Smart Parking System

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Abstract:* Urbanization and the increase in vehicle numbers has made efficient parking management a major issue. This project aims to use an Arduino Nano microcontroller to develop a smart parking system to help with parking management, by automating the entry and exit processes and provide real-time information about the status of parking space availability. This system has six IR sensors placed in each parking location for detecting vehicle presence. Based on the information from these sensors, the number of available parking spaces is calculated. To stop unauthorized entries, two servo motors are used to control entry and exit gates, permitting entry only when parking spaces are available. An LCD with TX2 I2C interface is incorporated to display available slots, allowing the user to see parking space availability and decide whether to enter or not. The system contains two SMPS units that help to ensure power stability to the Arduino Nano and peripherals. This provides an operating flexible and modular system capable of managing parking situations with many vehicles. The smart parking system manages to enhance the use of parking while decreasing manual intervention, helps to reduce the amount of time a driver would hope to wait that would be unnecessary in determining their space, and reduce congestion around the location of parking lots. Overall, the project provides a low-cost and easy to use and therefore scalable solution that can help with the management of parking, not limiting it to shopping malls, office complexes and even residential areas.

***Keywords*: Smart Parking System, Internet of Things (IoT), Real-Time Monitoring, Parking Sensors, Automated Payment System, Mobile Application, Data Analytics**

I. INTRODUCTION

The increase in automobiles in cities has created considerable complexities related to the management of parking resources. With traditional parking management methods, users often waste time, fuel, and the environment because they spend long periods of time searching for available spaces. Smart parking solutions are solutions based on smart parking that use advanced technologies such as IoT [1], Cloud Computing, and Machine Learning. Smart parking seeks to track, regulate, and optimize space use of parking spaces by monitoring data from parking systems. Smart parking solutions contain many components going beyond the physical parking spaces - like basic ground sensors, or camera-based systems [2], and mobile applications that supply the user and operator with real-time information. Smart parking solutions offer the ability to quickly identify vacant spaces and assists with revenue management by allowing payment automatically generated by the system, and using data to guide operators [15]. Smart parking initiatives will help to manage and mitigate the effects of vehicular congestion, reduce carbon emission sometimes [12], and improve the overall efficiency of public transportation systems in cities. They ensure the relevant development and operation of parking spaces, assist in supporting sustainable communities, and leverage new opportunities offered through smart city initiatives [9].

II. LITERATURE SURVEY

Smart parking systems have become crucial solutions to tackle city traffic congestion and parking management. Many researchers have studied various approaches and technologies for implementing smart parking systems. Bhor et al. (2015) proposed IoT based smart parking systems using cloud integration and sensors [1]. The system allowed users to view vacant parking spots using a mobile application while emphasizing the real-time aspect of available parking spots. Geng and Cassandras (2013) developed a smart parking model where they created models for vehicular parking restrictions and dynamic pricing [8]. The intelligent parking management was able to determine the optimal parking spots available by combining reservation algorithms and different optimization techniques to minimize the time searching for parking and optimize the modifiable constraints to maximize parking efficiency. Khanna and Anand (2016) developed a real-time parking system using Arduino and RFID modules [4]. The system focused on allowing secure access of vehicles and data recording. Lin et al. (2017) presented a detailed survey on smart parking solutions and classified them based on sensor-based, image-based, and hybrid-based solutions [2]. The survey covered and studied the advantages and disadvantages of smart parking systems with reflection of the environments in which they were in place. Hassan et al. (2018) proposed a smart parking system using cloud platforms and mobile application [10]. The platform allowed users to see, book, and navigate to the closest available parking spot available. Overall, smart parking solutions enhance user convenience. Rajput and Rawal (2017) completed a study on the implementation of a GSM-based parking system and an IR sensor-based parking system [13]. built upon microcontrollers, focusing on decreasing human reliance and providing slot status through SMS. In a more sophisticated approach, Rizwan et al. (2019) utilized machine learning through performance trends present from available parking, suggesting performance-based approaches to achieve optimal space utilization dynamically [6]. Alternately, Zhang et al. (2013) presented a sensor and embedded system-based approach that detects the occupancy's slot through a distributed wireless network [14] to maintain scalability and accuracy. Many other studies have also dealt with embedding smart displays, setting up automatic gates, and implementing solar-powered modules [3], among other advanced smart parking possibilities for sustainability and automation. Collectively, these studies make up the groundwork and presence of evolution for present-day smart parking systems, showcasing the paradigm transition from manual methods to automated and intelligent parking [7][11]. Despite the developments, sensor interference, real-time data syncing, and power control budgeting, just to name a few, must be resolved in future work [5] to remediate these hindrances.

III. METHODOLOGY

Connect each parking spot with an Infra-red (IR) sensor to detect if a vehicle is present. Put servo motors on either the entry and exit gates to allow for gates to function automatically. Attach an LCD screen with I2C for the total number of spaces available. Use a switching power supply (SMPS) to get a stable supply of power to the Arduino Nano, and any components connected to it.

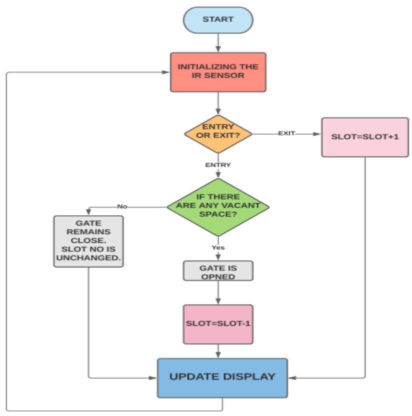
Programming and Logic Implementation code will need to be developed for the Arduino Nano to read data from the IR sensors and count how many of the parking spots are occupied. Code will need to be developed for the entry gate to only open when a parking space is available. Code will need to be created for the exit gate to only briefly open when the IR sensor detects a car at the exit. The total available spaces will need to be shown on the LCD in real time.

Testing and Calibration Each IR sensor will need to be tested to ensure it will auto-detect correctly the cars in the parking spots. Each servo motor will need to be adjusted to ensure that they operate properly once coded. The LCD will need to be adjusted to have the correct information displayed consistently.

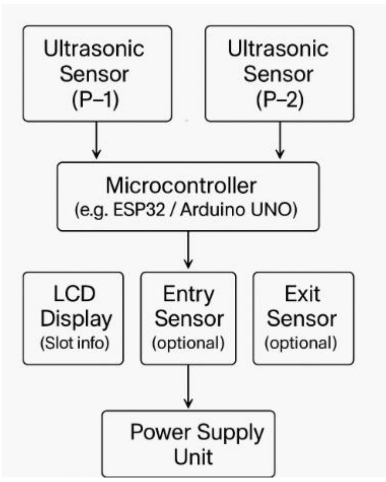
System Integration and Final Testing Combine all of the systems together and make sure that each component has a sufficient power allocation through the SMPS. Run each part of the system through 2-3 cycles to check reliability if the components can run through different parking conditions. Change any last minute adjournments if required for the final merging process.

This process will ensure an automated, real-time smart parking system with minimal manual interactions required.

IV. FLOW CHART



V.BLOCK DIGRAM



VI. DESCRIPTION OF COMPONENTS

1.IR Sensor

IR sensors are electronic devices designed to determine the presence of vehicles through infrared light. Specifically, each sensor emits an IR beam and senses the reflected signal, and measures whether an object (e.g., vehicle) is occupying a parking space. If a vehicle occupies a parking space, the sensor will send a signal to the microcontroller, which enables the owner to monitor each space's occupancy in real-time, as IR sensors play a critical role in smart parking systems efficiently tracking and managing availability.

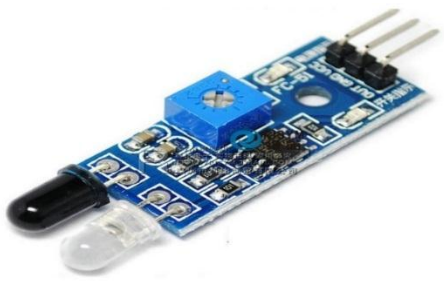


Fig.1. IR Sensor

2.Servo Motor

A servo motor is an electromechanical device that the ability to move or rotate precisely. It moves, or rotates, to a position, either set point or desired position with a control signal. The servo then maintains that position using the internal encoder feedback. In a smart parking application, servo motors can be used to control an entry or exit barrier by moving the barrier using a control signal to relocate it to either an open or closed position based on a signal from the parking sensors or microcontroller. Servos are accurate, reliable and maintain their position without the requirement to continuously power the motor.

Fig.2. Servo Motor

3.LCD With I2C

An LCD with I2C is a type of liquid crystal display that has an I2C (Inter-Integrated Circuit) interface to communicate with the microcontroller. The I2C connection simplifies connections by decreasing the number of data pins to only 2 wires, SDA for data and SCL for the clock, rather than 8+ without the I2C surface mount. Ideally, it can display text or simple data, and therefore is suitable for projects, for example, a smart parking, to display real-time information like the number of available parking spots or system status.

Fig.3. LCD With I2C

4. Switched-Mode Power Supply.

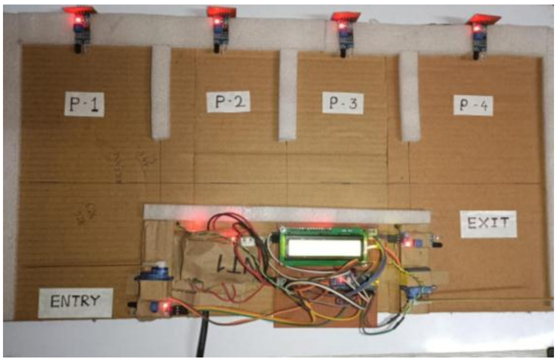
A Switched Mode Power Supply (SMPS) is an exceptionally efficient power supply unit that takes electrical power input, and converts it into relevant voltage and amperage for electrical devices. A linear power supply relies on a resistive method to regulate outgoing voltage and current, while an SMPS relies on multiple rapid on-off pulses to regulate outgoing voltage and current, i.e., high-frequency switching. The efficiency of SMPS reduces energy losses by minimizing the time components "burn," and thus, reduces the amount of heat produced too. With all the electronics in a smart parking system, an SMPS allows for stable power delivery to microcontrollers, sensors, and servo motors improving reliability of the system when operated correctly.

5. ARDUINO NANO

The Arduino Nano is a small, microcontroller board based on the ATmega328 or a variant thereof. It's compact and breadboard-friendly, perfect for embedded projects where space is a concern. The Nano features multiple I/O pins with analog inputs and PWM outputs, making it excellent for controlling sensors, motors, displays, etc. In smart parking systems, the Arduino Nano is the main processing unit, taking in data from sensors, controlling servos, and updating displays.

Fig.5. ARDUINO NANO

VII.ACTUAL PROJECT



VIII. ADVANTAGES

I. Efficient Space Utilization: Provides real-time space availability, optimizing parking IoT functions and eliminating unnecessary time spent searching for parking.
II. Decreased Conjunction: Automated entry and exit management decreases the delay waiting at the gating point and reduces vehicle buildup around the parking area.
III. Time Saver for Drivers: Drivers can see available spaces in real-time on the display, thereby decreasing the time spent searching for parking.
IV. Low Cost: Uses inexpensive components and Arduino-based automated functions, resulting in an affordable system that can be utilized in various areas.
V. Low Maintenance: Simple IR sensors, servo motors, and stable power sources (SMPS) equals minimal maintenance.
VI. Scalable: Easily expandable with additional sensors and displays for any parking configuration.

IX. FUTURE SCOPE

Attach IR sensors to each parking space in order to detect the presence of a vehicle. Attach a servo motor to the entry and exit gates to automatically control the gates. Attach an LCD with I2C to display the number of available parking spots. Use an SMPS in order to run all components, including the Arduino Nano and IR sensors. Programming and Logic Development Code the Arduino Nano to collect data from the IR sensors and count how many parking spots are occupied. Program the entry gate logic so that it opens only when there is an available parking spot. Program the exit gate to open (for a short time) when it detects that a car is at the exit. While detecting car presence, immediately show the available parking spots on the LCD display. Testing and Calibration Test each sensor and its accuracy in finding a car in a parking spot. Calibrate the servo motors angle in order to properly open and close the gates. Test the consistency of the LCD display to ensure it is displaying the correct available parking spaces. Integrating Components and Final Testing Integrate all components together while confirming that power distribution from the SMPS is done efficiently. Repeat many cycles to confirm that the system operates reliably under different parking conditions. Make final adjustments to ensure continued connection to the database, proper gate operation, and accuracy of available parking spaces. This method outlined a way for an automated, real-time smart parking system with little human interaction.

X. CONCLUSION

Smart parking systems enhance urban infrastructure by tackling traffic congestion, space under-utilization, and driver satisfaction [12]. Using IoT, sensors, computer vision, and data analytics, they enable real-time monitoring, automated payments, and predictions [6]. Studies across IEEE resources [1][8][9] show they not only boost parking efficiency but also support sustainable urban mobility. Mobile apps [10] further enhance user experience. Despite challenges like high costs and data privacy concerns [5], smart parking will likely become essential to future smart cities.

XI. REFFERENCE

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