Exploring the Different Approaches to Parking and their Limitations

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***Abstract*— The purpose of this paper is to review the various approaches and solutions that have been proposed to address the problem of inadequate parking in urban areas, as well as the limitations of these approaches. The paper begins by conducting a literature survey of existing research on the topic, including studies that propose new types of parking structures, the use of robots, the use of automated systems for parking management and the influence of various factors on parking choice behavior. The paper then discusses the potential benefits and challenges of implementing these solutions in urban areas. Ultimately, the goal of this paper is to contribute to the design and implementation of effective and sustainable parking solutions that address the problem of inadequate parking in urban areas.**

***Keywords*— parking solutions, traffic congestion, urban areas, parking areas**

I. Introduction

The problem of inadequate parking in urban areas has long been a source of frustration for city residents and visitors alike. As urban populations continue to grow and the number of private vehicles increases, the demand for parking spaces has outstripped supply in many cities, leading to traffic congestion and reduced mobility. In addition to these practical problems, inadequate parking can also have negative environmental impacts, as drivers circle the block looking for a spot or park illegally, leading to increased emissions and reduced air quality. To address the issue of inadequate parking, a variety of approaches and solutions have been proposed, ranging from the development of new types of parking garages to the use of robots or automated guided vehicles for parking management. In this paper, we review the different approaches and solutions that have been proposed to address the problem of inadequate parking in urban areas, as well as the limitations of these approaches. Our goal is to provide a comprehensive overview of the state of the art in parking solutions and to identify areas where further research and development is needed. By doing so, we hope to contribute to the design and implementation of effective and sustainable parking solutions in urban areas.

II. Literature Survey

The issue of insufficient parking in residential areas is explored in [1], with proposed solutions to optimize the utilization of available parking spaces. The authors conducted a market analysis of parking in St. Petersburg, Russia and discovered that there has been a notable increase in the number of private vehicles in the city over the past decade, while the number of available parking spaces has decreased. To tackle this problem, the authors suggest implementing intercepting and leveled parking solutions. The intercepting parking solution entails creating a parking space on the ground floor of a multi-story building, while the leveled parking solution involves constructing a sloped parking structure to facilitate easy access. The authors assert that these approaches can effectively address the issue of inadequate parking in residential areas and enhance the overall parking situation.

[2] analyzes the demand for parking systems in urban areas, examining the factors that influence parking choice behavior, including both out-vehicle cost and in-vehicle cost, as well as the overall demand for parking spaces. The article provides a comprehensive review of parking characteristics and policies in urban transportation. It highlights the need for developing demand models that account for different factors impacting parking demand and emphasizes the importance of metrics such as accessibility, parking fees, and guidance systems in policy-making. The insights provided in the article can help urban planners and policymakers design sustainable parking policies that support transportation goals and enhance the quality of life in urban areas.

Research outlined in [3] details the creation and development of an innovative parking garage tailored for smart cities. The project includes an automatic parking system (APS) that utilizes an arrangement of automated guided vehicles (AGVs) and a lift system to park vehicles safely on pallets. Furthermore, the APS is powered by a hybrid system that integrates renewable energy sources, resulting in an environmentally sustainable solution. The main goal of the APS is to reduce the time required for parking, while also minimizing dust and effectively managing storm water. A scale model of the building structure and functionality of the APS has been tested, yielding promising results. The primary objective of this novel approach to parking infrastructure is to tackle the lack of available parking spaces and increase efficiency by reducing bottlenecks and increasing automation through the use of AGVs.

[4] presents a study of a parallel lifting mechanism for a stereoscopic parking robot, which is a type of robot used to alleviate traffic congestion in urban areas. The focus of the study is on optimizing the energy efficiency of the mechanism, which is achieved by analyzing its kinematic performance and finding the optimal combination of structural parameters. The mechanism has two degrees of freedom and is designed to perform symmetrical movements using double-constrained triangles. The authors examine various aspects of the mechanism's performance, including its inverse and forward kinematics, singular configurations, and workspace, and propose evaluation indices to measure these aspects. They also construct a prototype of the mechanism and perform dynamic verification experiments to validate the results of their analysis. The results of this study provide insight into how to design a parallel lifting mechanism that is energy efficient and can perform stable, consistent movements.

[5] presents a control system for an automated parking house, which is a parking facility that uses robots or automated guided vehicles to move vehicles within the structure. The control system is designed to optimize the operation of the parking house by taking into account various inputs, such as the needs of vehicle owners and external factors like load management and optimal movement. The control system must also be able to connect with other technologies and city information systems, and enable the optimization of the parking house's moving components, such as elevators and gates, through multi-criteria optimization. Additionally, the control system must consider energy efficiency by optimizing trips based on the capacity of batteries or other technologies in order to reduce operating costs.

[6] explores the utilization of parking information guidance systems. It also discusses intelligent technologies in city regions and multi-storey car parks, aiming to assist drivers in locating parking spots and navigating within the parking facility. The article presents a range of traffic control systems and technologies, encompassing both online and offline control modes. It elaborates on how these systems can effectively direct drivers towards accessible parking spaces. Moreover, the paper delves into the advantages and disadvantages associated with the implementation of these technologies in urban settings, while evaluating their influence on transportation and logistics operations.

[7] discusses the development of a smart car parking system intended for Industry 4.0, which features the integration of the IOT and other advanced technologies. The system utilizes sensors and image processing to provide real-time updates on parking space availability and enables users to reserve their parking spots through a web or mobile application. Furthermore, it features a ticket vending machine for payment and is entirely automated, with a capacity to operate around the clock. The authors contend that such a system could enhance efficiency, decrease the need for human interaction, and mitigate parking issues in congested urban regions.

[8] presents a smart parking system that utilizes Arduino UNO hardware and the Internet of Things (IoT) to regulate parking space allocation in a bustling city. The system relies on sensors to detect parking space availability and assigns them to users based on a first-come, first-serve principle. Its primary objective is to optimize parking space management and reduce the time spent searching for parking spots. The system is designed to operate in real-time and is thoroughly tested under various scenarios to demonstrate its effectiveness. Furthermore, the system introduces an innovative automation feature that prioritizes parking space allocation to users.

[9] discusses the implementation of smart parking systems in airports as part of the concept of a smart airport. A smart airport utilizes advanced technologies, such as the IOT and big data, to improve infrastructure and enhance the customer experience. The authors conducted a survey to gather data on customer experiences with smart parking at airports. The paper analyzes current parking systems used at airports and presents potential smart solutions that can be implemented to improve parking efficiency and customer satisfaction. The goal of implementing smart parking at airports is to increase operational efficiency and improve the customer experience.

[10] proposes a new system named IPA (Intelligent Parking Assistant) for parking management in smart cities. Smart cities are defined as urban regions that employ modern technology and communication systems to enhance various aspects of urban life, including transportation and mobility. IPA intends to utilize advanced technologies like wireless

networks, sensor communication, and mobile payment systems to facilitate the proper management of public parking in cities. The authors explore the potential benefits and challenges of implementing this system in smart cities, including infrastructure, user behavior, and data management issues. The ultimate goal of IPA is to become the leading paradigm for parking management in smart cities.

The primary objective of Smart parking systems (SPS) [11] is to resolve the parking allocation challenges faced by modern cities. These systems employ various technologies such as the IoT, wireless sensors, and vehicle ad-hoc networks (VANET) to monitor and manage parking spaces. Through sensors like image processing, smartphone applications, and web applications, SPS provides parking space availability information to users. Furthermore, SPS can leverage computational approaches like machine learning and neural networks to enhance their effectiveness. The ultimate aim of SPS is to reduce the time and effort required to find a parking space, minimize fuel wastage and air pollution, and improve city management. The present study intends to review SPS by comparing different technological approaches, sensors, networking technologies, user interfaces, computational approaches, and services provided. Additionally, this paper assesses the suitability of SPS in various environmental conditions and highlights their benefits and drawbacks.

[12] proposes a system for autonomous valet parking in smart cities, in which a self-driving vehicle picks up and drops off passengers at their desired locations and then drives to a designated parking area. The goal is to minimize the overall distance traveled by the vehicle while ensuring that all passengers have a high quality of experience, including timely pickup and drop-off. To solve this problem, the authors present two algorithms: a double-layer ant colony optimization (DLACO) method and a deep reinforcement learning approach using a deep Q-learning network (DQN). Both algorithms are evaluated and found to have good performance. The use of autonomous valet parking is intended to reduce congestion in city centers and improve urban mobility.

[13] introduces a novel approach to assess the performance of an automated valet parking (AVP) system in a simulated environment that combines virtual and real elements. The AVP system under examination utilizes a distributed control scheme, and the primary objective of the evaluation is to ascertain the robustness of this scheme across diverse conditions. To accomplish this, the researchers establish a mixed-reality testing framework in which virtual vehicles interact with a real vehicle-in-the-loop system within a simulated world. By comparing the outcomes of this mixed-reality test with those obtained from a purely virtual simulation, the authors aim to identify any disparities and evaluate the efficacy of the AVP system's control scheme. This paper's proposed mixed-reality testing framework offers a comprehensive means of assessing the AVP system's capabilities since it enables the simulation of scenarios that may pose challenges or even be unattainable in real-world settings.

[14] introduces a demand model aimed at addressing parking needs in urban areas. The model takes into account the decision-making behavior of private vehicle users in selecting a parking spot and incorporates parking space reservation as well as three key variables - risk perception of off-street and on-street parking, pro-parking attitude, and their impact on modal split and parking policy evaluation. According to the study, the pro-parking attitude has the greatest impact on the modal shift, potentially causing a 7% shift in modal distribution. The authors discuss the potential applications and limitations of the model and suggest avenues for further research.

[15] examine the parking challenges faced by delivery services in urban environments and propose a solution of creating reserved parking spaces dedicated to delivery vehicles. The proposed parking spots would be selected based on various urban parameters and solved through location set-covering methods. Additionally, the study aims to determine the most probable locations for pickup or delivery requests and establish parameters for identifying potential parking spots. To gather data for the study, the authors observe user requests over a prolonged period and employ a geographic information system to identify nodes with the highest demand for mail delivery services.

[16] examined the impact of various parking management strategies on public roads using a micro-simulation model. The model simulated strategies that included charging for on-street parking and adjusting the fees at intervals of 5 to 15 minutes. The model was tested using data from Santander, Spain and a survey of parking space users. The authors found that dynamic pricing, which involves frequent updates to parking fees, can reduce search times, curb-induced traffic, emissions, and the distribution of parking between on- and off-street options. However, dynamic pricing also resulted in longer travel times from the parking location to the destination.

In [17], an analysis was conducted on the on-street parking situation on the urban streets of Al-Najaf, Iraq. The study focused on two crowded areas, namely Al-Rawan and Al-Iskan, using data obtained from drones, video cameras, and manual counts. The results revealed that parking activity in these locations was at its peak in the evenings and that the majority of parked vehicles had to wait for more than 30 minutes to secure a parking space. The study also observed that there was a prevalent issue of illegal parking in the area,

and regulation and the implementation of additional off-street parking facilities could potentially alleviate the problem.

In [18], the aim was to create a system for predicting the location of available parking spaces on roadways using machine learning techniques. The authors utilized artificial neural networks (ANNs), specifically the Deep Extreme Learning Machine (DELM), to analyze data and make predictions. The ultimate objective was to assist drivers in quickly and efficiently locating parking spaces and reducing traffic congestion. The authors discovered that DELM exhibited a high accuracy rate of 91.25% when predicting the availability of parking spaces. To evaluate the effectiveness of their proposed system, the authors conducted simulations, which demonstrated a high prediction rate. Overall, the authors assert that their method can enhance the efficiency and convenience of finding parking spaces, as well as alleviate traffic congestion in urban areas.

[19] proposes a solution to efficiently allocate parking spaces in urban areas with the aim of reducing traffic congestion and improving the experience of drivers. The proposed solution includes two models of linear integer programming for assigning parking spaces and a technique for redistributing parking demand to balance demand and prevent local gridlock. The solution was tested in Casablanca, Morocco and was demonstrated to effectively address parking issues, resulting in a 16.4% increase in satisfaction rate for parking requests and a 40% reduction in the average walking distance. The solution can be incorporated into a larger transportation system for managing parking in urban areas.

In [20], the authors explore the use of deep learning techniques, specifically recurrent neural networks, for predicting parking availability in urban areas. They examine existing methods for parking prediction and introduce their own models, which consider external factors such as weather and calendar effects. Their models were evaluated in different cities, and the initial results show that these techniques could enhance the management of parking areas, particularly on-street parking. This could help alleviate congestion and improve urban living conditions. The authors suggest further research in this area to explore the potential of these techniques in detail.

[21] presents a potential solution to distinguish between private and public parking spaces using data obtained from a driver's smartphone. The objective is to create a smart parking system that can provide drivers with information regarding available parking spaces without relying on expensive road infrastructure. To accomplish this, the authors analyze the key characteristics of private parking spots and employ a machine learning model to classify the driver's most recent parking location. This classification can serve various purposes, such as tagging parking spots in a city, facilitating parking exchanges, and predicting when a user is approaching a public or private spot based on their prior parking history in the same region.

[22] presents a method for using machine vision and the YOLOv2 target detection algorithm to identify the occupancy status of parking spaces. The process entails capturing images of parking spaces and vehicles using a camera, constructing a model to detect the contours of vehicles and parking spaces using the YOLOv2 algorithm, and obtaining the center coordinates of the parking spaces and vehicles. The parking space discrimination algorithm is then applied to compute the contours of vehicles and parking spaces and determine whether a vehicle is parked in a specific parking spot. The authors report a training accuracy rate of 99.1% for this method and assert that it has several advantages, including a straightforward structure, high recognition accuracy, resistance to external conditions, and versatility in various settings. The objective of the system is to enable car owners to promptly and accurately identify available parking spots and choose the best option, which can promote efficient parking, reduce environmental pollution, and minimize safety risks.

[23] explores the utilization of machine learning techniques for predicting truck parking occupancy, aiming to alleviate the shortage of truck parking spaces within the logistics industry. In this study, the effectiveness of various machine learning algorithms for predicting truck parking occupancy in real-time is compared. Decision trees are found to be the most appropriate algorithm for the task. The authors train their model using real-world data from a truck parking lot in the Netherlands, achieving high accuracy in predicting occupancy with a 4 seconds training time and an RMSE of 0.0029 for one-hour ahead predictions. The tool proposed by the authors could aid truck drivers, parking managers, and road authorities in optimizing the use of truck parking facilities. The authors suggest that future research should expand upon their approach and apply the model to other parking areas for truck.

In [24], researchers investigate the potential of the Internet of Things (IoT) and artificial intelligence (AI) for predicting parking occupancy in urban areas. The study utilizes traffic cameras as IoT sensors, in addition to weather forecasting web services, and applies machine learning techniques - random forests and specifically neural networks - to analyze the collected data. The results show that the developed ML models outperform previous methods in predicting parking availability, at the horizon of 60 minutes it achieves a mean squared error (MSE) of 7.18. The ultimate goal of this research is to enhance parking efficiency and convenience in

cities by providing accurate predictions of parking occupancy.

[25] proposes a new method for optimizing the prediction of parking space availability in smart cities by combining the Internet of Things (IoT) and ensemble-based predictive modeling. The authors conducted experiments using the Birmingham parking dataset and achieved outstanding results. They employed the Bagging Regression (BR) algorithm and obtained an average Mean Absolute Error (MAE) of only 0.06%, surpassing the previous best performance by more than 6.6%. Notably, this advancement in accuracy was accompanied by a notable reduction in system complexity. The primary objective of this system is to tackle the challenges associated with urban mobility in smart cities, such as limited capacity in transport and parking infrastructure. By doing so, it aims to enhance the quality of services offered to fulfill the demands of smart urban mobility. The researchers underline the significance of accurately predicting parking availability, as it can effectively alleviate traffic congestion and enhance the overall driver experience.

An automated parking system [26] utilizes a combination of sensors and cameras to aid in parking a vehicle in a designated area. The computer vision algorithms used in such systems analyze the surrounding environment and decide on safe maneuvers for the vehicle. To achieve this, several key elements are employed, including 3D reconstruction, recognition of parking slots, as well as the identification of free space and obstacles such as pedestrians and other vehicles. The authors of this paper delve into the design and implementation of an automated parking system, highlighting the challenges and considerations involved in developing a functional and secure system. Additionally, they explore the different use cases for such systems and demonstrate how different types of sensors can be utilized to increase their accuracy and robustness.

The concept of utilizing demand-based pricing for curb parking in cities to diminish cruising and optimize the utilization of curb parking spaces is discussed in [27]. According to the author, implementing higher fees for parking spots located in closer proximity to destinations would incentivize drivers to park further away and walk. This, in turn, would mitigate traffic congestion, minimize the collective expense of drivers' parking search time, and enhance the effectiveness of curb parking space usage.

[28] explores the effects of policies that offer on-street parking permits for residents in shopping districts with little or no charge on the demand and supply of parking. The authors estimate the reduction in welfare linked with such policies and conclude that the supply of parking is not entirely price elastic, which results in significant welfare losses owing to underpriced parking permits. Additionally, [28] finds that providing residential parking permits in shopping districts contributes to an increase in parking demand and a decline in parking supply, resulting in an increase in parking fees and a decrease in the well-being of non-permit holders. To offset the adverse effects of these policies, the authors suggest that charging market prices for parking permits could be a viable solution.

[29] delves into the effects of introducing parking charges in residential areas and presents a model that evaluates the social costs and benefits of these charges using a case study conducted in Stockholm. The study results show that while the implemented charges had a significant impact on parking demand, they also caused a welfare loss due to being higher than the optimal levels. The model used in the study considers both arrival time and duration when analyzing parking as a two-dimensional good and calculates optimal charges and occupancy levels based on a balance between parking search costs and the loss of consumer from unused parking spaces. These findings suggest that the implementation of parking charges in suburban residential areas may not always be advantageous and should be carefully examined before making policy decisions.

[30] investigates the use of discriminatory policies for parking, such as designated loading zones or exclusive parking for certain groups, and examines the circumstances under which it is optimal to restrict some drivers from using certain parking spaces. The research finds that privileged parking is optimal when drivers have different preferences and can adjust their search behavior in response to the availability of these spaces. The study also explores the most effective pricing policies for parking in situations where drivers searching for a space create external costs, and looks at the optimal policies for "special needs" parking, such as spaces reserved for disabled drivers.

[31] investigates the determinants the inclusion of private parking owners' in shared type parking. Their parking spaces are rented out to others for a fee. To understand the decision-making process, a survey was conducted. The survey presented three options. The three options of shared parking are as Fixed mode, Flexible mode, and not interested. The study employs a statistical model that considers the uncertainty surrounding the decision, as well as the owners' characteristics, variables, revenues, and psychological concerns. The research findings have the potential to assist policymakers and planners in refining shared parking policies and promoting the growth of the shared parking industry.

[32] discusses the challenges and complexities of managing parking on city streets. The authors argue that cities often use a variety of policies, such as meters, time

limits, permits, and fines, rather than pricing to manage curb parking, which leads to low quality and payment and high reliance on revenue from fines. The study uses data from various cities in the US, with a focus on Los Angeles, to examine the factors contributing to this system of curb parking management and its implications for economic efficiency, social equity, and transportation outcomes. The authors propose that the public ownership of the curb and low production costs contribute to the current system and suggest potential reforms to improve curb parking management.

[33] investigates how the availability of commuter impacts the mode choice for commuting to work in the Washington, DC region. The analysis was conducted on data collected from 4,630 regular commuters. The results showed that individuals who were provided with benefits for public transportation, walking, or cycling but no free car parking were more likely to use those modes for their commute. Conversely, free car parking at work was linked to more driving. The provision of benefits for all three modes, was associated with an increased likelihood of using these modes and a decrease in driving. However, the addition of free car parking in benefit packages seemed to offset the positive effects of the other benefits. Based on these findings, the researchers suggest that benefits for public transportation, walking, and cycling are most effective when car parking is not provided for free.

[34] examines the influence of different parking policies on parking duration in the Netherlands. The study evaluates the effectiveness of three common policies: pricing only, time restrictions combined with pricing, and daily tickets only. The data analyzed for the study included 32 million mobile parking transactions from 2018. The findings reveal that time restrictions are more effective in managing parking duration compared to pricing-only policies. Moreover, the combination of pricing and time restrictions is more effective in residential and mixed land use areas than in commercial areas. The authors suggest that context-specific factors should be considered by local authorities when designing parking policies to effectively influence parking behavior.

The study conducted by [35] delves into the potential advantages of legalizing illegal parking spaces in Hanoi, Vietnam. The researchers conducted a survey to assess the prevailing parking conditions, the parking behavior of users, and the consequences of illegal parking in the city center. They further proposed a plan for para-parking, which involves legitimizing these parking spaces. The authors also analyzed the various opportunities, risks, and forms of para-parking and recommended a way to evaluate the economic impact of investing in parking facilities. Ultimately, the study concludes that legalizing the illegal parking spaces could be advantageous for parking users, urban planning, and transport planning.

III. On-street/Off-street parking

A. On-street parking

Instead of being located in a parking lot or garage, on-street parking means parking spaces that are situated on the roadside/street. These spaces are often marked with painted lines or other visual indicators, often regulated by the government may require the use of a meter or other payment method. In urban areas where space is limited and demand for parking is high, on-street parking is a common sight. Additionally, on-street parking can be more convenient for people who are visiting or doing business in these areas, as it may be closer to their destination. However, it can also lead to congestion and limited availability, and may require drivers to move their vehicles periodically to comply with parking regulations. Drivers must follow the rules and regulations for using these spaces.

B. Off-street parking

Unlike on-street parking, off-street parking means parking spaces that are located in a designated parking lot or garage. In urban areas where space is limited and demand for parking is high, off-street parking can provide more spaces, better security, and the ability to control access. However, it may also be more expensive and require a longer walk to reach destinations.

IV. Parking methods

Different methods can be used for parking vehicles, and the method chosen may depend on the type of vehicle, the location, and the availability of parking spaces.

A. Head-in parking

In head-in parking, drivers park their vehicles facing the front of a parking space rather than backing into it. This type of parking, also known as "nose-in" parking, is commonly found in parking lots, garages, and on-street spaces. Drivers enter the space from the front and exit from the front as well, allowing them to easily see pedestrians and other vehicles and maneuver their vehicle when leaving the space. Head-in parking is the most common type of parking arrangement.

B. Back-in parking

Back-in parking is a type of parking system where drivers park their vehicles by reversing into a parking space, rather than driving forward into it. This method is often used to

ensure that drivers have a clear view of the area behind their vehicle when leaving the parking space. In back-in parking, drivers enter the space from the rear and exit from the front, allowing them to easily see pedestrians and other vehicles and maneuver their vehicle when leaving the space. This type of parking is commonly found in parking garages, lots, and on-street spaces.

C. Parallel parking:

Parallel parking is a type of parking a vehicle alongside the road, with the front of the vehicle facing the direction of traffic. Parallel parking is typically used in areas where space is limited and there is a high demand for parking. This is often the case in urban areas, where space is at a premium and there are many vehicles vying for parking spots. Parallel parking is also often used in busy streets and commercial areas, where there is a need to maximize the use of available parking space.

D. Perpendicular parking

Perpendicular parking is a method of parking a vehicle at a 90-degree angle to the road, with the front of the vehicle facing the sidewalk.Perpendicular parking is often used in parking lots and other off-street parking areas, where there is more space available. It is also commonly used in residential areas, where there is less traffic and fewer pedestrians.

Perpendicular parking can help to reduce congestion and improve traffic flow in parking areas, since the cars are parked alongside each other rather than in front of or behind each other.

This can make it easier for drivers to find and access their vehicles, and can also improve the overall appearance of the parking area.It can be more convenient for drivers, since they do not need to maneuver their vehicles as much as they would with parallel parking.

E. Angled parking

Angled parking is a method of parking a vehicle at an angle to the road, with the front of the vehicle facing the direction of traffic.

To park in an angled parking space, a driver must turn their vehicle at an angle of 45 or 60 degrees to enter the space. Angled parking spaces are ideal for small parking lots because they allow for better traffic flow due to the positioning of the cars. Because of their smaller turning radius, angled parking spaces are easier to access than traditional straight-in parking spaces. These types of parking spaces are preferred by businesses where customers are likely to come and go quickly, as they are easier to access and allow for better traffic flow. One downside to angled parking spaces is that they are only suitable for one-way traffic. However, this also has the added benefit of making them safer, as drivers only need to be concerned with traffic coming from one direction.

F. Drive-through parking:

Drive-through parking is a type of parking system that allows drivers to enter a parking area from one side and exit from the other, rather than having to park their vehicles and then walk to their destination. This type of parking arrangement is often used in situations where

space is limited or where it is important to keep traffic flowing smoothly. Some common examples of places that might use drive-through parking include fast food restaurants, convenience stores, and gas stations, where the drive-through parking spaces are typically located near the main entrance or exit of the business, allowing customers to quickly park their vehicles, make their purchases, and then leave.

V. Parking Systems

There are many types of parking systems, including traditional lots or garages with attendants, meter-based systems, smart systems using sensors, valet services. Each has its own advantages and disadvantages.

A. Valet Parking

Valet parking is a service offered by many restaurants, stores, and businesses. In this system, an employee known as a valet will park your vehicle for you. The cost of this service may vary depending on the establishment and the length of time that you need to park. With valet parking, customers don't need to worry about finding a parking space on their own. This system also allows for efficient use of parking space, as the valet holds the keys to all of the parked vehicles. Additionally, valet parking can provide customers with a sense of security, as their vehicles are typically parked in a designated, secure area.

Limitations: Valet parking is generally more expensive than self-parking. Valet services may not be offered at all locations, and there may be wait times to retrieve your car. Additionally, valet services may not be able to accommodate certain types of vehicles.

B. Parking Meter System

A parking meter system is used to collect fees for public parking spaces. These systems involve the installation of parking meters, which regulate the amount of time a vehicle can be parked in a particular space. Drivers must pay the required fee at the parking meter and display the receipt on their dashboard. If they fail to pay or overstay the paid time, they may be subject to a parking ticket or fine. The system is designed to ensure fair and efficient use of parking spaces.

Limitations: One disadvantage of parking meters is that they may not accept newer forms of payment, such as mobile payment apps or digital wallets, which can be frustrating for users who prefer to pay for things electronically. Parking Meters typically have time limits, and enforcement measures

such as parking tickets may be in place to ensure compliance with the rules.

C. Parking Permit/Pass

A parking permit is a document that grants the right to park in a specific area or location. These permits are often issued by government agencies, schools, universities, or businesses to employees, students, or residents. Parking permits are used to manage parking space availability and ensure that only authorized vehicles park in a particular area. There are different types of parking permits, including residential, visitor, and employee permits, which may have restrictions or limitations on their use. Parking permits are usually displayed on a vehicle's dashboard or rear view mirror, or they may be scanned or checked by parking attendants or automated systems. Some permits may also be stored electronically and accessed through a mobile app or website.

Limitations: Parking permits can be expensive and may have limited availability, leading to frustration for those who rely on them. There is also a risk of abuse or misuse, which can lead to overcrowding and competition for parking spaces. Inconvenience and ineffectiveness in reducing congestion are also disadvantages of parking permits.

D. Compact car parking

Compact car parking is a solution that allows for efficient use of space in crowded urban or suburban areas. It is specifically designed for smaller vehicles such as subcompacts, compacts, and mid-sized cars. The spaces in a compact car parking system are usually narrower than traditional parking spaces, and they are often arranged in rows to maximize the number of vehicles that can be accommodated in a given area. In some cases, compact car parking may also include features such as electric vehicle charging stations or other amenities. This type of parking system is ideal for areas where space is limited and every square foot counts.

Limitations: Compact car parking may not be suitable for larger vehicles and can be difficult for inexperienced drivers. It may also increase the risk of damage to vehicles and may not be available in all areas.

E. Parking garages/Multi-level parking structures

Multi-level parking structures are parking facilities that have multiple levels or floors to park cars. They are commonly used in urban areas where space is limited. In a multi-level parking structure, cars are parked on different levels and drivers can access their cars using ramps or elevators. These systems often use ticketing or payment systems to manage the flow of cars. Multi-level parking structures can accommodate a large number of cars in a small area.

Limitations: Parking garages have limitations including high construction costs, space constraints, limited accessibility for people with mobility issues, lack of natural ventilation, and limited flexibility for future use.

F. Automated parking garages

Automated parking garages are parking facilities that use robots to park cars in a more efficient and space-saving way. In these systems, cars are typically driven onto a platform and lifted up by the robot, which then moves the car to an available parking space. The robot uses sensors and other technology to navigate the parking garage and avoid obstacles. Automated parking garages can reduce the amount of space required for parking and improve the speed and efficiency of the parking process.

Limitations: Automated parking garages can be expensive, complex, and limited in terms of vehicle size and flexibility. They also depend on technology and may have safety concerns due to the risk of malfunctions.

G. IoT based parking systems/Smart parking systems

IoT based parking systems use a network of connected devices and sensors to manage and control parking spaces. These systems can provide real-time information about parking availability, which can help drivers find available spots and reduce traffic congestion. The use of IoT technology allows for automatic and efficient allocation of parking spaces, improving the overall experience for drivers and parking managers.

Limitations: IoT based parking systems have several disadvantages, including high implementation costs, reliance on technology, data privacy concerns, limited accessibility, limited coverage, and limited compatibility with certain vehicles.

H. Online parking

Online parking is the process of booking a parking space through an online platform. It is offered by the facility owner or operator, or by a third-party service. Online parking is convenient for drivers as it allows them to easily locate and reserve a parking space in advance, which can be useful in high-demand areas. It can also reduce the amount of time spent searching for a parking spot and reduce congestion and emissions in areas with high vehicle traffic.

Limitations: Some of the limitations of online parking include fees for using the service, reliance on technology, data privacy concerns, and limited availability of spots. It is important for companies to be transparent about how they use and protect user data to address privacy concerns.

VI. Revenue from Parking

Revenue from parking refers to the money that is generated from the use of parking spaces, either through fees paid by drivers or through the sale of parking spaces or lots.

The revenue from parking can vary significantly depending on the location and type of parking facility. Some parking facilities, such as those operated by cities or other government agencies, may be designed to break even or provide a small profit, while others, such as private garages and valet services, may be designed to generate a significant profit.

Factors that can affect the revenue from parking include the number of available spaces, the demand for parking, and the cost of parking. Other factors that can affect revenue include the length of stay, discounts offered, and any additional services or amenities provided, such as car washing or charging stations.

In general, parking facilities in busy, urban areas with high demand for parking are likely to generate more revenue than those in less densely populated areas with lower demand. Private facilities may also generate more revenue than public facilities due to the ability to charge higher rates.

VII. Machine Learning in Parking

Machine learning has the potential to revolutionize the way we think about parking. With the use of predictive algorithms, drivers can more easily find available parking spots and parking operators can optimize the allocation of spaces to improve utilization and reduce the need for additional infrastructure. Additionally, machine learning can be used to predict occupancy levels and optimize pricing strategies, helping to increase revenue for parking operators and improve the overall efficiency of the system. Finally, machine learning can be used to predict traffic patterns and congestion, allowing drivers to avoid congested areas and reducing the overall amount of traffic on the roads. Overall, the use of machine learning in parking has the potential to greatly improve the experience of both drivers and parking operators, and to help reduce congestion and improve the utilization of resources.

VIII. Conclusion

In conclusion, the literature reviewed in this paper explores the issue of limited parking in urban areas and presents a range of potential solutions for optimizing the utilization of parking spaces. These solutions aim to increase the availability of parking, enhance the efficiency of parking, and alleviate traffic congestion in cities. The research also emphasizes the importance of considering various factors such as cost, demand, accessibility, and sustainability in the planning and policy development of parking systems. Overall, the literature suggests that innovative and comprehensive approaches are necessary to address the increasing demand for parking in urban areas and promote sustainable growth.

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