UNIVERSITY OF PETROLEUM AND ENERGY STUDIES, DEHRADUN

Optimal Parking Spot Allocation

Synopsis Report of the (Minor Project - 1) in Semester V
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Introduction

In the evolving urban landscape, efficient parking allocation is a pressing challenge. The "Optimal Parking Spot Allocation System" project addresses this issue by integrating advanced algorithms, real-time updates, and user-friendly interaction. This synopsis report offers an overview of the project's objectives, key components, and anticipated benefits.

As cities grow and vehicles multiply, finding parking spots becomes increasingly time-consuming. This project aims to transform this experience by employing algorithms like shortest path techniques and binary search. By dynamically calculating optimal routes and efficiently selecting suitable parking spots based on vehicle size, the system aims to minimize search times and enhance user satisfaction.

Central to the project is its intelligent interplay of data structures, algorithmic principles, and user interface design. Through a command-line interface, drivers receive real-time parking spot suggestions, visual paths, and navigation guidance. The project's integration of technology and user experience aims to redefine the parking experience in urban environments.

This synopsis will delve into the project's core elements, exploring data representation, algorithmic implementation, real-time adaptability, and user interface design. It aims to display how the "Optimal Parking Spot Allocation System" project aspires to streamline parking allocation, saving time for drivers and contributing to more organized urban spaces.

Background Information

In today's urban landscape, the escalating number of vehicles and limited parking spaces have led to congestion, wasted time, and environmental concerns. Traditional parking allocation methods often fall short, resulting in inefficient space utilization and prolonged search times for drivers.

The "Optimal Parking Spot Allocation System" project emerges as a response to these challenges. By leveraging advanced algorithms, real-time data updates, and user-friendly design, the project seeks to revolutionize parking allocation. The goal is to minimize search times, enhance user satisfaction, and contribute to more organized urban spaces.

Motivated by the pressing need for efficient parking solutions, the project envisions a future where technology streamlines the allocation process. By optimizing routes and selecting suitable parking spots, the project aims to transform the parking experience, saving time for drivers and fostering sustainable urban mobility.

Motivation

Designing this system enables users to create a solution that streamlines the process of finding available parking spots.
It could significantly reduce the time users spend circling around parking lots searching for empty slots.

Related work

Efforts to optimize parking allocation and enhance urban mobility have spurred a range of related research and technological developments. The following represents a snapshot of key areas in related work:

- Smart Parking Solutions: Numerous smart parking systems have emerged, integrating real-time data from sensors and mobile apps to guide drivers to available parking spots. These systems utilize occupancy sensors, data analytics, and user interfaces to streamline parking allocation.
- Pathfinding Algorithms in Navigation: Pathfinding algorithms, such as Dijkstra's, and Floyd-Warshall, have been extensively used in navigation and robotics. These algorithms efficiently compute routes from point A to B, a concept directly applicable to guiding drivers to optimal parking spots.
- Parking Guidance Systems: Parking guidance systems, both indoor and outdoor, use various technologies like cameras and sensors to monitor parking spot availability. These systems offer real-time information to drivers, improving parking efficiency.
- Sustainable Urban Planning: Urban planning research addresses the need for sustainable transportation solutions. Integrating efficient parking allocation with urban planning strategies contributes to reduced traffic congestion and improved environmental outcomes.

Problem Statement

Develop an "Optimal Parking Spot Allocation System" that employs advanced algorithms to efficiently guide vehicles to suitable parking spot, reducing search times and enhancing urban mobility, user experience, and environmental sustainability.

Problems and Challenges in the model:

- **Grid Complexity**: As the parking lot grid grows in size, the graph representation and pathfinding algorithms become more complex. This can result in longer preprocessing times and slower path calculations.
- **Dynamic Update**: If the parking lot occupancy changes frequently, you need to handle real-time updates to the graph representation and shortest path data structures. This can be challenging to maintain efficiently.
- **Implementation Complexity:** Integrating different algorithms (Dijkstra's, binary search) and managing their interactions can lead to complex code and potential bugs.
- **Real-time Constraints:** The entire process needs to be fast enough for real-time parking spot allocation. Balancing computational speed with accuracy is critical.
- **Edge Cases and User Experience**: Handling edge cases like oversized vehicles, limited-size spots, or crowded areas can be challenging. Ensuring a smooth user experience in these cases is important.

Example illustration

In the bustling urban landscape characterized by a complex parking lot featuring parking spots of varying sizes, the deployment of the "Optimal Parking Spot Allocation System" is aimed at refining parking allocation processes and elevating the user experience. The system's methodology unfolds in a sequence of steps, as outlined below:

Step 1: Data Representation

The project commences with the establishment of a structured data representation of the parking lot. A 2D grid configuration is employed to map out individual parking spots indicating whether each spot is occupied or vacant, alongside denoting the size of each parking spot.

Step 2: Preprocessing

A pivotal facet of this preprocessing entails creating an innovative graph representation of the parking lot. In this conceptual graph, the vacant parking spots are translated into nodes, with edges interlinking adjacent spots, symbolizing pathways. The magnitude of the edges' weights corresponds to the distances between the respective parking spots.

Additionally, the vacant parking spots are subjected to size-based sorting, furnishing a foundation for streamlined binary search functionality in subsequent steps.

Step 3: Allocation Algorithm

3.1: Finding Shortest Path

When a vehicle seeks parking, a judicious amalgamation of shortest path algorithms serves to identify the most fitting parking spot. Depending on the parking lot's dimensions, distinct algorithms are engaged to optimize pathfinding:

- For smaller parking lots, the project employs algorithms such as Dijkstra's algorithm or the Floyd Marshall algorithm. These techniques ascertain the shortest route from the entry point to all available parking spots.

- For more expansive parking lots, the A* search algorithm comes to the fore. This heuristic-driven approach expeditiously determines an efficient path to the nearest vacant parking spot, thereby curtailing computation times.

3.2: Binary Search for Spot Size

Upon the identification of potential parking spots, the system harnesses the power of binary search. This search is executed on the sorted list of vacant parking spots, which has been organized based on spot sizes. This aligns the allocations process with the right size spots and narrows down the searching space.

Having settled on an appropriate parking spot, the project undertakes a further refinement of the allocation. In essence, the proposed methodology systematically navigates the complexities of parking allocation by combining data ate representation, preprocessing strategies, and algorithmic finesse. The orchestrated sequence of steps reflects a holistic endeavor to usher in a parking allocation system that thrives on efficiency and elevates the parking experience for users.

Proposed Method

The comparative analysis of pathfinding algorithms within the "Optimal Parking Spot Allocation System" command-line project aims to evaluate the efficiency and accuracy of various algorithms in the context of real-time parking spot allocation. The following approach outlines the implementation of multiple pathfinding algorithms, their execution, comparative analysis, and the selection of the most suitable algorithm based on performance metrics.

- **Data Initialization:** A representative parking lot grid is set up, encompassing diverse sizes of parking spots and varying occupancies to create realistic test scenarios. Entry points are designated, and predefined vehicle arrival scenarios are defined for consistent comparisons.

- **Algorithm Implementation:** Dijkstra's, Floydd Warshall and potentially additional pathfinding algorithms are implemented as separate modules within the project. Each algorithm module calculates the shortest path from parking lot entry points to vacant parking spots using its specific methodology.

- **Execution and Timing:** The execution time for each pathfinding algorithm is measured. For each algorithm, the system allocates parking spots for the predefined scenarios and records the execution time.

- **Comparative Analysis:** Collected execution times are analyzed to assess the efficiency of each algorithm under different parking lot conditions. Average execution times are calculated and compared to quantify algorithm performance.

- **Algorithm Selection:** The algorithm demonstrating the shortest average execution time consistently across scenarios is identified. Performance considerations encompass accuracy, path quality, and execution time.

  - **Performance Visualization:** Text-based or graphical visualizations are included within the command-line interface to present the comparative analysis outcomes.
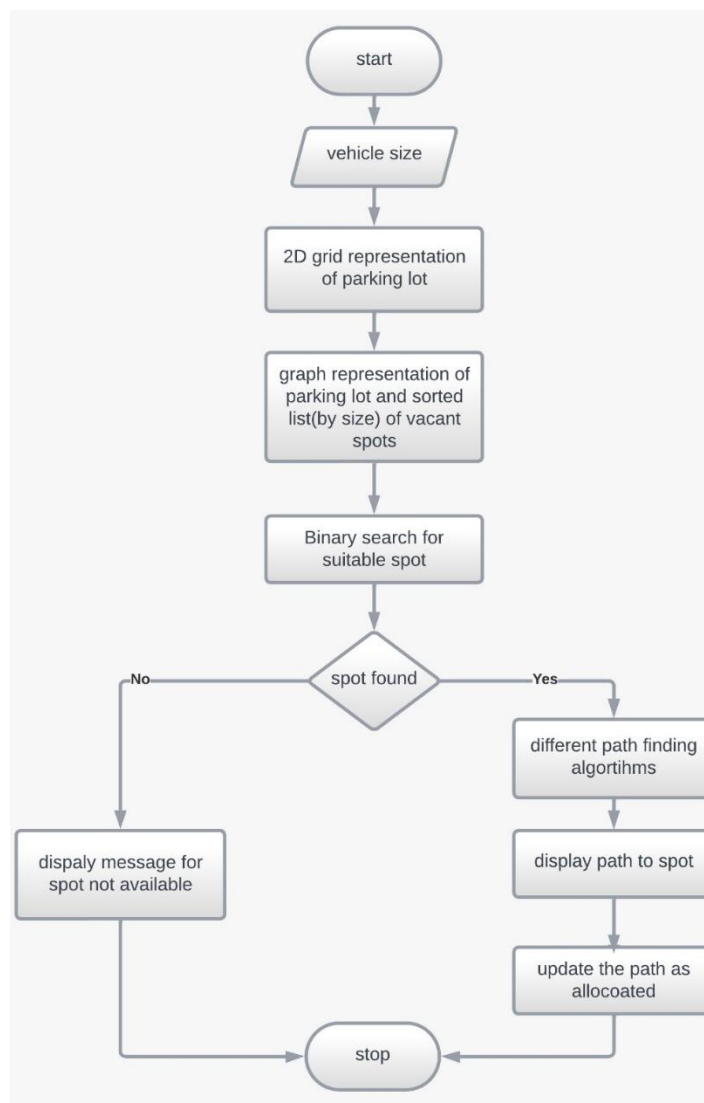
Fig: Proposed Flowchart

Users gain insights into the advantages of the selected algorithm in terms of performance metrics.

By following this approach, the "Optimal Parking Spot Allocation System" project systematically compares and evaluates pathfinding algorithms, ultimately enabling the informed selection of the most efficient algorithm for real-time parking spot allocation. This contributes to enhancing the overall user experience by optimizing the allocation process.

Work has to be done

- Input the size of the vehicle (2 /4 wheeler).
- Both linear and binary search are used in combination with diff path finding algorithms and their time and results are analyzed and compared in order to determine the optimal one.
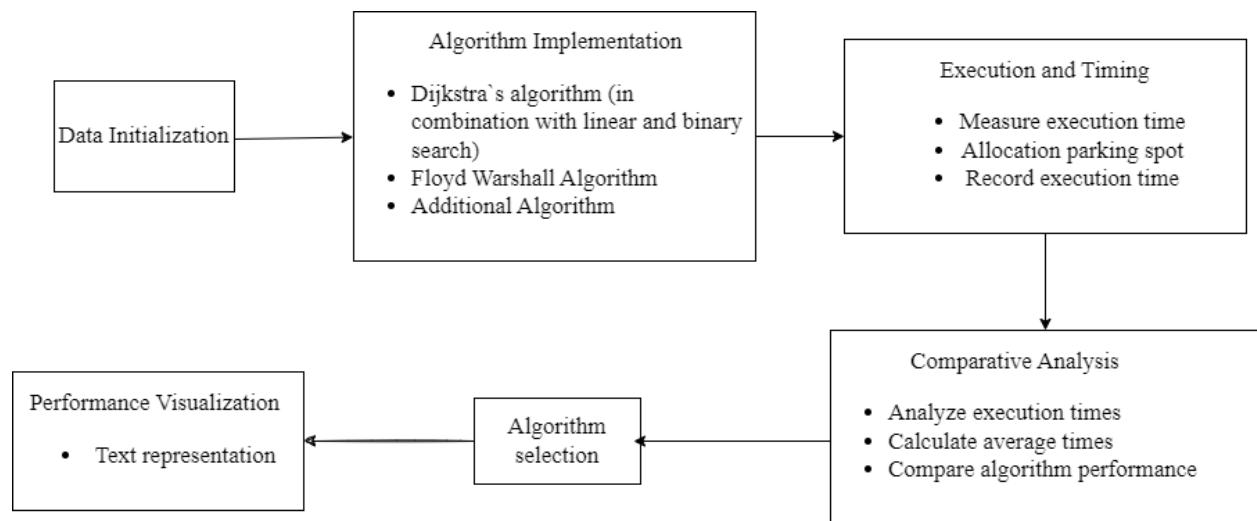
Fig: Proposed Methodology

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