Literature Review

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1 Introduction

Efficient parking management is a crucial aspect of urban planning, influencing traffic congestion, driver experience, and environmental impact. Discrete event simulation (DES) is widely used to model parking systems which can allow researchers to analyze vehicle arrivals, departures, and lot occupancy under various conditions. This literature review examines existing research on parking simulations, highlighting methodologies, findings, and gaps that justify the need for this project. By leveraging prior studies, this project aims to develop a simple yet effective DES model to analyze parking lot efficiency, search times, and potential optimization strategies.

2 Literature Summary

Discrete event simulation (DES) has been greatly used in parking studies because it enables the modeling of event-driven processes such as vehicle arrival, parking, or departure. There are many research articles that talk about how DES can achieve the best parking lot solution with the lowest search time. Torres and Nosedal-Sanchez [2019] studied the efficiency of university parking lots by simulating different policy interventions, like restrictions to peak hour access or the use of reserved spaces. Their model tracked key performance indicators, including occupancy levels, search times, and the number of drivers unable to find a spot.

A DES study by Surpris [2012] for a university campus using smart parking technology deduced that real-time information on parking availability, reduced search times by 11 seconds per vehicle on average. This plays a crucial role in reducing congestion due to the smart parking technology. Despite that, the technology has mainly focused on large institutional car parks, meaning small-scale commercial or office building lots remain one of the gaps in the current studies.

Using smart parking systems (SPS) has been a common way to improve parking efficiency. The benefits of implementing an automated parking system have been highlighted by Alshahrani et al. [2021] who have developed a DES-based model that has been found applicable within hospitals in Saudi Arabia. Their

research findings observe that search times have been minimized and overall lot utilization made effective by making use of smart sensors and automated access gates.

A similar study by Dominici et al. [2021] investigates conflict resolution in parking environments that are pitched at high demand. The authors model driver behavior whereby multiple vehicles compete for a single parking space. They test a variety of policy interventions aimed at reducing congestion. Findings from their analysis suggest that dynamic pricing models and pre-reserved spaces for frequent users are effective at optimizing space utilization and minimizing confrontation between drivers. Although these studies focus on technological interventions, they leave out many aspects of the underlying structure of parking occupancy models, thus opening up opportunities for simpler, event-driven simulation frameworks.

The modeling of parking dynamics has created several computational approaches. The PLISM-l simulation method from Matsunaga and Takada [1994] divides parking lots into manageable components in a block-network system for the simulation. This way, it uses multi-level parking structures which becomes rather complicated and impractical for lightweight simulations.

Another methodological focus trains on driver behavior modeling within parking lot simulations. Gavish and Schweitzer [2000] studied the effects of search patterns and decision-making on overall parking efficiency. Their DES model consisted of probabilistic decision rules, like whether a driver continues to search for a closer available free spot or parks as soon as one is there. Thus, this research is quite important with respect to my project because it emphasizes to a greater extent the role of driver behavior in parking efficiency in real-time.

3 Relevance

Although previous studies have indicated the applicability of discrete-event simulation (DES) in parking lot dynamics, further simplified approaches are still required, particularly for the consideration of smaller settings like office buildings or commercial districts. The larger projects studied mainly focus on big-scale applications in smart parking systems and complex structures, whereas research into simpler adaptive schemes is almost nonexistent. The purpose of this project is to counter this absence by developing a minimalist simulation, an event-driven simulation using SimPy in Python, focusing on basic parking dynamics and management strategies without complex technological infrastructures.

With the above considerations in mind, an operational framework will be created to derive performance metrics such as occupancy rates and search times from existing research. These metrics will be leveraged to inform urban planners and facility managers to optimize parking space utilization by altering certain behaviors or modifying structural attributes as a low-cost alternative to technology-heavy smart parking systems. Such an initiative could pave the way for further studies incorporating grounded data and predictive analytics to

increase their value and accuracy concerning real-world applicability.

Works Cited

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