applied sciences

MDPI

Review

A Systematic Review of Computer Vision and AI in Parking Space Allocation in a Seaport

Hoon Lee [1], Indranath Chatterjee [2,3,*] and Gyusung Cho [4]

[1] Logistics System Institute, Total Soft Bank, Ltd., Busan 48002, Republic of Korea; hlee@tsb.co.kr
[2] Department of Computer Engineering, Tongmyong University, Busan 48520, Republic of Korea
[3] School of Technology, Woxsen University, Hyderabad 502345, India
[4] Department of Port Logistics System, Tongmyong University, Busan 48520, Republic of Korea; gscho@tu.ac.kr
* Correspondence: indranath@tu.ac.kr; Tel.: +82-010-4395-1186

Abstract: Urban expansion has ushered in a landscape of opportunities and challenges across housing, transportation, education, health, and the economy. In response to these evolving dynamics, the application of artificial intelligence (AI) and computer vision (CV) technologies has emerged as a transformative solution. While smart traffic monitoring and advanced parking distribution systems have eased urban pressures, optimizing mobility remains pivotal in the context of burgeoning smart cities. However, the seaport industry grapples with formidable issues in the efficient transport of containers. In light of this, the fusion of AI and CV technology holds promise as a solution. This study pioneers a systematic review, representing a novel exploration, delving into a comprehensive evaluation of the existing literature. It scrutinizes the profound advantages AI and CV offer in constructing sustainable, efficient parking ecosystems within seaports. Our methodological approach encompasses data collection, rigorous quality assessment, and meticulous exploration of the application of CV and AI in the realm of smart parking management. The findings underscore the pivotal role of AI and CV technologies in the development of efficient, sustainable transportation systems, particularly for optimizing container movement within seaports. This research presents a comprehensive analysis of the literature in the area of the application of AI and CV technologies in optimizing parking management at seaports, shedding light on the potential for sustainable transportation solutions in this critical domain. As these technologies usher in enhancements in traffic management, parking space allocation, and container logistics within seaports, this study represents a vital and timely contribution to the field, serving as a cornerstone for future innovations in seaport management and the broader context of smart cities.

Keywords: port management; computer vision; deep learning; machine learning; artificial intelligence (AI); parking space allocation

check for updates

Citation: Lee, H.; Chatterjee, I.; Cho, G. A Systematic Review of Computer Vision and AI in Parking Space Allocation in a Seaport. *Appl. Sci.* **2023**, *13*, 10254. https://doi.org/10.3390/app131810254

Academic Editors: Mehmet Aydin, Yong Yue and Xiaohui Zhu

Received: 24 July 2023
Revised: 3 September 2023
Accepted: 11 September 2023
Published: 13 September 2023

1. Introduction

Urbanization has brought about numerous opportunities and challenges in various sectors, such as housing, transportation, education, health, and the economy, as highlighted by Ke et al. (2020) [1]. These opportunities and challenges have led to rapid changes in human behavior. To address the challenges, artificial intelligence (AI) and computer vision (CV) tools have been implemented in fields such as health, education, housing, and transportation. The Oxford Learner's Dictionary defines AI as "the study and development of computer systems that can copy intelligent human behavior" [2]. Hence, the need of the hour is a machine that can replicate human intelligence to solve various problems.

A review study on smart cities by Winkowska (2019) [3] suggests that the term smart city has been described as a digital city, information city, sensing city, and more. According to the review, a smart city comprises six main elements: smart economy, smart mobility, smart environment, smart people, smart living, and smart governance. Among all elements, smart mobility is a crucial component of a smart city. In designing sustainable and effective transportation systems in a smart city, the increasing number of automobiles poses a challenge. Traffic management and parking space allocation become problematic. Hence, smart traffic surveillance and parking space allotment systems have been introduced, as highlighted by Ke et al. (2020) [1]. A survey by Turjman et al. (2019) [4] on smart parking indicates that it takes approximately 107 h per year to find a parking spot in New York City. However, with technological advancements, on-road traffic can be managed, and space can be allocated in random parking areas.

For a city to be truly 'smart', all areas must be well-developed and equipped with technology. Thus, this study focuses on the need for AI and CV in seaports. The transportation of containers between storage spaces and cargo ships is a significant challenge in any seaport. The lanes between the stacks of containers are narrow, and heavy-duty trucks often cause traffic congestion. With globalization and the increasing import and export of goods, seaports have become busier day by day [4,5]. Therefore, optimizing the space allocation in seaports using AI and CV techniques can improve overall efficiency.

Smart cities have arisen as a solution to these difficulties, utilizing technologies such as AI and CV to improve people's quality of life. Despite substantial progress in smart city development, the primary focus has been on upgrading city transportation systems. Smart city technology, on the other hand, must be expanded to encompass seaports, which are key components of the global economy. Seaports play an important role in the transportation of products, and optimizing space allocation within them can have considerable efficiency and sustainability benefits [6]. As a result, the purpose of this research is to investigate the use of AI and CV techniques in seaport parking management and provide a thorough knowledge of their potential benefits.

In contrast to the development of smart cities, which often focuses on enhancing transportation systems inside urban regions, this study investigates the potential of AI and CV as tools for optimizing traffic management and space allocation at seaports [7]. This study aims to shed light on the benefits of AI and CV in managing seaport parking to streamline space allocation and traffic flow.

Seaports stand as critical nodes in the global economy, facilitating the movement of goods and contributing significantly to international trade [8]. However, the efficient operation of seaports is beset by a unique set of challenges, many of which revolve around parking space allocation and traffic management. In this study, we delve into these seaport-specific challenges, shedding light on their urgency and relevance to our study.

(a) **Narrow Lanes Between Container Stacks:** One of the primary challenges faced within seaports is the limited space available for the movement of heavy-duty trucks and cargo transport vehicles. The narrow lanes between towering stacks of containers present a logistical bottleneck [9]. Maneuvering through these confined spaces not only consumes time but also elevates the risk of accidents and damage to valuable cargo.
(b) **Heavy-Duty Truck Congestion:** Seaports are bustling hubs of activity, with an incessant flow of heavy-duty trucks ferrying containers to and from cargo ships [10]. This constant stream of vehicular traffic often leads to congestion, causing delays in cargo handling and impacting the overall efficiency of seaport operations.
(c) **Global Significance of Seaports:** Seaports are the lifeblood of international trade, playing a pivotal role in the transportation of goods across borders. As globalization continues to expand, the importance of seaports in sustaining the global economy cannot be overstated. Any disruption or inefficiency in seaport operations reverberates worldwide, affecting trade, economies, and supply chains on a global scale.

Understanding the unique challenges faced by seaports in parking space allocation and traffic management is essential to appreciate the critical role that AI and CV technologies can play in mitigating these issues. By addressing these challenges effectively, our research aims to contribute to the enhancement of seaport efficiency, sustainability, and their role as a key driver of global economic growth.

Beginning with a survey of the pertinent literature on the use of AI and CV in parking management and smart cities, the research sets forth precise objectives to achieve this goal. The second objective is to determine the problems with traffic control and geographical distribution at seaports. The third objective is to investigate how AI and CV might be used to optimize space usage and traffic flow at seaports. Reviewing previous studies and case studies on the use of AI and CV in managing seaport parking is the fourth objective. The article concludes by outlining potential research areas and applications for AI and CV in managing seaport parking.

Additionally, this paper provides a thorough examination of the advantages of AI and CV in designing sustainable and efficient parking systems. Data gathering and quality evaluation, an investigation of CV and AI in smart parking management, and a discussion of parking spot distribution are all part of this. The findings are analyzed and prospects for future studies are emphasized by summarizing the studies included in this research. Finally, this article contends that AI and CV have the potential to greatly enhance traffic management and space allocation in seaports, resulting in large efficiency and sustainability gains for the global economy.

2. Methodology: Conducting a Systematic Review

2.1. Purpose and Scope of the Systematic Review

A systematic review is a meticulous and structured examination of existing literature on a specific research topic or question. Its purpose is to identify, select, and synthesize relevant research, providing an unbiased and thorough summary of available knowledge comprehensively and transparently. In this section, we delineate the purpose and scope of our systematic review [11].

2.2. Adherence to PRISMA Guidelines

To ensure transparency and rigor in our systematic review, we rigorously adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [12]. PRISMA offers a standardized checklist that enables clear and complete reporting of the systematic review process. This encompasses defining the research focus, formulating a search strategy, selecting studies, extracting data, and synthesizing results.

2.3. Research Scope and Keywords

In this systematic literature review, we carefully defined our research target and employed a set of essential keywords: 'AI', 'CV', 'parking', and 'seaport'. Additionally, we incorporated related terms and phrases such as "AI and its role in smart parking", "The Role of CV in Parking Systems", and "AI-Assisted Smart City Planning". Furthermore, we extended our search to encompass articles addressing the "importance of seaport parking", the "role of AI and CV in seaport parking", "AI and seaport parking", and "CV and AI in maintaining seaport parking".

2.4. Search and Selection Process

2.4.1. Initial Manuscript Selection

The initial selection of manuscripts was rigorously based on an evaluation of their titles and abstracts. Manuscripts whose abstracts explicitly discussed the significance and role of AI in parking systems or elaborated on how AI and CV contributed to the enhancement of parking system efficiency were selected for further review. Multiple platforms, including Google Scholar, ScienceDirect, Scopus, and IEEE Xplore, were instrumental in conducting our study. To ensure the inclusion of the most current and pertinent information, our search was confined to articles published between 2013 and 2023.

2.4.2. Manuscript Identification

Our initial search yielded 92 relevant studies within the first 10 pages of Google Scholar. To comprehensively assess the available literature, we extended our search to encompass ScienceDirect, Scopus, and IEEE Xplore. However, it became evident that many of the additional manuscripts discovered on these platforms replicated those found on Google Scholar. In total, we identified 60 manuscripts related to the exploration of AI and CV in parking space allocation.

2.4.3. Rigorous Review and Inclusion Criteria

Inclusion Criteria

Our systematic review applied stringent inclusion criteria based on the following strong and valid reasons:

(a) **Relevance to Research Focus**: Manuscripts were included if their abstracts directly addressed the role and importance of AI in parking systems or demonstrated the impact of AI and CV on the efficiency of parking systems. This criterion ensured that the selected studies closely aligned with our research focus.
(b) **Methodological Rigor**: Inclusion criteria required that studies exhibited robust methodological rigor, adhering to rigorous research methodologies. This criterion aimed to uphold the overall quality and reliability of the included literature.
(c) **Publication Date**: To maintain relevance and ensure the inclusion of recent developments, our search encompassed articles published between 2013 and 2023.

Exclusion Criteria and Reasons

Equally important, our systematic review employed exclusion criteria accompanied by valid reasons:

(a) **Irrelevance to Research Focus**: Studies that did not directly engage with the role of AI in parking systems or were not closely aligned with our research focus were excluded. This criterion ensured that all included studies directly contributed to our research question.
(b) **Methodological Flaws**: Manuscripts with evident methodological flaws or inadequacies in research quality were excluded. This strict criterion aimed to uphold the overall quality and reliability of the included literature.
(c) **Publication Date**: To maintain relevance and currency, studies published before 2013 or after 2023 were excluded.

2.4.4. Final Selection and Exclusion Statistics

Following the application of inclusion and exclusion criteria, we meticulously reviewed and selected 50 studies that aligned with our research objectives. These studies formed the core dataset for our systematic review. Additionally, we excluded 10 studies that did not meet the predefined criteria.

2.5. Data Extraction Process

2.5.1. Addressing Limited Directly Related Papers

The data extraction process encountered challenges due to the limited number of directly related papers. To effectively address this challenge, we structured our work into two distinct subtopics:

(a) The application of AI and CV in various parking systems
(b) The role of AI and CV in seaports within smart cities

2.5.2. Collaborative Data Extraction

For each study included in our systematic review, a systematic extraction process was employed to collect comprehensive information. This included categorizing the type of parking area, outlining proposed solutions, specifying the AI and CV techniques applied, and summarizing key findings. Collaboration among team members was instrumental in constructing Tables 1 and 2, where complex and challenging papers were collectively assessed.

Table 1. Summary of all the selected manuscripts on parking systems for on-road vehicles.

Author	Year	Type of Study	Parking Space	Explanation/Solution/Conclusion
Chandrasekaran et al. [13]	2022	Prototype	Random parking spaces	Proposed a CV model built on the Django framework written in Python 3.0 for space allotment in random parking areas.
Ke, R et al. [1]	2020	Experimental	Public parking garage	Processes the real-time videos from the CCTV using edge computing and AI
Ruili et al. [14]	2018	Experimental	University car parking	The proposed solution includes multiple technologies such as AI, image processing, and ultrasonic sensors. The algorithm is built using big data analysis and a neural network system.
Sudhakar et al. [15]	2021	Comparative and analytical study	Smart parking system for public places	After identifying problems in the smart parking system, the use of AI and machine learning was suggested for optimizing the system.
Fahim, A et al. [16]	2021	Review	Numerous smart parking systems	Systematically describes all approaches used by various researchers to build a smart parking system for on-road vehicles.
Barriga, J. J. et al. [17]	2019	Review	Various e-parking and smart parking systems	Retrieved and analyzed multiple manuscripts. The authors concluded that techniques such as low power wide area networks (LPWANs) are used; however, the sensors used in smart parking systems have some disadvantages.
Yigitcanlar, T. et al. [18]	2020	Review	AI in building a smart city and its parking system	The authors opened a viewpoint on technocentric solutions but also highlighted the variety of risks associated with it.
Antoniou, C. et al. [19]	2018	Research article	Indoor parking system	The study mentions and proposes a framework to reduce the risk for large-scale indoor parking facilities and depots.
Xiang, Z. et al. [20]	2022	Research paper on the smart parking system	Car parking in a multilevel parking system	The researchers studied and designed an efficient car parking system using ARM and ZigBee. This system reads the number plate and records if the parking space is available or not. Ultrasonic sensors are also used to identify vacant and used parking places.
Qadir, Z. Al-Turjman, F. Khan, M. A., & Nesimoglu, T. [21]	2018	Conference publication on ZIGBEE used in the smart parking system	Public parking areas such as shopping malls, hospitals, and offices	ZIGBEE is efficient when compared with WI-FI and Bluetooth technologies. Saved time and contributed to lower emissions of CO_2.
Krieg, J. G. et al. [22]	2018	Experimental Study	Proposed for city hall (no pilot testing done)	Proposed a model named SmarPark. It is a smartphone-based model that not only helps in identifying a parking space but also makes it available once the vehicle is pulled out. The authors have also added a feature where the driver can enter the parking spot number and later easily find the vehicle.
Aydin, I., Karakose, M., & Karakose, E. [23]	2017	Research article on navigation and reservation in the parking system	Office and public parking area	With the help of the IoT, the authors have built a model that helps in navigation and reserving a parking slot in advance. They have also used genetic algorithms. The authors claimed that their model delivered accurate results.

Table 2. Summary of all the selected manuscripts about seaports.

Author	Year	Type of Study	Problem	Explanation/Solution/Conclusion
Jin Z et al. [24]	2021	Numerical and comparative Study	Lane allocation at seaports	Prioritize the trucks taking and bringing containers. Construct more lanes for traffic management.
Torkjazi, M. et al. [25]	2018	Numerical experiment	Seaport–truck appointment system	Addressed challenges in designing a truck appointment system. Proposed a numeric hypothetical network where the impact of TAS is reduced on both terminal and drayage operations. There are limitations to this study.

Table 2. *Cont.*

Author	Year	Type of Study	Problem	Explanation/Solution/Conclusion
Agatić, A., & Kolanović, I. [26]	2020	Review	Digital technologies at seaports	Studied and concluded the advantages of using digital technologies at seaports. The authors highlighted the use of technologies such as IoT, ML, AI, various sensors, and twin technologies for optimizing seaport services.
Yeo, G. T. et al. [27]	2015	Survey and proposed a model for Korean container ports	Port service quality	The authors surveyed 313 members of the Korean Port Logistics Association and concluded with partial least squares structural equation modeling (PLS-SEM) that will help in keeping a check on customer satisfaction.
Heilig, L., & Voß, S. [28]	2017	Comprehensive survey	Information systems in seaports	Reviewed all the possible ports and concluded how various information systems are optimizing the seaports. Starting from gate allotment to truck to container recognition, from vessel traffic control to seaport communication, the authors have mentioned every detail. However, the authors also mentioned that there is still a need for multidisciplinary research for optimizing seaports.
Carlan, V. et al. [29]	2017	Analytical study of 32 innovation cases of information and communication technology (ICT).	Digitalization in the sector	The study mentions a truck appointment system where the driver informs about their arrival and details in advance through an e-portal. This avoids long queues at the gate.
Jović, M. et al. [30]	2022	Thematic review analysis	Is digitalization in seaports good or not	The authors have concisely selected and analyzed different digitalization systems in seaports. However, the authors mentioned the risk of scooping and manipulation of data.
Ma, M., Fan, H., Jiang, X., & Guo, Z. [31]	2019	Research and proposed vessel-dependent time windows (VDWT) model	Reducing long queuing at the gate	Using the hybrid genetic algorithm, the authors have built a new model named the 'vessel-dependent time window'. In this, the trucks book their arrival time, which is used in lane allotment and container shifting.
Carlan, V et al. [32]	2019	Research	Truck guidance systems using digital techniques in seaports	The study encourages the installation of a truck guidance system in the seaport because once the truck is dispatched for container collection or delivery the truck should have information about parking availability, container area, and the queue at the gate.
Othman, M. R. [33]	2021	Research article	Examining the quality of seaports while they adopt changes for Industrial Revolution 4.0	Malaysia Seaport has adopted various changes for IR 4.0. Hamburg Port authorities have adopted a cyber-physical system named 'SmartPort'. This helps in making the seaport digital and work in real-time.
Shiri, S., & Huynh, N. [34]	2016	Research article on drayage optimization	Optimization of the drayage system at seaports.	The authors have identified the need to optimize the drayage system at the seaport. They have proposed a model where the trucks must make an appointment and each truck is given a time window. The driver must pick up and deliver the container in that specific time window.
Heilig, L., Lalla-Ruiz, E., & Voß, S. [35]	2017b	Research article	Optimization of inter-terminal truck routes to avoid traffic	The authors highlighted a major issue. Inside the port, the containers are constantly moved from one place to another. Therefore, it is necessary to optimize the lane and truck routes in a way that there is no traffic inside the seaport. The authors proposed a model using two greedy heuristics and two hybrid simulated annealing algorithms. The model was able to improve routes within seconds at the port of Hamburg.

Table 2. *Cont.*

Author	Year	Type of Study	Problem	Explanation/Solution/Conclusion
Yi, S. et al. [36]	2019	Research article	Scheduling trucks that took an appointment to avoid congestion	The authors highlighted that when making an appointment, many trucks can select the same arrival time; therefore, it is important to make a schedule. The authors formulated a mathematical model and a heuristic algorithm based on the Frank–Wolfe algorithm for making a schedule in minutes for all trucks.
Meisel, F., & Bierwirth, C. [37]	2013	Research article	Framework for scheduling the cranes in seaports	The study proposed a three-phase model for crane allocation using famous heuristics. In phase 1, the crane productivity is estimated. In phase 2, the crane is assigned to a berth, and in phase 3 the decision is cross-checked. The authors claimed that their proposed model is cost-efficient.

This comprehensive approach ensures that our research adheres to best practices in systematic literature review methodologies, bolstering the rigor, transparency, and reliability of our study. The inclusion and exclusion criteria were thoughtfully defined, and their application was meticulous, based on strong and valid reasons. Figure 1 provides a comprehensive overview of the research framework presented in this paper. It encompasses the entire plan of the work, starting from the initial planning phase through to the selection and exclusion criteria for the literature review study, followed by the review and discussion of findings. Additionally, this figure highlights the scope of future work, offering a visual representation of the systematic approach undertaken in this research. This approach ensures the quality, relevance, and timeliness of the studies included in our systematic review, ultimately contributing to the robustness of our research findings.

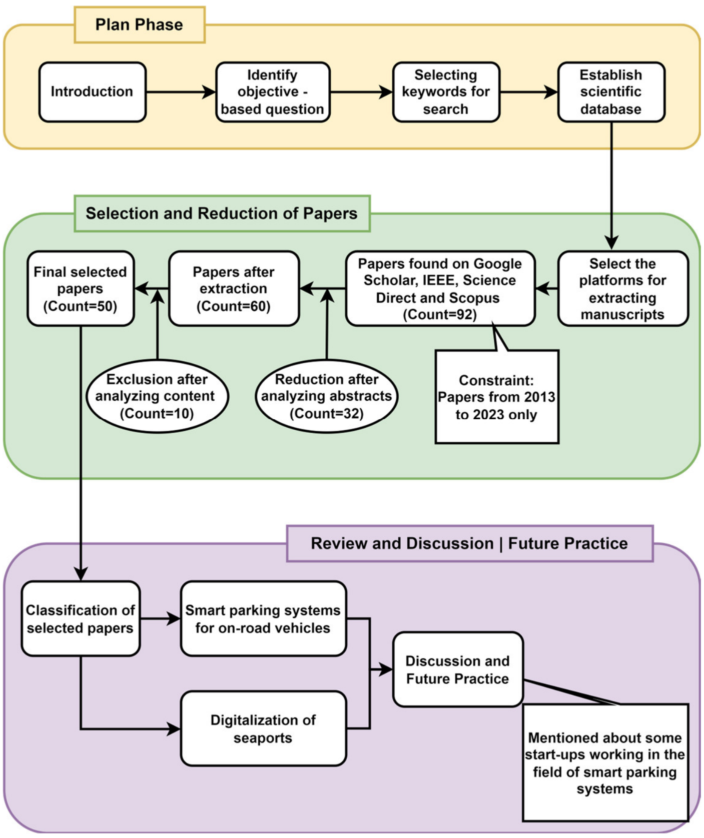


Figure 1. Research framework overview: A visual representation of the research framework, spanning from initial planning to selection criteria, review, and future work scope.

3. Computer Vision and AI in Parking Space Allocation

Several studies have explored the use of computer vision (CV) and artificial intelligence (AI) to manage parking spaces. Chandrasekaran et al. (2022) [13] proposed a prototype model that uses CV built on the Django framework in Python 3.0. The authors discussed various studies and emphasized how the use of CV could be advantageous in identifying occupancy in parking slots. According to their prototype, users can be informed about the available slots in the parking area for a selected time duration through video capturing using CCTV cameras. It's worth noting that their prototype is based on school and university parking areas.

Another study by Ke et al. (2020) [1] explored the feasibility of using edge computing and AI to identify space in the parking area. The prototype used real-time video feeds from CCTV cameras in the Angle Lake Parking Garage to allocate space in the garage. The authors achieved an accuracy of 95% in real-time scenarios.

As previously mentioned, a driver in New York City spends approximately 107 h per year searching for a parking spot while driving, which becomes even worse during peak hours [22]. Finding a parking spot manually in a multilevel parking garage is tough and leads to air pollution. Therefore, using AI and CV for the same is advantageous.

The next question is which CV or AI technologies should be used for managing parking slots effectively. Researchers have suggested that technologies such as image processing and analysis, object detection and recognition, machine learning, deep learning algorithms, and real-time monitoring and control systems have been working effectively in space allotment in different parking areas.

Sudhakar et al. (2021) [15] developed a smart parking system integrating image processing with AI and machine learning. The researchers identified various problems in a smart parking system and resolved them using AI and ML. Their model detects a vehicle at the entrance and enters the details of available slots. If there are no slots available, it will say 'Parking Full'. If there are slots available, the model will capture the number plate and open the entrance gate. On reaching the parking spot, the system will update itself with the date and time, and once the vehicle leaves, it will capture the date and time. Using machine learning, the authors calculate the parking charges, and once a payment is made, the entrance gate opens for the vehicle to leave.

Similarly, Kaur J. (2019) [38] used automatic license plate identification (ALPI) using image processing technology while designing a smart parking system. With the help of imaging processing and machine learning techniques, the authors successfully demonstrated how the model works. However, it was a pilot study, and scaling this study needs more details.

Ruili et al. (2018) [14] built a smart parking system using image processing (reading number plates), AI, machine learning, big data, and neural networks. Ultrasonic sensors extract data on available parking spaces for parking a vehicle. Despite the advantages of using AI, CV, and machine learning in allocating space in parking areas, this system still has limitations. One limitation is the weather conditions when using sensors. The second is coverage. When using techniques such as AI and big data or machine learning, all data gets stored on the cloud, which must be strongly protected against hackers. A simple bug in the model could lead to complete model failure.

The use of CV and AI technology has shown to be advantageous in properly managing parking lots. Researchers have developed several models that include image processing, machine learning, and deep learning algorithms to identify car occupancy, distribute parking spaces, and compute parking rates. Nevertheless, these systems have limits, such as weather conditions and data security concerns, that must be addressed. Further research and development are required to scale up these models and make them more dependable and secure for use in real-world applications.

4. Parking Space Allocation in Sea Ports

With the rise of globalization and the smart city concept, seaport industries are expanding at an unprecedented rate. To increase efficiency and profitability, seaports are increasingly implementing digital technologies [26].

The application of the "simple shuttle problem" has been highlighted for distribution problems in seaports [39]. Seaports are more than just places for cargo import and export, they also involve loading and unloading goods, warehousing, storing, shipment, packing, and delivery. Due to the added value of seaports, any delay in the process could lead to significant losses and time consumption.

In a detailed study on how Malaysia's seaports developed and embraced IR 4.0, Othman (2021) [33] highlighted the adaptations made by Hamburg Port authorities to accept IR 4.0. The port authorities have coined the term "SmartPort" to refer to their adaptation to IR 4.0. The "SmartPort Logistics" feature manages internal truck parking areas in the port, and the "SmartPort Monitor" enables easy accessibility to all essential data necessary for port optimization.

However, the design of a seaport is very compact in nature, and the internal traffic and parking management of trucks remains a significant challenge. Long queues of trucks in seaports are a common problem [24]. The authors have proposed a lane allocation framework to manage truck allocation and traffic. By implementing a truck appointment system and lane allocation planning, the flow of trucks in the seaport could be optimized. The authors have identified four types of trucks in a seaport: those sending loaded containers, those sending empty containers, those taking loaded containers, and those taking empty containers. They have divided the lanes in the port accordingly. At the gate, there are four lanes, and during a given time duration, one lane opens for one type of truck while the other three lanes are open for the remaining type of truck.

Optimizing the truck parking system at a seaport could be improved if the storage of different containers is performed more effectively. Researchers have used various models for efficient container storage in seaports. Moreno et al. (2012) [40] highlighted the difficulties faced in a multiproduct manufacturing factory in labeling and storing products. The authors used a mixed-integer linear programming model to optimize tank allocation and storage. Similarly, there are several studies on how to solve the supply vessel scheduling problem, also known as the periodic supply vessel planning problem (PSVPP) [41]. Along with many other authors [42], Kisialiou (2018) [41] proposed the use of heuristic algorithms for optimizing container storage systems. All these studies had one thing in common: constraints. Space allocation of containers was based on size, weight, color, and destination. Positive results were seen in several studies, including a case study of the Port of Montreal in Canada [43]. Their objective was to optimize the container terminal, and they proposed a new layout by adding new pathways and some new handling equipment, such as an electric straddle carrier. Abu Aisha et al. (2020) [43] successfully achieved their objective by reducing transportation costs and CO_2 emissions.

Container storage optimization is an important component of seaport optimization since it has a substantial influence on a port's efficiency and productivity. Furthermore, the truck parking system at a seaport is a crucial aspect that might generate traffic congestion during peak hours.

The Port of Hamburg [26] has utilized digitalization to continuously monitor parking spot availability. While the port now employs radar technology to locate ship parking places, they are also attempting to optimize the intermodal traffic produced by trucks and other vehicles. The port employs a variety of sensors to monitor all of its assets, including cranes, trucks, and carriers, allowing it to apply AI and computer vision technology to enhance port operations and traffic management.

AI and computer vision technology [44] can help optimize seaport operations and traffic management by giving real-time information on traffic congestion and container storage capacity. Using this data, port managers may make informed decisions regarding truck routing and scheduling, reducing traffic congestion and increasing overall port efficiency. Furthermore, AI and computer vision technologies can improve port safety by detecting potential hazards, such as incorrect container stacking, and alerting operators to the need for corrective action. Furthermore, these technologies may help in the predictive maintenance of port equipment, ensuring that it is always functioning at optimal efficiency, reducing downtime, and increasing production. Figure 2 displays a typical schematic diagram of the lane parking while loading and unloading the container from the truck to the container stacks. However, Figure 3a,b show the real photographs of Busan Seaport showing the real-time congestion created by the incoming container trucks, waiting for the loading and/or unloading of containers in the terminal.

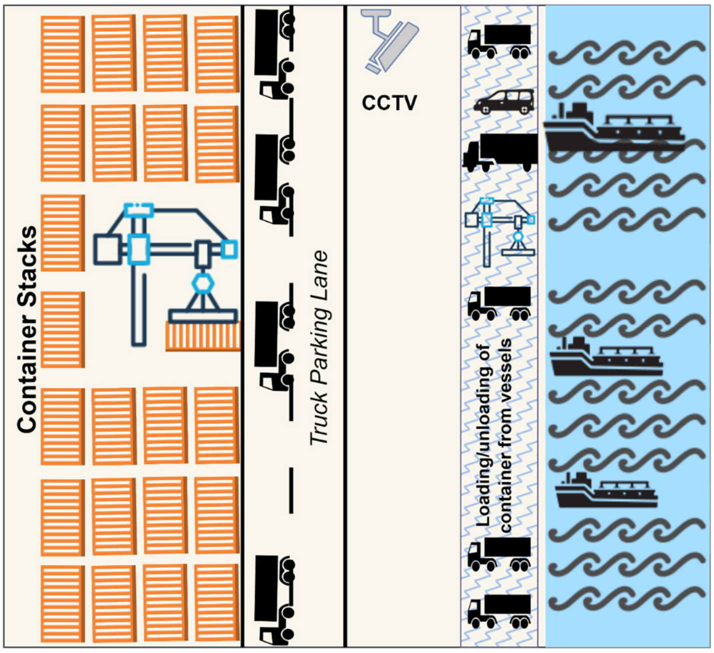
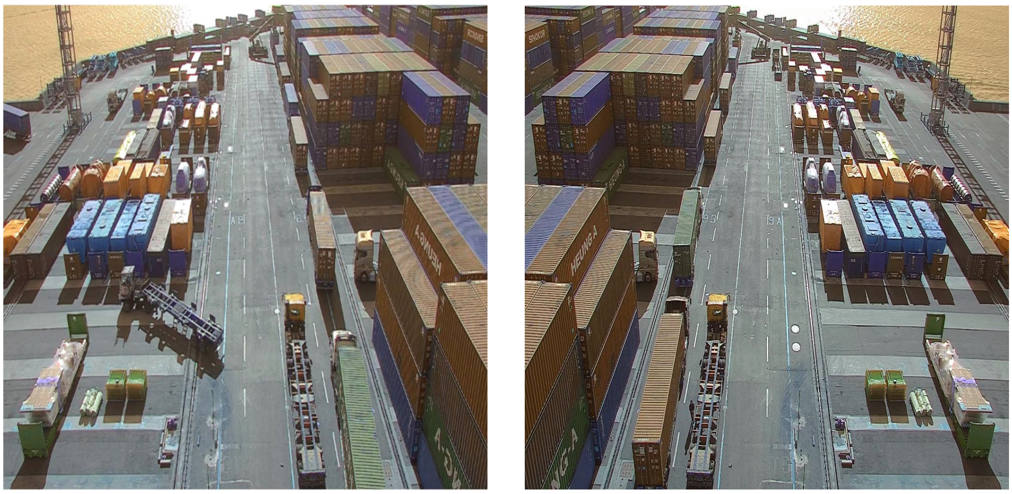


Figure 2. A parking space allocation scheme in a seaport.



(**a**) (**b**)

Figure 3. (**a**,**b**): Real photographs showing the congestion created by incoming container trucks for loading/unloading containers in the terminal. These pictures were taken by a CCTV camera located at a seaport in Busan, South Korea. Data Source: Total Soft Bank pvt ltd, South Korea.

Seaport optimization, in essence, demands an integrated strategy that considers all aspects of port operations, such as container storage, traffic control, and equipment maintenance. By using AI and computer vision technologies, port authorities may improve the efficiency, safety, and productivity of their operations, resulting in a better overall experience for all stakeholders involved in maritime activities.

5. Critical Appraisal of the Contribution of Key Studies

We believe that we have identified and selected 50 highly relevant papers for our systematic review based on a comprehensive search and analysis of several academic databases, including Google Scholar, IEEE Xplore, Scopus, and ScienceDirect. The thoroughness with which we analyzed this research confirmed the scientific legitimacy of our results and conclusions.

Table 1 provides a thorough tabular representation of all relevant data on smart parking systems, offering a variety of parking space distribution algorithms that may be used for various parking places, including seaports. The table is an invaluable resource for smart parking system academics and practitioners alike.

We summarized all important publications on seaport optimization in Table 2, stressing the critical role that technology plays in enhancing efficiency, safety, and environmental sustainability in seaport management. Our research emphasizes the need for port authorities to use digitization in their operations to remain competitive in the global market.

Several technologies typically employed in road parking or multilane parking systems for road vehicles that can be used to improve seaport infrastructure and reduce traffic congestion were also discovered during our analysis. Better parking spot allocation and traffic management may be achieved by adding CV and AI into smart parking systems, resulting in reduced congestion, fuel use, and carbon emissions.

Furthermore, we have covered significant CV and AI technologies that may be applied in seaports to improve parking space allocation, such as multitask learning, sensor data fusion, and integration with navigation systems. Our analysis presents practical solutions that port authorities and other stakeholders may use to optimize seaport operations and improve efficiency, safety, and sustainability by offering insights into the potential advantages and constraints of these technologies in seaport settings.

Our in-depth examination provides evidence-based insights into the use of smart parking systems and seaport optimization technologies, as well as their potential advantages in seaport operations. We hope that our findings will be beneficial to scholars, politicians, and port authorities as they work to enhance seaport efficiency, safety, and environmental sustainability.

6. Discussions

After analyzing the relevant literature, it is clear that various CV and AI applications have successfully been implemented for on-road vehicle parking systems. Sensors play a crucial role in any smart parking system, and therefore, it is recommended to use microelectromechanical sensors due to their low energy consumption, cost-effectiveness, and high performance [45]. Among the different sensors available, ultrasonic and camera sensors are the most commonly used, as they accurately identify parking spaces for vehicles [1,17,46]. Qadir, Z., Al-Turjman, F. Khan, M. A., & Nesimoglu, T. (2018) [21] conducted a study where they compared different sensor technologies such as Bluetooth and Wi-Fi with infrared sensors and found that infrared sensors reduce time and CO_2 emissions, making them an efficient choice for smart parking systems.

If the sensors effectively collect the required information, it is the software that performs all processing. In various studies, different software solutions such as information management, prediction models, and e-booking models have been discussed for on-road vehicle smart parking systems. Barone, R. E. et al. (2014) [47] developed a system that used a webpage for booking parking spaces in real-time situations, which was only possible due to effective information management. However, since it uses cloud storage to store data, the risk of cyber-attacks is high. Taherkhani, M. A., Kawaguchi, R., Shirmohammad, N. & Sato, M. (2016) [48] proposed an e-booking or reservation model for driverless cars, allowing the driver to reserve a parking space in advance. Nieto, R. M. et al. (2018) [49]

developed a smart parking system that can be installed with existing cameras. In their proposed model, data from all cameras are used to compose a final parking matrix, and empty spaces are not colored. Prediction models are another type of software used in smart parking systems.

In a survey conducted by Al-Turjman, F. & Malekloo A. (2019) [4] on IoT-enabled cities, the importance of embedding sensors in vehicles and the city's infrastructure for smart parking systems was highlighted. The authors analyzed several studies and found that not all smart parking designs are thoughtfully designed; therefore, to achieve more efficiency, smart city planners should opt for conceptual hybrid parking systems.

Using the right sensors and software is crucial for the development of an efficient on-road vehicle smart parking system. While various sensors and software solutions have been discussed in the reviewed studies, it is important to choose the most suitable one based on the requirements and limitations of the project. Additionally, smart city planners should consider hybrid parking systems to achieve maximum efficiency.

After reviewing the relevant studies on on-road vehicle parking systems, it became imperative to investigate the advancements made in managing seaports. Several papers discussed the digitalization of seaports, including the decision by Malaysia Seaport Development to align with Industrial Revolution 4.0 [33]. The authors examined the advantages and disadvantages of the cyber-physical system named 'SmartPort', which manages container and asset management, among other things. Further research revealed that ports are currently employing AI, ML, and CV to optimize container and crane management and reduce queues at the gate. The Korean Port Logistics Association utilizes a particular model for port service quality. However, to the best of our knowledge, no paper explicitly mentions the use of AI and CV in managing trucks inside the port during container delivery or pickup.

Despite several studies on the significance of seaport digitalization, one critical problem remains unaddressed: truck traffic management inside seaports. Studies discussing lane and container allocation fail to consider the port's infrastructure, where narrow lanes near the containers could cause significant delays [50]. The COVID-19 pandemic brought a significant shift towards digitalizing seaports, with AI and CV playing critical roles in maintaining port efficiency and productivity, as suggested by Jeevan J. (2020) [51] in their research on Johor Port and the Port of Tanjung Pelepas.

In 2022, Caldeirinha V. (2022) [52] reiterated the importance of AI in supply chain management and highlighted the challenge of ensuring the information reaches the intended recipients within the required timeframe.

Container storage allocation is a critical aspect of container handling operations in seaports [53]. Proposed approaches and techniques, such as optimization models, heuristic algorithms, and machine learning techniques, have shown promising results in enhancing container handling operation efficiency. However, further research is needed to investigate their effectiveness under different scenarios and address the limitations associated with each approach. Real-time location tracking of all objects in seaports is crucial. Therefore, after reviewing significant manuscripts, it is necessary to add a GPS setting to all trucks to control their movement in and out of the port.

6.1. Start-Ups in the Field of Smart Parking Solutions at the Seaport

Several start-ups have developed in the sector of smart parking solutions in recent years, offering novel products and services to increase the efficiency and efficacy of seaport parking [54]. 'CUROPark', an Indian start-up, provides a variety of smart parking options. Their CUROPark Harbour system is particularly developed for seaports, and it assigns parking places based on the kind of container. The system employs several sensors, and the data is analyzed using AI to give real-time parking spot assessments. Parking heavy-duty trucks in seaports is becoming easier and more efficient thanks to 'CUROPark'.

In a similar vein, a start-up has launched a test project at the Port of Barcelona, where AI is used to identify wagons and containers. This concept requires more development and assessment, but it has the potential to improve the efficiency of parking at seaports.

Several start-ups have developed in recent years to provide smart parking solutions for seaports. These techniques aim to enhance overall harbor operations, reduce congestion, and boost parking allocation efficiency. Seaports can use "Parknav", for instance, which offers an AI-powered parking navigation system. Their system uses machine learning to forecast parking demand, identify free spaces, and direct vehicles to them. Additionally, the system provides real-time information on occupancy rates and parking availability, which may help seaport management make better choices and optimize parking allocation. Another firm, "ParkPow", uses artificial intelligence and computer vision to enable automated parking and reduce the amount of time and effort required for drivers to find parking spaces. Their system uses cameras and sensors to find vacant parking spaces and direct vehicles to them.

Furthermore, smart parking solutions are not restricted to startups. Smart parking systems for seaports have also been developed by established firms such as Siemens and Cisco. Siemens has created a "Smart Parking System" that detects unoccupied parking places and guides cars to available spaces using sensor data. In addition, the technology gives real-time reports on parking availability and occupancy rates, which can assist harbor management in making educated decisions. Cisco has created a "Smart Parking Management" solution that monitors parking behavior and detects open parking spaces using cameras and sensors. The technology also offers real-time parking occupancy data, which can assist seaport administrators in optimizing parking allocation and reducing congestion.

Overall, the rise of both start-ups and established firms in the market for smart parking solutions for seaports demonstrates the potential for additional innovation and growth in this industry. Further studies can investigate the efficacy of these methods in other seaport situations and scenarios.

6.2. Recommendations for Future Research and Practice

After a comprehensive analysis of the existing state of the art in the field of AI and CV for seaport parking management, several gaps and opportunities for future research and practice have been identified. Each recommendation is justified as follows:

(a) **Multi-Task Learning:** Multi-task learning is an increasingly relevant teaching model that allows for the simultaneous execution of various tasks, such as locating parking spots and forecasting parking demand. The potential of multitask learning techniques for seaport parking management is promising due to their ability to optimize multiple facets of parking operations simultaneously. Investigating and implementing multi-task learning methods can lead to more efficient and comprehensive solutions.

(b) **Sensor Data Fusing**: Fusing sensor data from multiple sources, such as video feeds and photographs, can significantly enhance the accuracy and reliability of parking management systems [55]. By integrating and processing data from various sensors, researchers and practitioners can explore new ways to improve the effectiveness of seaport parking management. Investigating sensor data fusion techniques offers a practical avenue for enhancing real-time decision-making and system performance.

(c) **Smart Parking Solutions and the Environment**: The environmental impact of smart parking solutions is a critical aspect to consider. These solutions have the potential to reduce fuel consumption and emissions by minimizing the time vehicles spend searching for parking spaces. Future research should delve into the environmental implications of smart parking systems within seaports, exploring how these technologies contribute to long-term sustainability and environmental conservation.

(d) **Integration with Navigation Systems**: Integrating seaport parking management systems with navigation systems can streamline the parking process for vehicles, reduce congestion, and minimize fuel consumption. Investigating the feasibility and benefits of this integration is essential for optimizing seaport operations. Such integration has the potential to enhance the overall efficiency of seaports, making them more attractive and functional for both maritime and land-based transport.

(e) **Integration with Other Smart Port Systems**: To provide a holistic and integrated solution for seaport operations, smart parking solutions can be combined with other smart port systems, such as cargo tracking and fleet management [56]. This approach enhances overall port efficiency, improves resource allocation, and ensures a seamless flow of goods and services. Research focusing on the synergy between smart parking and other port-related technologies is essential for a more integrated and efficient seaport ecosystem.

(f) **Economic Benefits of Smart Parking Solutions**: Assessing the economic advantages of implementing smart parking solutions within seaports is crucial. Research in this area should explore the financial benefits, including cost savings resulting from reduced congestion, increased operational efficiency, and additional revenue generated from parking fees. A thorough economic analysis can provide stakeholders with valuable insights into the return on investment and long-term financial viability of smart parking systems.

(g) **Exploration of New Technologies and Innovations**: As technology continues to evolve, new solutions and innovations in the field of smart parking for seaports may emerge. Future studies should be proactive in exploring upcoming technologies such as blockchain and edge computing, as well as their potential applications in seaport parking management. Staying at the forefront of technological advancements ensures that seaports can adapt to changing industry dynamics and remain competitive in the global market.

7. Conclusions

Our systematic review has illuminated the pivotal role of AI and CV technologies in addressing critical challenges in seaport management, particularly in the domains of transportation and container movement. By thoroughly examining the existing literature, we have underscored the potential and significance of these technologies in developing sustainable and efficient parking systems at seaports. Moreover, our findings emphasize their crucial role in enhancing traffic management, optimizing parking space allocation, and streamlining container movement within seaports.

Looking ahead, future research directions may explore real-time AI algorithms for dynamic parking allocation, integration with IoT sensors for improved traffic flow, and the development of smart port solutions to further enhance efficiency, sustainability, and global economic benefits. These areas offer exciting opportunities to harness the power of AI and CV in revolutionizing seaport management, ultimately contributing to smarter, more resilient, and more efficient seaport operations.

This research serves as a vital contribution, shedding light on the transformative impact of AI and CV technologies in the context of port management, and calls for further exploration and innovation in this promising field. As we navigate the complexities of urban expansion and global trade, AI and CV stand as beacons of hope, guiding us toward more efficient, sustainable, and responsive seaport operations that benefit us all.

Author Contributions: H.L., I.C. and G.C. conceptualized the study. I.C. performed the systematic analysis of the study. I.C. wrote the first draft of the manuscript. H.L., I.C. and G.C. have reviewed and wrote the final draft. All authors have read and agreed to the published version of the manuscript.

Funding: This research work was supported by the Korea Institute of Marine Science & Technology Promotion (KIMST) funded by the Ministry of Oceans and Fisheries, Korea (20220583).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: This review article does not contain any original data. All information presented in this paper is based on a thorough analysis and synthesis of existing literature sources. Therefore, no data availability statement is required.

Acknowledgments: All the authors are thankful to Total SoftBank Pvt. Ltd. for supporting this study.

Conflicts of Interest: All authors declare no conflict of interest.

References

1. Ke, R.; Zhuang, Y.; Pu, Z.; Wang, Y. A smart, efficient, and reliable parking surveillance system with edge artificial intelligence on IoT devices. *IEEE Trans. Intell. Transp. Syst.* **2020**, *22*, 4962–4974. [CrossRef]
2. Artificial Intelligence. Artificial Intelligence Noun—Definition, Pictures, Pronunciation, and Usage Notes | Oxford Advanced Learner's Dictionary at OxfordLearnersDictionaries.com. Available online: https://www.oxfordlearnersdictionaries.com/definition/english/artificial-intelligence?q=artificial%2Bintelligence (accessed on 22 March 2023).
3. Winkowska, J.; Szpilko, D.; Pejić, S. Smart city concept in the light of the literature review. *Eng. Manag. Prod. Serv.* **2019**, *11*, 70–86. [CrossRef]
4. Al-Turjman, F.; Malekloo, A. Smart parking in IoT-enabled cities: A survey. *Sustain. Cities Soc.* **2019**, *49*, 101608. [CrossRef]
5. Mai, T.L.; Vo, A.K.; Jeon, M.; Yoon, H.K. Changes in the Hydrodynamic Characteristics of Ships During Port Maneuvers. *J. Ocean Eng. Technol.* **2022**, *36*, 143–152. [CrossRef]
6. Chatterjee, I.; Cho, G. Development of a Machine Learning-Based Framework for Predicting Vessel Size Based on Container Capacity. *Appl. Sci.* **2022**, *12*, 9999. [CrossRef]
7. Chatterjee, I.; Cho, G. Port Container Terminal Quay Crane Allocation Based on Simulation and Machine Learning Method. *Sens. Mater.* **2022**, *34*, 843. [CrossRef]
8. Khandare, V.B. Impact of Globalization on International Trade (With Special Reference to India). *Int. J. Trade Serv.* **2011**, *3*, 1–14.
9. Song, L.; Cherrett, T.; Guan, W. Studys on berth planning problems in a container seaport: Using an integrated programming approach. *Comput. Ind. Eng.* **2012**, *62*, 119–128. [CrossRef]
10. Jeevan, J.; Mohd Salleh, N.H.; Mohd Zaideen, I.M.; Othman, M.R.; Menhat, M.N.S.; Divine Caesar, L. Application of geoeconomics in seaport operations: A theoretical proposal for post-COVID-19 recovery strategy. *Aust. J. Marit. Ocean Aff.* **2020**, *12*, 217–242. [CrossRef]
11. Linnenluecke, M.K.; Marrone, M.; Singh, A.K. Conducting systematic literature reviews and bibliometric analyses. *Aust. J. Manag.* **2020**, *45*, 175–194. [CrossRef]
12. Moher, D.; Liberati, A.; Tetzlaff, J.; Altman, D.G.; PRISMA Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Med.* **2009**, *6*, e1000097. [CrossRef]
13. Chandrasekaran, S.; Reginald, J.M.; Wang, W.; Zhu, T. Computer Vision-Based Parking Optimization System. *arXiv* **2022**, arXiv:2201.00095.
14. Ruili, J.; Haocong, W.; Han, W.; O'Connell, E.; McGrath, S. Smart parking system using image processing and artificial intelligence. In Proceedings of the 2018, the 12th International Conference on Sensing Technology (ICST), Limerick, Ireland, 4–6 December 2018; IEEE: New York, NY, USA, 2018; pp. 232–235.
15. Sudhakar, M.V.; Reddy, A.A.; Mounika, K.; Kumar, M.S.; Bharani, T. Development of smart parking management system. *Mater. Today Proc.* **2021**, *80*, 2794–2798. [CrossRef]
16. Fahim, A.; Hasan, M.; Chowdhury, M.A. Smart parking systems: Comprehensive review based on various aspects. *Heliyon* **2021**, *7*, e07050. [CrossRef]
17. Barriga, J.J.; Sulca, J.; León, J.L.; Ulloa, A.; Portero, D.; Andrade, R.; Yoo, S.G. Smart parking: A literature review from the technological perspective. *Appl. Sci.* **2019**, *9*, 4569. [CrossRef]
18. Yigitcanlar, T.; Desouza, K.C.; Butler, L.; Roozkhosh, F. Contributions and risks of artificial intelligence (AI) in building smarter cities: Insights from a systematic review of the literature. *Energies* **2020**, *13*, 1473. [CrossRef]
19. Antoniou, C.; Gikas, V.; Papathanasopoulou, V.; Mpimis, T.; Perakis, H.; Kyriazis, C. A framework for risk reduction for indoor parking facilities under constraints using positioning technologies. *Int. J. Disaster Risk Reduct.* **2018**, *31*, 1166–1176. [CrossRef]
20. Xiang, Z.; Pan, J. Design of Intelligent Parking Management System Based on ARM and Wireless Sensor Network. *Mob. Inf. Syst.* **2022**, *2022*, 2965638. [CrossRef]
21. Qadir, Z.; Al-Turjman, F.; Khan, M.A.; Nesimoglu, T. ZIGBEE based time and energy efficient smart parking system using IOT. In Proceedings of the 2018 18th Mediterranean Microwave Symposium (MMS), Istanbul, Turkey, 31 October–2 November 2018; IEEE: New York, NY, USA, 2018; pp. 295–298.
22. Krieg, J.G.; Jakllari, G.; Toma, H.; Beylot, A.L. Unlocking the smartphone's sensors for smart city parking. *Pervasive Mob. Comput.* **2018**, *43*, 78–95. [CrossRef]
23. Aydin, I.; Karakose, M.; Karakose, E. A navigation and reservation-based smart parking platform using genetic optimization for smart cities. In Proceedings of the 2017, 5th International Istanbul Smart Grid and Cities Congress and Fair (ICSG), Istanbul, Turkey, 19–21 April 2017; IEEE: New York, NY, USA, 2017; pp. 120–124.
24. Jin, Z.; Lin, X.; Zang, L.; Liu, W.; Xiao, X. Lane Allocation Optimization in Container Seaport Gate System Considering Carbon Emissions. *Sustainability* **2021**, *13*, 3628. [CrossRef]

25. Torkjazi, M.; Huynh, N.; Shiri, S. Truck appointment system considering impact of drayage truck tours. *Transp. Res. Part E Logist. Transp. Rev.* **2018**, *116*, 208–228. [CrossRef]
26. Agatić, A.; Kolanović, I. Improving the seaport service quality by implementing digital technologies. *Pomorstvo* **2020**, *34*, 93–101. [CrossRef]
27. Yeo, G.T.; Thai, V.V.; Roh, S.Y. An analysis of port service quality and customer satisfaction: The case of Korean container ports. *Asian J. Shipp. Logist.* **2015**, *31*, 437–447. [CrossRef]
28. Heilig, L.; Voß, S. Information systems in seaports: Categorization and overview. *Inf. Technol. Manag.* **2017**, *18*, 179–201. [CrossRef]
29. Carlan, V.; Sys, C.; Vanelslander, T.; Roumboutsos, A. Digital innovation in the port sector: Barriers and facilitators. *Compet. Regul. Netw. Ind.* **2017**, *18*, 71–93. [CrossRef]
30. Jović, M.; Tijan, E.; Brčić, D.; Pucihar, A. Digitalization in maritime transport and seaports: Bibliometric content and thematic analysis. *J. Mar. Sci. Eng.* **2022**, *10*, 486. [CrossRef]
31. Ma, M.; Fan, H.; Jiang, X.; Guo, Z. Truck arrival scheduling with vessel-dependent time windows to reduce carbon emissions. *Sustainability* **2019**, *11*, 6410. [CrossRef]
32. Carlan, V.; Naudts, D.; Audenaert, P.; Lannoo, B.; Vanelslander, T. Toward implementing a fully automated truck guidance system at a seaport: Identifying the roles, costs, and benefits of logistics stakeholders. *J. Shipp. Trade* **2019**, *4*, 12. [CrossRef]
33. Othman, M.R. Malaysia Seaport Development towards Embracing Industrial Revolution 4.0: Enhancing the Quality and Competitiveness of Seaport Industry. *Turk. J. Comput. Math. Educ. (TURCOMAT)* **2021**, *12*, 1625–1635.
34. Shiri, S.; Huynh, N. Optimization of drayage operations with time-window constraints. *Int. J. Prod. Econ.* **2016**, *176*, 7–20. [CrossRef]
35. Heilig, L.; Lalla-Ruiz, E.; Voß, S. portIO: An integrative mobile cloud platform for real-time interterminal truck routing optimization. *Flex. Serv. Manuf. J.* **2017**, *29*, 504–534. [CrossRef]
36. Yi, S.; Scholz-Reiter, B.; Kim, T.; Kim, K.H. Scheduling appointments for container truck arrivals considering their effects on congestion. *Flex. Serv. Manuf. J.* **2019**, *31*, 730–762. [CrossRef]
37. Meisel, F.; Bierwirth, C. A framework for integrated berth allocation and crane operations planning in seaport container terminals. *Transp. Sci.* **2013**, *47*, 131–147. [CrossRef]
38. Kaur, J. Implementation of Smart Parking Using Artificial Intelligence. *Int. J. Sci. Dev. Res.* **2019**, *4*, 284–290.
39. Stopka, O.; Gašparík, J.; Šimková, I. The methodology of the customers' operation in the seaport applies the "simple shuttle problem". *NAŠE MORE Znan. Časopis Za I Pomor.* **2015**, *62*, 283–286.
40. Terrazas-Moreno, S.; Grossmann, I.E.; Wassick, J.M. A mixed-integer linear programming model for optimizing the scheduling and assignment of tank farm operations. *Ind. Eng. Chem. Res.* **2012**, *51*, 6441–6454. [CrossRef]
41. Kisialiou, Y.; Gribkovskaia, I.; Laporte, G. Robust supply vessel routing and scheduling. *Transp. Res. Part C Emerg. Technol.* **2018**, *90*, 366–378. [CrossRef]
42. Lin, D.Y.; Chiang, C.W. The storage space allocation problem at a container terminal. *Marit. Policy Manag.* **2017**, *44*, 685–704. [CrossRef]
43. Abu Aisha, T.; Ouhimmou, M.; Paquet, M. Optimization of container terminal layout in the seaport—Case of Port of Montreal. *Sustainability* **2020**, *12*, 1165. [CrossRef]
44. Chatterjee, I. *Machine Learning and Its Application: A Quick Guide for Beginners*; Bentham Science Publishers: Sharjah, United Arab Emirates, 2021.
45. Kotb, A.O.; Shen, Y.C.; Huang, Y. Smart parking guidance, monitoring, and reservations: A review. *IEEE Intell. Transp. Syst. Mag.* **2017**, *9*, 6–16. [CrossRef]
46. Nawaz, S.; Efstratiou, C.; Mascolo, C. Smart sensing system for the daily drive. *IEEE Pervasive Comput.* **2016**, *15*, 39–43. [CrossRef]
47. Barone, R.E.; Giuffrè, T.; Siniscalchi, S.M.; Morgano, M.A.; Tesoriere, G. Architecture for parking management in smart cities. *IET Intell. Transp. Syst.* **2014**, *8*, 445–452. [CrossRef]
48. Taherkhani, M.A.; Kawaguchi, R.; Shirmohammad, N.; Sato, M. BlueParking: An IoT based parking reservation service for smart cities. In Proceedings of the Second International Conference on IoT in Urban Space, Tokyo, Japan, 24–25 May 2016; pp. 86–88.
49. Nieto, R.M.; Garcia-Martin, A.; Hauptmann, A.G.; Martinez, J.M. Automatic vacant parking place management system using multicamera vehicle detection. *IEEE Trans. Intell. Transp. Syst.* **2018**, *20*, 1069–1080. [CrossRef]
50. Mair, R. *How Will City Infrastructure and Sensors Be Made Smart? Cambridge Centre for Smart Infrastructure and Construction*; University of Cambridge: Cambridge, UK, 2015. Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/443531/future-cities-smart-infrastructure.pdf (accessed on 1 April 2023).
51. Jeevan, J.; Salleh, N.H.M.; Loke, K.B.; Saharuddin, A.H. Preparation of dry ports for a competitive environment in the container seaport system: A process benchmarking approach. *Int. J. E-Navig. Marit. Econ.* **2017**, *7*, 19–33. [CrossRef]
52. Caldeirinha, V.; Nabais, J.L.; Pinto, C. Port Community Systems: Accelerating the Transition of Seaports to the Physical Internet—The Portuguese Case. *J. Mar. Sci. Eng.* **2022**, *10*, 152. [CrossRef]
53. Abourraja, M.N.; Kringos, N.; Meijer, S. Exploiting the simulation model potential in investigating the handling capacity of Ro-Ro terminals: The case study of Norvik seaport. *Simul. Model. Pract. Theory* **2022**, *117*, 102513. [CrossRef]
54. Start-Ups and AI in Port Operations—PierNext. 17 September 2021. Available online: https://piernext.portdebarcelona.cat/en/technology/aim-to-identify-wagons-and-containers-the-new-drive-of-the-port-of-barcelona/ (accessed on 9 April 2023).

55. Curopark. Intelligent Parking Management System: ANPR based Parking Management System in India: Vehicle Parking Management Software. CuroPark. Available online: https://www.curopark.com/curopark-harbor.php (accessed on 25 March 2023).
56. Kovač, M. Autonomous AI, smart seaports, and supply chain management: Challenges and Risks. In *Regulating Artificial Intelligence in Industry*; Routledge: New York, NY, USA, 2021; pp. 127–137.