholds and sensitivity levels if needed to optimize performance.

3. **Gate Automation Testing:** Test the gate automation process to ensure that the servo motors open and close the gates accurately based on the sensor readings. Verify the rotation angles and delays to ensure smooth gate operations.

By effectively collecting and utilizing data, The IoT-based Smart Garage System enables efficient parking space management, reduces congestion, and enhances user satisfaction. The system's data-driven approach provides valuable information for improving parking operations and optimizing resource allocation.

LIMITATIONS

1. Reliance on Stable Internet Connectivity: The IoT-based Smart Garage System heavily depends on a stable internet connection for real-time monitoring and data transmission. In areas with poor connectivity or network outages, the system's functionality may be compromised.

2. Potential Sensor Inaccuracies: While IR sensors are generally reliable, environmental factors such as extreme weather conditions or physical obstructions may affect their accuracy in detecting vehicle presence. Regular calibration and maintenance are necessary to minimize sensor inaccuracies.

3. Scalability Challenges: The system may face challenges when scaling up to accommodate a larger number of parking spaces. Ensuring seamless communication and synchronization between many sensors and the central control unit becomes more complex.

4. Maintenance Requirements: The hardware components, including IR sensors and servo motors, may require periodic maintenance to ensure their proper functioning. Regular inspections, cleaning, and replacement of faulty components may be necessary to maintain the system's reliability.

FUTURE RECOMMENDATIONS

1. License Plate Recognition (LPR) Integration: Implementing License Plate Recognition technology can enhance the system's capabilities by automatically identifying vehicles entering and exiting the parking area. This can improve security and enable features such as pre-registered vehicle access and personalized user experiences.

2. Advanced Analytics and Predictive Parking Availability: Integrate advanced analytics algorithms to analyze historical data and predict parking availability based on historical patterns and real-time data. This can provide users with accurate predictions of available parking spaces and optimize parking resource allocation.

3. Mobile Application Integration: Develop a mobile application that allows users to access real-time parking information, reserve parking spots, make payments, and navigate to available parking spaces. This enhances user convenience and provides a seamless end-to-end parking experience.

4. Smart Payment Systems: Implement contactless payment systems, such as mobile wallet integration or RFID-based payment options, to streamline the payment process and eliminate the need for physical payment methods.

CONCLUSION

In conclusion, The IoT-based Smart Garage System using Arduino is a promising solution to address the challenges of parking management and traffic congestion in metropolitan areas. By leveraging the capabilities of IoT devices, sensor technology, and cloud-based platforms, the system offers several benefits including improved parking efficiency, enhanced user convenience, and data-driven insights.

Through the implementation of this system, real-time data on parking availability and parking time can be collected, allowing users to quickly locate vacant parking spaces and reduce the time spent searching for parking. The automated gate system with IR sensors and servo motors ensures smooth entry and exit processes, optimizing the overall efficiency of the parking system.

The integration with the IO platform enables remote monitoring and accessibility from anywhere in the world, providing users with the convenience of real-time information and control over the parking system. The system's data-driven approach also allows for insights into parking patterns and utilization, enabling better decision-making for parking management.

However, it is important to acknowledge the limitations of the system, such as its reliance on stable internet connectivity, potential sensor inaccuracies, scalability challenges, and maintenance requirements. These limitations should be considered during implementation and addressed to ensure the system's optimal performance and reliability.

Overall, The IoT-based Smart Garage System using Arduino demonstrates great potential in revolutionizing parking management, reducing congestion, and enhancing user satisfaction. By embracing technology and innovation, we can pave the way for smarter and more sustainable urban environments.

References:

IoT Design Pro. (2019, Nov 8). IoT-Based Smart Parking Using ESP8266. Retrieved from https://iotdesignpro.com/projects/iot-based-smart-parking-using-esp8266