Scientific Research Communications

Evaluation of Autonomous Robot Alternatives for Warehouse Optimization Using the Analytic Hierarchy Process

Huriye Akpınar *

Independent Researcher, İzmir, Türkiye

*Correspondence: huriyeaakpinar@gmail.com

Research Article

Received: 9 November 2024
Accepted: 10 July 2025
Published: 30 July 2025

Keywords
Multi-criteria decision making
Analytic hierarchy process
Robot selection

Abstract

In today's world, the optimization of storage and logistics processes is of great importance for efficiency and cost-effectiveness. In this context, the use of autonomous robots emerges as a potential solution to improve storage operations. However, selecting among different autonomous robot alternatives is a complex process that requires consideration of multiple criteria. This study examines the use of the analytic hierarchy process method, a multi-criteria decision-making technique, for evaluating autonomous robot alternatives in warehouse optimization. These techniques allow decision-makers to evaluate alternatives systematically and objectively based on defined criteria. The method used in the study assesses the hierarchical structure between criteria and sub-criteria, using pairwise comparison matrices to determine the relative importance of each criterion. The evaluation was based on five main criteria: carrying capacity, speed, maneuverability, battery life, and investment cost. This approach facilitates a clear articulation of priorities among the criteria by decision-makers. The study aims to select the most suitable one among three different robot alternatives for a warehouse. As a result of the study, the most suitable robotic alternative was identified, and the findings were analyzed and interpreted.

1. Introduction

In today's rapidly evolving industrial landscape, the optimization of storage and logistics processes has become increasingly critical for ensuring operational efficiency and cost-effectiveness. With the rise of e-commerce and the demand for faster delivery times, warehouses are under constant pressure to enhance their operational capabilities. Autonomous robots present a promising solution for improving these processes by automating tasks that were traditionally performed manually. However, the challenge lies in selecting the most suitable autonomous robot for a specific warehouse environment, given the wide variety of available options and the complex requirements of modern warehousing operations (Peng et al., 2014).

Selecting the right autonomous robot involves evaluating multiple factors, including cost, performance, reliability, flexibility, and sustainability. Each of these criteria plays a significant

How to cite this paper: Akpınar, H. (2025). Evaluation of autonomous robot alternatives for warehouse optimization using the analytic hierarchy process. *Scientific Research Communications, 5*(2), 67–76. https://doi.org/10.52460/src.2025.006

role in determining the overall effectiveness of the robot within the warehouse setting. Cost considerations encompass both the initial investment and the ongoing operational expenses, while performance metrics include the robot's speed, accuracy, and ability to handle various tasks (Bensalem et al., 2009). Reliability is crucial for minimizing downtime and ensuring consistent operations, whereas flexibility refers to the robot's adaptability to different tasks and environments. Sustainability, increasingly important in today's business world, addresses the environmental impact and energy efficiency of the robot (Chakraborty et al., 2018).

Given the multifaceted nature of this decision-making process, multi-criteria decision-making (MCDM) techniques offer a structured and objective approach to evaluating and comparing different autonomous robot alternatives. The Analytic Hierarchy Process (AHP) is one such MCDM technique that is particularly well-suited for this purpose. AHP helps decision-makers systematically assess the importance of various criteria and sub-criteria, providing a clear framework for comparing alternatives based on these prioritized factors. By using pairwise comparison matrices, AHP quantifies the relative importance of each criterion, enabling a detailed and nuanced evaluation of each robot option.

In this study, we apply the AHP method to evaluate three different autonomous robot alternatives for a warehouse environment. Our goal is to identify the most suitable robot that aligns with the specific needs and priorities of the warehouse, considering all relevant criteria. The structured approach provided by AHP not only facilitates a thorough comparison but also helps in making a well-informed and transparent decision. This ensures that the selected robot will enhance the overall efficiency, reliability, and sustainability of the warehouse operations.

The following sections of this paper will delve into the specifics of the criteria used for evaluation, the methodology of the AHP process, and the detailed analysis of each robot alternative. We will discuss the results of the pairwise comparisons, highlight the strengths and weaknesses of each robot option, and present our final recommendation based on the comprehensive evaluation. By thoroughly examining the selection process and outcomes, this study aims to contribute valuable insights into the application of MCDM techniques for optimizing warehouse operations through the integration of autonomous robots.

2. Literature Review

Markowski & Bilski (2023) discuss the evaluation of distributed frameworks using optimization routines to determine the shortest path for robots in a warehouse, comparing Dijkstra, Floyd-Warshall, and Bellman-Ford algorithms for avoiding downtime and collisions among robots. Kattepur et al. (2018) highlight the use of distributed optimization techniques in coordinating robotic units for warehouse inventory automation, emphasizing the importance of task/resource allocation among autonomous agents to maximize efficiency and scalability. Yang et al. (2021) introduces a maximin-based multi-objective evolutionary algorithm using a one-by-one update scheme, which enhances multi-robot scheduling optimization for intelligent warehouse systems and addresses real-world scheduling challenges effectively. Smit et al. (2024) proposes a multi-objective Deep Reinforcement Learning approach to learn effective allocation policies in collaborative human-robot order picking systems, aiming to maximize pick efficiency and improve workload fairness among human pickers.

Haghani et al. (2021) discusses optimizing the coordination of a fleet of robots in a warehouse to maximize net profit while respecting constraints, providing insights into vehicle routing problems with time windows. Ho et al. (2024) introduce a Federated Deep Reinforcement Learning algorithm for task scheduling in heterogeneous autonomous robotic systems, optimizing warehouse task scheduling and showing improved performance in minimizing task queue length. Gödeke & Detzner (2023) propose a simulative approach to address the fleet sizing problem combined with decentralized Multi-Robot Task Allocation (MRTA) for Autonomous Mobile Robots (AMRs) in warehouses. Liu et al. (2024) focus on enhancing robot perception and navigation in logistics warehouses through an improved Gmapping algorithm, resulting in better obstacle detection rates and increased accuracy in travel distance. Sugiura et al. (2023) proposes a method utilizing BLPSO and MIQCPs for optimizing product assignments and in-shelf layout in warehouses to enhance picking operations efficiency through autonomous mobile robots. Kalempa et al. (2021) present a novel approach to optimize production in smart factories using autonomous robots for efficiency and flexibility in warehouse logistics through Multi-Robot Preemptive Task Scheduling with Fault Recovery (MRPF). Thammachantuek & Ketcham (2022) develop an algorithm for path planning of autonomous mobile robots that considers the shortest, smoothest, and safest paths, offering an evolutionary operator to prevent local optimum trapping.

Al Khatib et al. (2024) discusses the use of Autonomous Mobile Robots in warehouse operations to lower human error and increase efficiency, highlighting advancements in inventory management within the healthcare industry. Cognominal et al. (2021) examine the evolving field of autonomous mobile robotics, detailing recent technological advancements and a broad spectrum of applications across industries driven by innovation and interdisciplinary integration. Farinelli et al. (2017) explore advanced strategies for coordinating multiple robots in logistics settings, focusing on algorithms and architectures that enable efficient task distribution, path planning, and system scalability in dynamic environments. Taleb et al. (2025) focus on developing robust path-planning algorithms to ensure seamless navigation of autonomous mobile robots in warehouse settings, addressing challenges related to dynamic obstacles and real-time decision-making.

Zhan (2025) explores innovative applications of artificial intelligence in logistics scheduling, presenting advanced computational methods designed to optimize task allocation, resource utilization, and real-time decision-making in complex supply chain environments. Dabic-Miletic and Knezevic (2024) examine methods for selecting optimal alternatives to achieve sustainable intralogistics in automotive industry warehouse supply chains, with an emphasis on balancing operational efficiency and environmental considerations. Lee & Kim (2024) develop an adaptive path planning method based on the AHP, tailored to account for varying mobile robot driving environments, with the goal of enhancing navigation efficiency and decision-making in dynamic operational contexts.

Liu et al. (2022) propose a deep learning-based approach for accurately identifying warehouse goods, aiming to enhance the precision and efficiency of robot-assisted picking operations within automated logistics systems. Puljiz et al. (2018) explore the implementation of augmented reality technologies in autonomous warehouses, identifying key challenges and potential opportunities for enhancing human-robot collaboration, spatial awareness, and operational efficiency. Pietrantoni et al. (2024) investigate the integration of collaborative robots across manufacturing, logistics, and agriculture, presenting expert insights into technical challenges, safety considerations, and human factors influencing successful adoption.

Parikh et al. (2022) present the design and implementation of an autonomous mobile robot system tailored for inventory management in the retail industry, highlighting its potential to improve stock accuracy, operational efficiency, and real-time data tracking. Suszyński and Rogalewicz (2020) apply multi-criteria decision-making methods to support the selection of industrial robots for assembly tasks, aiming to improve decision quality by systematically evaluating key performance and operational factors. D'Andrea and Wurman (2008) discuss the future challenges associated with coordinating large fleets of autonomous vehicles within distribution facilities, emphasizing issues related to scalability, real-time decision-making, and system robustness in practical robotic applications. Finco et al. (2023) investigate various manual picking workstation configurations within robotized and automated warehouse systems, analyzing the trade-offs between ergonomic design and productivity to inform optimal system integration and worker performance.

Keith and La (2024) provide a comprehensive review of autonomous mobile robots designed for warehouse environments, examining their capabilities, deployment challenges, and the evolving technologies that support their integration into modern logistics systems. Li et al. (2024) explore the use of machine learning techniques to enhance the performance of automated picking systems in warehouse robots, aiming to improve efficiency and accuracy in warehouse operations. Sayeed et al. (2022) explore various approaches and challenges within the Internet of Robotic Things (IoRT), focusing on the integration of robotics with IoT technologies to enable intelligent perception, communication, and autonomous decision-making in connected environments. Dabic-Miletic (2024) addresses the challenges of integrating artificial intelligence and robotics into sustainable warehouse management systems (WMS), focusing on how these technologies can enhance economic resilience within supply chains. Finally, Licardo et al. (2024) conduct a systematic review of intelligent robotics, highlighting emerging technologies and trends that are shaping the future of autonomous systems across various industrial applications.

Although a wide range of studies have focused on improving robotic coordination, navigation, and scheduling in warehouse environments, few have directly addressed the challenge of selecting the most suitable autonomous robot using a structured, criteria-based evaluation framework. Moreover, many of these studies do not explicitly incorporate expert judgment or prioritize decision criteria systematically.

To address this gap, this study applies the AHP, which is well-suited for problems involving subjective judgment and hierarchical structuring of decision factors. By integrating expert preferences and performing pairwise comparisons, AHP provides a transparent and consistent basis for evaluating autonomous robot alternatives in a warehouse setting.

3. Analytic Hierarchy Process

AHP is a method used to solve multi-criteria decision-making problems. AHP is used to reduce complexity in the decision-making process and helps the decision-maker to weigh different criteria and alternatives. Here are the basic steps of the AHP method (Saaty, 1980):

- Step 1: Creating a Decision Tree: The first step is to create a decision tree. This tree shows the goals, criteria, and alternatives in a hierarchical structure.
- Step 2: Creating Pairwise Comparison Matrices: For each criterion or alternative, a pairwise comparison matrix is created. In these matrices, it is indicated how much more important each pair is compared to the other. The scale usually ranges from 1 to 9, where 1 means equal importance and 9 means much more important.
- Step 3: Calculating Priorities: Using the pairwise comparison matrices, the importance of each criterion or alternative relative to others is determined. In this step, a consistency check is also performed.
- Step 4: Consistency Check: The consistency of the importance degrees for each criterion or alternative is checked using the pairwise comparison matrices. If the matrices are inconsistent, the comparisons are reviewed and redone.
- Step 5: Determining the Best Alternative: After calculating the priorities and checking consistency, the best alternative or alternatives are determined. These alternatives represent the most suitable ones in the decision-making process.

4. Problem Statement

In this section, a problem related to optimizing operations in a large warehouse of a company operating in the logistics sector is addressed. The company's warehouse is where the entry and exit of hundreds of products are managed, and it is desired to modernize it by replacing manual operations with autonomous robots. The company is evaluating different autonomous robot alternatives: These alternatives are Autonomous Robot (AR)-1, AR-2 and AR-3. The logistics company used the AHP method to determine which autonomous robot is the most suitable. Criteria such as Carrying Capacity (C1), Speed (C2), Maneuverability (C3), Battery Life (C4), and Investment Cost (C5) were determined by experts. The decision matrix was first created as follows. The AHP steps are applied to Table 1 and the final weights are provided in Table 2. The hierarchy of the problem is provided in Figure 1.

To derive the pairwise comparisons required by the AHP method, expert judgments were obtained from three professionals with more than 10 years of experience in logistics and warehouse automation. The experts included a warehouse operations manager, a robotics systems engineer, and a supply chain consultant. Data were collected through structured interviews where each expert completed a Saaty scale-based comparison matrix. The geometric mean method was used to aggregate the individual judgments into a single consensus matrix for analysis.

The pairwise comparisons among the criteria were conducted through structured interviews with three logistics experts working in warehouse management. Each expert independently evaluated the relative importance of the criteria using the Saaty 1–9 scale, where 1 represents equal importance and 9 indicates extreme importance of one element over another. Their responses were aggregated using the geometric mean to form the final pairwise comparison matrix. The consistency ratio (CR) of the matrix was calculated and found to be 0.07, which is within the acceptable limit (CR < 0.10), indicating consistent judgments.

Table 1. The decision matrix

Criteria	C1	C2	C3	C4	C5
C1	1	5	3	7	5
C2	1/5	1	2	5	3
C3	1/3	1/2	1	3	5
C4	1/7	1/5	1/3	1	9
C5	1/5	1/3	1/5	1/9	1

Table 2. Criteria weights

Rank	Criterion name	Criterion weight
1	C1	0.513
2	C2	0.261
3	C3	0.129
4	C4	0.063
5	C5	0.033

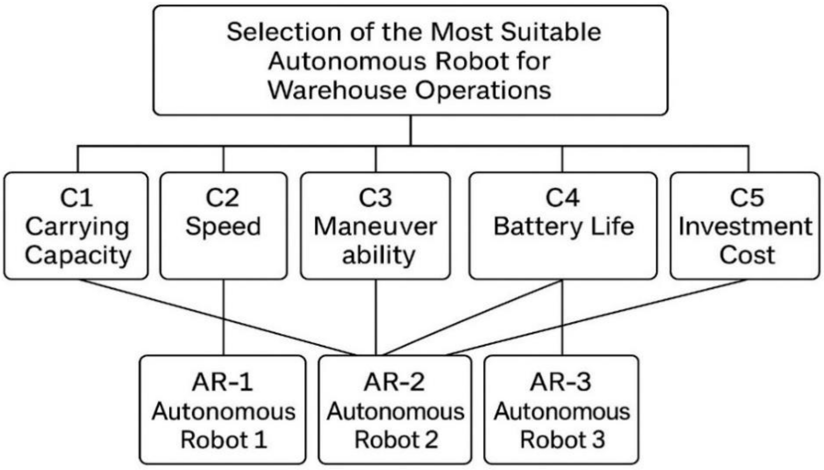

Figure 1. The hierarchy of the problem

As shown in Table 2, the AR selection results indicate that C1 holds the highest priority. The subsequent priorities, based on the calculated weights, are assigned to C2, C3, C4, and C5, respectively.

The evaluation of each AR is presented in Table 3, while Table 4 provides the final values for each AR. According to Table 4, AR-1 holds the highest priority, followed by AR-2 and AR-3 based on the calculated weights.

Table 3. AR weights

	C5	
1	AR-1	0.785
2	AR-2	0.149
3	AR-3	0.066
	C4	
1	AR-1	0.63
2	AR-2	0.218
3	AR-3	0.151
	C3	
1	AR-1	0.709
2	AR-2	0.179
3	AR-3	0.113
	C2	
1	AR-1	0.799
2	AR-2	0.105
3	AR-3	0.096
	C1	
1	AR-1	0.637
2	AR-2	0.258
3	AR-3	0.105

Table 4. Autonomous robot results

Rank	Alternatives	Alternative Weight
1	AR-1	0.693
2	AR-2	0.201
3	AR-3	0.106

5. Conclusion

The logistics sector is a continuously growing and evolving industry that plays a crucial role in the transportation, storage, and distribution of goods along the supply chain. Effective and efficient logistics operations are essential for enhancing the competitiveness of businesses. In recent years, autonomous robots have emerged as a significant innovation in the logistics sector. These robots are machines that can perform tasks without the need for human intervention, and they are typically used in storage and transportation operations. The use of autonomous robots can make operations such as warehouse management and material handling faster, more efficient, and safer.

Autonomous robots, especially those used in large warehouses and distribution centers, are less prone to errors compared to manual labor and can ensure the continuity of operations. Moreover, these robots can often work in areas that are inaccessible or difficult for humans to reach, allowing for more efficient use of warehouse space. Therefore, many businesses in the logistics sector are considering integrating autonomous robots into their operations.

This study evaluates three different autonomous robot alternatives for optimizing the warehouse operations of a company in the logistics sector. The comparison criteria include Carrying Capacity, Speed, Maneuverability, Battery Life, and Investment Cost. Separate comparison matrices were created for each criterion for the three alternatives, AR-1, AR-2, and AR-3, and the importance ranking of the criteria was determined using the AHP method. The results show that Carrying Capacity is the most important criterion. Among the three autonomous robot alternatives, AR-1 was found to be the most suitable, followed by AR-2 and AR-3.

The selection of AR-1, which ranked highest in carrying capacity, speed, and maneuverability, suggests a strong operational fit for warehouses prioritizing high throughput and flexibility. However, it should be noted that AR-1 had a relatively lower performance in terms of investment cost, indicating a trade-off between performance and affordability. Organizations with budget constraints may need to reconsider the weight assigned to investment cost or conduct a cost-benefit analysis to justify the higher initial expenditure. This result underscores the importance of aligning robot selection not only with technical performance but also with the financial and strategic goals of the organization.

The findings of this study provide practical value for warehouse managers and logistics companies seeking to integrate autonomous robots into their operations. The AHP-based framework can be directly applied to assess robot procurement decisions by tailoring the criteria weights according to firm-specific needs (e.g., cost sensitivity, speed priorities). Moreover, the decision model is adaptable and can be reused in other warehouse contexts or expanded to include more alternatives and criteria over time. This makes the methodology both scalable and customizable for strategic decision-making in automation planning.

Despite its usefulness, this study has several limitations. First, the number of alternatives was limited to three, which may not reflect the full spectrum of available autonomous robot solutions in the market. Second, the weightings were based on expert judgment, which may introduce subjectivity despite consistency checks. Third, the decision criteria were assumed to be independent, whereas real-world decisions often involve interdependencies that may be better captured using methods like Analytic Network Process (ANP).

Future research can expand the model by incorporating more alternatives, additional criteria (e.g., maintenance cost, software compatibility), and dynamic criteria interrelationships using fuzzy AHP or ANP. Additionally, combining AHP with other MCDM techniques such as TOPSIS or MARCOS may enhance the robustness of decision-making. Longitudinal studies involving real-life implementation of selected robots would also help validate the practical impact of such models.

Authorship Contribution Statement

The author is solely responsible for the conceptualization, methodology, data collection, analysis, and manuscript preparation.

Conflict of Interest

The author declares no conflict of interest.

References

Al Khatib, I., Alasheh, S., & Shamayleh, A. (2024). The drivers of complexity in inventory management within the healthcare industry: A systematic review. *International Journal of Service Science, Management, Engineering, and Technology (IJSSMET), 15*(1), 26. https://doi.org/10.4018/IJSSMET.347332

Bensalem, S., Gallien, M., Ingrand, F., Kahloul, I., & Thanh-Hung, N. (2009). Designing autonomous robots. *IEEE Robotics & Automation Magazine, 16*(1), 67–77. https://doi.org/10.1109/MRA.2008.931631

Chakraborty, S., Mukherjee, S., Nag, T., Biswas, B., Garang, B., & Nayak, A. (2018). A low cost autonomous multipurpose vehicle for advanced robotics. *2018 9th IEEE Annual Ubiquitous Computing, Electronics & Mobile Communication Conference (UEMCON)* (pp. 1067–1078). IEEE. https://doi.org/10.1109/UEMCON.2018.8796543

Cognominal, M., Patronymic, K., & Wańkowicz, A. (2021). Evolving field of autonomous mobile robotics: Technological advances and applications. *Fusion of Multidisciplinary Research, An International Journal, 2*(2), 189–200. https://doi.org/10.63995/USAS3015

Dabić-Miletić, S., & Knežević, N. (2024). Selecting optimal alternatives for sustainable intralogistics in automotive industry warehouse supply chains. *Journal of Green Economics and Low-Carbon Development, 3*(4), 223-234. https://doi.org/10.56578/jgelcd030402

Dabić-Miletić, S. (2024). The challenges of integrating AI and robotics in sustainable WMS to improve supply chain economic resilience. *Journal of Industrial Intelligence, 2*(2), 119-131. https://doi.org/10.56578/jii020205

D'Andrea, R., & Wurman, P. (2008, November). Future challenges of coordinating hundreds of autonomous vehicles in distribution facilities. *2008 IEEE International Conference on Technologies for Practical Robot Applications* (pp. 80-83). IEEE. https://doi.org/10.1109/TEPRA.2008.4686677

Farinelli, A., Boscolo, N., Zanotto, E., & Pagello, E. (2017). Advanced approaches for multi-robot coordination in logistic scenarios. *Robotics and Autonomous Systems, 90*, 34-44. https://doi.org/10.1016/j.robot.2016.08.010

Finco, S., Ashta, G., Persona, A., & Zennaro, I. (2023). Investigating different manual picking workstations for robotized and automated warehouse systems: Trade-offs between ergonomics and productivity aspects. *Computers & Industrial Engineering, 185*, 109668. https://doi.org/10.1016/j.cie.2023.109668

Gödeke, J., & Detzner, P. (2023, September). A simulative approach to AMR fleet sizing in decentralized multi-robot task allocation. *2023 IEEE 28th International Conference on Emerging Technologies and Factory Automation (ETFA)* (pp. 1-8). IEEE. https://doi.org/10.1109/ETFA54631.2023.10275717

Haghani, N., Li, J., Koenig, S., Kunapuli, G., Contardo, C., Regan, A., & Yarkony, J. (2021). *Multi-robot routing with time windows: A column generation approach* [Preprint]. arXiv. https://doi.org/10.48550/arXiv.2103.08835

Ho, T. M., Nguyen, K.-K., & Cheriet, M. (2022, December). Federated deep reinforcement learning for task scheduling in heterogeneous autonomous robotic system. *GLOBECOM 2022 - 2022 IEEE Global Communications Conference* (pp. 1134-1139). IEEE. https://doi.org/10.1109/GLOBECOM48099.2022.10000980

Kalempa, V. C., Piardi, L., Limeira, M., & de Oliveira, A. S. (2021). Multi-robot preemptive task scheduling with fault recovery: A novel approach to automatic logistics of smart factories. *Sensors, 21*(19), 6536. https://doi.org/10.3390/s21196536

Keith, R., & La, H. M. (2024). *Review of autonomous mobile robots for the warehouse environment* [Preprint]. arXiv. https://doi.org/10.48550/arXiv.2406.08333

Lee, J., & Kim, C. (2024). Development of an adaptive AHP path planning method considering the mobile robot driving environment. *IEEE Access, 12*, 95565-95575. https://doi.org/10.1109/ACCESS.2024.3423421

Li, K., Wang, J., Wu, X., Peng, X., Chang, R., Deng, X., & Hong, B. (2024). *Optimizing automated picking systems in warehouse robots using machine learning* [Preprint]. arXiv. https://arxiv.org/abs/2408.16633

Licardo, J. T., Domjan, M., & Orehovački, T. (2024). Intelligent robotics—A systematic review of emerging technologies and trends. *Electronics, 13*(3), 542. https://doi.org/10.3390/electronics13030542

Liu, X., Gong, G., Hu, X., Shang, G., & Zhu, H. (2024). Cognitive enhancement of robot path planning and environmental perception based on Gmapping algorithm optimization. *Electronics, 13*(5), 818. https://doi.org/10.3390/electronics13050818

Liu, H., Zhou, L., Zhao, J., Wang, F., Yang, J., Liang, K., & Li, Z. (2022). Deep-learning-based accurate identification of warehouse goods for robot picking operations. *Sustainability, 14*(13), 7781. https://doi.org/10.3390/su14137781

Markowski, T., & Bilski, P. (2021). Optimization of autonomous agent routes in logistics warehouse. *International Journal of Electronics and Telecommunications, 67*(4), 559-564. https://doi.org/10.24425/ijet.2021.137846

Parikh, H., Saijwal, I., Panchal, N., & Sharma, A. (2022). Autonomous mobile robot for inventory management in retail industry. In P. K. Singh, S. T. Wierzchoń, J. K. Chhabra, & S. Tanwar (Eds.), *Futuristic trends in networks and computing technologies* (pp. 93-110). Springer. https://doi.org/10.1007/978-981-19-5037-7_7

Peng, L., Liu, L., Long, T., Wang, H., & Chen, L. (2014). Sequential RBF surrogate-based efficient optimization method for engineering design problems with expensive black-box functions. *Chinese Journal of Mechanical Engineering*, 27, 1099-1111. https://doi.org/10.3901/CJME.2014.0820.138

Pietrantoni, L., Favilla, M., Fraboni, F., Mazzoni, E., Morandini, S., Benvenuti, M., & De Angelis, M. (2024). Integrating collaborative robots in manufacturing, logistics, and agriculture: Expert perspectives on technical, safety, and human factors. *Frontiers in Robotics and AI, 11*, 1342130. https://doi.org/10.3389/frobt.2024.1342130

Puljiz, D., Gorbachev, G., & Hein, B. (2018). *Implementation of augmented reality in autonomous warehouses: Challenges and opportunities* [Preprint]. arXiv. https://doi.org/10.48550/arXiv.1806.00324

Sayeed, A., Verma, C., Kumar, N., Koul, N., & Illés, Z. (2022). Approaches and challenges in Internet of Robotic Things. *Future Internet, 14*(9), 265. https://doi.org/10.3390/fi14090265

Saaty, T. L. (1980). *The analytic hierarchy process: Planning, priority setting, resource allocation*. McGraw-Hill.

Smit, I. G., Bukhsh, Z., Pechenizkiy, M., Alogariastos, K., Hendriks, K., & Zhang, Y. (2024). *Learning efficient and fair policies for uncertainty-aware collaborative human-robot order picking* [Preprint]. arXiv. https://doi.org/10.48550/arXiv.2404.08006

Suszyński, M., & Rogalewicz, M. (2020). Selection of an industrial robot for assembly jobs using multi-criteria decision making methods. *Management and Production Engineering Review, 11*(1), 62-72. https://doi.org/10.24425/mper.2020.132944

Sugiura, A., Suzuki, T., Ihara, K., Sakuma, T., & Kato, S. (2023). Generating products placement in warehouse using BLPSO and MIQCPs. *Proceedings of the International Conference on Robotics and Automation, 22*(2), 345-358. https://doi.org/10.5220/0012359600003636

Taleb, M. A., Korsoveczki, G., & Husi, G. (2025). Automotive navigation for mobile robots: Comprehensive review. *Results in Engineering, 27*, 105837. https://doi.org/10.1016/j.rineng.2025.105837

Thammachantuek, I., & Ketcham, M. (2022). Path planning for autonomous mobile robots using multi-objective evolutionary particle swarm optimization. *PLOS ONE, 17*(8), e0271924. https://doi.org/10.1371/journal.pone.0271924

Ueno, K., Kinoshita, T., Kobayashi, K., & Watanabe, K. (2015). Development of a robust path-planning algorithm using virtual obstacles for an autonomous mobile robot. *Journal of Robotics and Mechatronics, 27*(3), 286-292. https://doi.org/10.20965/jrm.2015.p0286

Yang, S., Chen, W., Wang, L., Zhang, X., & Li, Y. (2021). A novel maximin-based multi-objective evolutionary algorithm using one-by-one update scheme for multi-robot scheduling optimization. *IEEE Access, 9*, 121316-121328. https://doi.org/10.1109/ACCESS.2021.3105102

Zhan, Y. (2025). Innovative applications of artificial intelligence in logistics scheduling. In G. A. Tsihrintzis, M. N. Favorskaya, R. Kountcheva, & S. Patnaik (Eds.), *Advances in computational vision and robotics: ICCVR 2024* (pp. 451-465). Springer. https://doi.org/10.1007/978-3-031-85952-6_45