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Real-Time Parking Slot Detection and Allocation with Arduino

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Abstract - The aim of the paper is to provide a simple automatic car parking allocation system with basic components like microcontroller that provides solution to the problems in car parking allocation. Parking allocations provided in shopping complexes, malls, multi-store buildings etc usually have persons allocated to supervise manually the traffic and to allocate spaces available for parking, directing vehicles to be parked without any disturbances making the process more complex. A simple parking automation system with IR sensors provided at the parking space to detect the presence of vehicle parked, LED notification board to show specific empty parking slots and a display to direct individuals can avoid trafficking at the gateways of parking slots and helps them to park their vehicles easily. Therefore, the proposed research work designs and implements a prototype system model, which will regulate trafficking in parking garages along with providing information to the drivers about the availability of spaces. Also, a gate has been provided with servomotor whose main function is to allow and restrict vehicles inside and outside the parking garages by opening and closing the gate with respect to the information obtained from the IR sensors in the entrance and based on the information from the IR sensors in the parking slots.

Key Words: Space Vehicles, Systematics, Logic Gates, Sensors, Automobile Traffic Congestion

1. INTRODUCTION

Overview of parking congestion issues

Parking congestion is a growing challenge in urban areas, shopping malls, and commercial spaces due to the increasing number of vehicles and limited parking infrastructure. This problem leads to several issues, including:

1. Increased Traffic Congestion – Drivers searching for parking spots contribute to unnecessary traffic buildup, especially in peak hours.

2. Wasted Time and Fuel – On average, drivers spend significant time circling for a parking spot, leading to fuel wastage and higher costs.

3. Environmental Impact – Excess fuel consumption results in increased carbon emissions, contributing to air pollution.

4. Driver Frustration and Stress – Difficulty in finding parking spots often leads to frustration, road rage, and poor driving decisions.

5. Inefficient Space Utilization – Many parking areas are either underutilized or mismanaged, leading to inefficient use of available space.

6. Impact on Businesses – Lack of convenient parking discourages customers from visiting businesses, affecting sales and revenue.

Importance of automated slot allocation

1. Streamlining Parking Operations

•Reduces manual intervention by automating the slot detection and allocation process.

•Ensures optimal space utilization, preventing unnecessary vacant spots.

•Provides real-time updates to drivers, minimizing confusion and delays.

2. Reducing Environmental Impact

•Lower fuel consumption: Drivers spend less time searching for parking, reducing fuel wastage.

•Decreased emissions: Efficient parking reduces CO_2 emissions, contributing to cleaner air.

•Smart lighting systems: Automated control of lights in parking lots saves electricity.

3. Enhancing User Convenience

•Real-time slot availability updates via mobile apps or digital displays.

•Contactless access through RFID, QR codes, or mobile booking systems.

•Reduced wait times, making the parking experience seamless and stress-free.

4. Supporting Smart City Initiatives

- Integrates with IoT and AI to enhance urban infrastructure.
- Contributes to data-driven decision-making for city planners.
- Supports sustainable urban development with intelligent traffic management.

5. Improving Urban Traffic Flow

- Reduces traffic congestion caused by vehicles searching for parking.
- Enables better parking space management in crowded metropolitan areas.
- Enhances public transportation integration, allowing multimodal travel options.

Automated parking slot allocation is a game-changing solution that not only streamlines parking operations but also reduces environmental impact, enhances user convenience, and supports smart city initiatives. Implementing such technology will significantly improve urban traffic flow and parking efficiency in the long run.

Role of Arduino and sensors in automation

1. Real-Time Parking Slot Monitoring

•Sensors continuously detect vehicle presence in parking slots.

•Arduino processes sensor data and updates slot availability dynamically.

•Information is transmitted to LED displays, mobile apps, or cloud-based systems for real-time tracking.

2. Sensor Technologies for Smart Parking

Different types of sensors are integrated based on the requirements:

•Ultrasonic Sensors: Measure distance to detect vehicle presence.

•Infrared (IR) Sensors: Detect movement and occupancy in slots.

•RFID & NFC Sensors: Enable contactless entry/exit authentication.

•Cameras with AI: Use image recognition for advanced vehicle tracking.

3. Data Processing & Decision Making

•Arduino processes sensor inputs and allocates vacant slots accordingly.

•The system sends real-time updates to displays, apps, or cloud dashboards.

•Can integrate AI-based predictive analytics to optimize slot allocation.

4. Efficient Communication System

- Arduino connects with Wi-Fi, Bluetooth, or GSM modules for seamless data exchange.
- Real-time updates help drivers navigate directly to available slots.
- Integration with cloud servers allows remote monitoring & control.

5. Energy Efficiency & Cost-Effectiveness

- Sensors operate with low power consumption, making the system energy-efficient.
- Arduino-based solutions are cost-effective compared to complex industrial systems.
- Reduces manual labor and maintenance costs for parking facilities.

Arduino and sensors play a crucial role in automating parking slot allocation by enabling real-time monitoring, data processing, and intelligent decision-making. Their integration forms the backbone of smart parking systems, ensuring accuracy and efficiency.

Objective of the project

1. Optimize Parking Space Management

•Accurately detect and allocate available parking slots.

•Ensure maximum utilization of parking areas in commercial and urban spaces.

2. Reduce Traffic Congestion

•Minimize the time spent searching for parking spots.

•Provide real-time slot availability updates to drivers via display panels or mobile apps.

3. Enhance User Convenience

•Develop a user-friendly interface for slot booking and navigation.

•Enable contactless and hassle-free parking through RFID/ NFC authentication.

4. Real-Time Monitoring & Automation

•Use Arduino and sensors to monitor slot occupancy dynamically.

•Automate data transmission to ensure accurate and up-to-date information.

5. Integration with Smart City Initiatives

•Support IoT-based infrastructure for intelligent urban parking solutions.

•Enhance sustainability and efficiency in modern transportation systems.

The primary objective of this project is to develop an automated parking slot allocation system using Arduino and sensors to optimize parking space management, reduce congestion, and enhance user conv

2. Problem statement

Existing parking management systems Research on IoT-based smart parking Comparison between manual & automated systems Identified gaps and proposed solution Challenges in traditional parking systems: Difficult slot searching Traffic congestion Lack of real-time updates Need for a smart, automated solution

Literature Review on Parking Management Systems

1. Existing Parking Management Systems

Traditional parking management systems primarily rely on manual supervision, ticket-based entries, and simple sensor-based slot indicators. These systems lack real-time monitoring, predictive analytics, and automated slot allocation, leading to inefficiencies.

2. Research on IoT-Based Smart Parking

Recent advancements focus on IoT-based parking systems, integrating sensors, cloud computing, and mobile applications for real-time slot detection and reservation. Studies highlight the effectiveness of smart parking solutions in reducing congestion and optimizing space utilization.

3. Comparison Between Manual & Automated Systems

Feature	Manual Parking System	Automated Parking System
Slot Detection	Requires human intervention	Uses sensors for real-time updates
Time Efficiency	Time-consuming	Fast and automated
Congestion Reduction	No real-time updates lead to delays	Smart allocation reduces search time
User Convenience	Prone to errors	Seamless and user-friendly

3. Literature Survey

3.1 We promise a car parking demonstration unit with five parking places in this most recent virtual generation, when practically everyone has a smartphone and there are no extra spots. The project's goal is to confirm that the consumer interface requires the hardware. Large drivers who want to park their cars in parking lots typically know if there are any parking spots available to them and if the city has at least one automobile that you can afford. Thus, the issue of parking in the city has been resolved. An Android application will be a contributing component in this case. the severe pollution, traffic, and parking issues. The project's goal is to highlight the quantity of free issues that many cities are now dealing with.

3.2 In this rapidly evolving world of technology, every platform has challenges. Finding parking spaces is where most people spend the majority of their time. People have several challenges when parking their cars in designated spots, such as having to devote time and effort. People would prefer to use that time for other crucial tasks. When people are parking their cars in commercial settings, such as malls, movie theaters, etc., they must first locate a spot before they may park. We created a system that uses automation technologies to save people time and labor. Both software and hardware would be used to build this technology. This technology, which uses an RFID module and GSM, is called an autonomous car parking system**.**

3.3 The quick rise in motorization and urbanization in developing nations is a glaring example of mobility advancements. In many metropolises, the parking issue has been growing increasingly significant since the sharp increase in traffic demand.

This article addresses the use of geographic information systems in parking planning and management for the efficacy of traffic operations in cities, with the goal of identifying ways to make the parking system run more efficiently through the use of new technology and new approaches. This paper focuses on the characteristics of parking demand and the causes of parking issues. In particular, it discusses the fundamental parking principle and approaches to parking problem solving from the standpoint of geographic information systems in sufficient detail.

3.4 Our primary goal is to develop a fully automated parking system with the least amount of human intervention possible. Time is of the essence due to the world's growing population, thus we must cut down on time spent on pointless tasks like navigating traffic and finding a parking spot in a busy area. According to current systems, cars traveling at fast speeds or irate drivers who have been looking for a parking spot for a long time might occasionally cause accidents in parking situations. Our concept suggests an automated and intelligent parking model that would assist users in reserving parking spots in advance and the vehicle

3.5 There are many people living in metropolitan areas, and the highways are congested with long-distance autos.It gets challenging to locate a place to park our cars in a place with this many people. We've given you a concept that allows users to access our online application and find the appropriate parking space. Our mission's online parking booking application is entirely built in Java and MySQL. Users save

time and gasoline by doing this. With the help of the net utility, the user may quickly view the parking spot and move quickly to the location. Details of parking fees are visible to users. The challenge is to park the cars on time, and the supervisor will pay for everything.

3.6 Automobiles are becoming a necessary item in everyone's life. A car's engine and other electrical systems will last longer if it is kept in a secure location. As a result, parking spaces take up a significant amount of space when building homes, apartments, and shopping centers. These locations' lighting systems use more energy, which results in needless electricity bill expenses. The purpose of the suggested microcontroller-based energy-saving system is to efficiently reduce the amount of light energy used in parking places. The efficiency of the suggested system is determined by comparing its outcomes with those of the overall operation. When compared to the current lighting system, the suggested approach saves up to 46.35% on electricity**.**

3.7 In order to create efficient, cost-effective, and productive solutions for minimizing fatalities at unmanned railway gates, ongoing research is conducted to enhance existing technologies. Although a number of solutions have been proposed in this area of study, none of them are good enough to be implemented at automated level crossings and completely eliminate human presence. By examining existing approaches and their drawbacks, the study has created a remote monitoring system that is both economical and effective for unmanned railway gates, allowing for wireless sensors and automated traffic management systems. The purpose of the study is to design an automated traffic control system for India's unmanned railway gates.

3.8 In metropolitan areas, parking spaces are limited and costly due to the massive urbanization and increasing number of automobiles. Drivers spend more time looking for and meandering through empty parking spaces, which contributes to traffic jams, increased fuel use, and pollution. We suggest a novel cloud-based smart vehicle parking system (SVPS) over pervasive VANETs to offer more reliable parking options. The suggested SVPS architecture has a special algorithm that delivers booking recommendation options and relevant information about available parking spaces to help vehicles in an efficient, accurate, and real-time way. Many elements, including travel time, distance to the suggested parking facility, parking charge, walking distance from the parking facility to destination, and traffic congestion, must be considered in order to make the greatest use of the parking facilities that are currently in place**.**

3. CONCLUSIONS

This system gives solution to the problem of traffic congestion in front of the parking garage. Conventionally there is no such automated system for allocating spaces for parking vehicles. So, this will make parking allocation simple and well organized with systematic first come first serve basis. Directing people to empty parking slots and indicating exact locations adds more credibility to this system. In case of no space in that specific floor's parking garage, it will direct the driver to go to next floor for parking. These were some of the merits of the system.
Though this will be useful, there is no assurance of its speed of regulation when more vehicles accumulate. It may regulate the traffic, but this system will not be very useful during leisure hours and this system cannot work ideally. The concept of pre-booking of parking slots will be new but it will create some confusions. If the person who booked a parking slot arrived lately, the place should be spared to another individual.

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PROPOSED SYSTEM

The proposed system aims to automate the process of parking slot allocation using Arduino-based hardware and sensors to monitor the availability of parking spaces in real-time. This system addresses common parking issues such as traffic congestion, inefficient space usage, and time consumption during parking searches.

Key Components and Working:

1. Vehicle Detection:

Each parking slot is equipped with an Infrared (IR) or Ultrasonic sensor to detect the presence or absence of a vehicle. These sensors send data to the central Arduino microcontroller.

2. Arduino Microcontroller:

The Arduino processes input from all sensors and determines the occupancy status of each slot. It acts as the control unit for the entire system.

3. LED Display Board:

An LED or LCD screen placed at the parking entrance displays the number and location of available slots in real-time, guiding drivers efficiently.

4. Servo Motor-Controlled Gate:

A gate controlled by a servo motor is installed at the entrance, which opens only when a free slot is available, thus avoiding unnecessary entry.

5. Mobile App (optional extension):

The system can be extended with a mobile application that displays real-time availability and allows pre-booking of slots, providing added convenience.

6. Wireless Communication (optional):

ESP8266 Wi-Fi modules or Bluetooth can be integrated for remote monitoring or app connectivity, enhancing system accessibility and control.

Advantages of the Proposed System:

- Minimizes vehicle search time
- Reduces traffic congestion near parking areas
- Offers real-time slot availability updates
- Low-cost and energy-efficient
- Easily scalable for malls, offices, and public lots