UTILIZATION OF MULTIFUNCTIONAL ROBOTS IN LOGISTICS, HEALTHCARE, AND FIELD SERVICES: A SYSTEMATIC LITERATURE REVIEW

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Abstract: The increasing integration of intelligent robotic systems into human work environments has intensified the adoption of multifunctional robots capable of performing heterogeneous tasks and collaborating directly with humans. Despite the growing body of research on human–robot collaboration, the existing literature remains fragmented across application domains and lacks a consolidated understanding of multifunctional robotic systems. This paper presents a Systematic Literature Review aimed at synthesizing the state of the art regarding the applications, enabling technologies, impacts, and challenges of multifunctional robots in logistics, healthcare, and field services. Following PRISMA guidelines, studies published between 2020 and 2025 were systematically identified, screened, and assessed across major scientific databases, resulting in a final set of 58 high-quality articles. The analysis reveals that multifunctional robots consistently contribute to improvements in productivity, safety, and ergonomics, while also highlighting persistent challenges related to trust, safety assurance, and organizational adoption. The findings provide a comprehensive overview of current research and identify directions for future studies focused on the effective and human-centered integration of multifunctional robots in real-world environments.

1 INTRODUCTION

The increasing integration of humans and robotic systems has been redefining the boundaries of automation and the role of machines in contemporary work environments. Advances in artificial intelligence, machine learning, and adaptive design have enabled the emergence of multifunctional robots capable of performing multiple tasks and interacting with people across diverse operational contexts. These systems represent a significant transition from rigid automation toward more flexible and collaborative forms of work. According to Gartner projections, by 2030 approximately 80% of humans will interact daily with intelligent robots, a substantial increase compared to current levels. This trend reinforces the need to understand how these technologies are being applied, the impacts they generate, and the challenges they face for safe and effective integration into human-centered environments. However, the scientific literature still exhibits gaps and fragmentation on this topic, with studies often concentrated on specific applications and limited synthesis regarding human–robot collaboration in multi-sector scenarios. In this context, this paper aims to map and systematize existing knowledge on the integration of multifunctional robots in the logistics, healthcare, and field services sectors through a Systematic Literature Review (SLR). The adopted method seeks to collect and analyze empirical and conceptual evidence related to applications, enabling technologies, impacts, and barriers to the adoption of these systems. As a contribution, the study provides an integrated and critical overview of the state of the art in multifunctional robotics, identifying trends, gaps, and research opportunities, as well as proposing guidelines for advancing human–robot collaboration in real-world work contexts. The paper is structured as follows: the next section presents the theoretical background, followed by the description of the review method; subsequently, the main results and implications are discussed; and finally, conclusions and recommendations for future research are presented.

2 BACKGROUND AND RELATED WORK

2.1 Multifunctional Robots And Human–Robot Interaction

Multifunctional robots represent a significant evolution in automation, as they are designed to perform multiple tasks across different operational contexts through the integration of advanced sensing, intelligent architectures, and adaptive control systems. Unlike traditional single-purpose robots restricted to highly structured processes, multifunctional robots combine advanced perception, artificial intelligence, dynamic planning, and flexible manipulation, enabling operation in variable environments and collaborative interaction with humans.

This evolution is closely linked to advances in computer vision, machine learning, robotic cognition, and learning from demonstration, which enhance autonomy and adaptability. In complex domains such as logistics, healthcare, and field services, these capabilities are essential for supporting human workers and adjusting robotic behavior to contextual demands.

Human–Robot Interaction (HRI) has therefore emerged as a central research area focused on ensuring safe, efficient, and acceptable collaboration between humans and robots. Key aspects highlighted in the literature include physical safety, behavioral predictability, communication, trust, and user acceptance. Multifunctional robots intensify traditional HRI challenges, as they operate in dynamic scenarios requiring continuous decision-making and close coordination with human partners.

2.2 Enabling Technologies For Multifunctionality

Robotic multifunctionality results from the convergence of technological advances that enhance autonomy, adaptability, and interaction capabilities. Core foundations include intelligent perception, machine learning, cognitive decision-making models, and adaptive control mechanisms.

Advanced perception, enabled by multimodal sensors and computer vision techniques, allows robots to interpret their environment in real time, recognize objects and human actions, and respond to contextual changes. Machine learning approaches—such as supervised learning, reinforcement learning, and learning from demonstration—enable robots to acquire new skills and perform multiple tasks without extensive reprogramming, which is particularly relevant in collaborative environments.

In addition, cognitive architectures integrate perception, planning, and action, allowing robots to reason about goals and risks, while adaptive control and modular hardware designs support safe task execution and functional reconfiguration. Together, these technologies transform robots from rigid, task-specific machines into flexible systems capable of operating across multiple domains in collaboration with humans.

2.3 RELATED WORK

Prior studies have explored complementary aspects of human–robot collaboration. The work Human–robot collaboration in industrial environments: A literature review on non-destructive disassembly focuses on collaborative practices in industrial disassembly, providing insights into interaction models, coordination, and safety, although its scope is limited to a single domain.

The study Healthcare Robotics synthesizes advances and challenges in medical robotics, emphasizing how autonomy and versatility influence efficiency, safety, and acceptance in clinical environments. While aligned with the present work in addressing real-world HRI, it is restricted to the healthcare sector.

Finally, Risk Assessment for Human–Robot Collaboration in an Automated Warehouse Scenario addresses safety in logistics by proposing adaptive, context-aware risk assessment models for shared environments. Unlike these domain-specific approaches, the present systematic review adopts a cross-sectoral perspective, integrating technical, human, and organizational dimensions to provide a comprehensive understanding of multifunctional robot integration.

3 RESEARCH METHOD

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3.1 Research Questions

The present Systematic Literature Review (SLR) aims to synthesize scientific knowledge on the integration of multifunctional robots in human work environments, considering their applications, impacts, and challenges in the logistics, healthcare, and field services sectors. The research questions were formulated to guide the analysis and enable a comprehensive understanding of the technological, human, and organizational factors that influence this integration.

- **RQ1:** How have multifunctional robots been applied across different domains—particularly logistics, healthcare, and field services—and what impacts do they generate on human–robot collaboration dynamics?
- **RQ2:** Which enabling technologies (such as artificial intelligence, learning from demonstration, and adaptive perception) support the multifunctionality and autonomy of these systems in real-world work environments?
- **RQ3:** What are the main technical, safety, and human acceptance challenges identified in the literature regarding the implementation of multifunctional robots in collaborative contexts?
- **RQ4:** How do organizational, ergonomic, and ethical factors influence the adoption and integration of multifunctional robots in shared human–machine environments?
- **RQ5:** What gaps and future opportunities are identified in the literature for advancing the effective and socially accepted integration of multifunctional robots in human work contexts?

3.2 Databases

To ensure breadth and rigor in the bibliographic search, this Systematic Literature Review (SLR) considered five internationally recognized databases relevant to engineering, robotics, computer science, and technological applications. The selected databases were:

- ACM Digital Library, which focuses on computer science and provides extensive coverage of algorithms, human–robot interaction, and cognitive robotics;
- IEEE Xplore, a primary reference in engineering and robotics, encompassing studies on human–robot collaboration, advanced automation, and intelligent systems;
- Scopus, a broad multidisciplinary database used to complement the search and identify relevant studies in logistics, healthcare, and field services;
- Web of Science, a comprehensive index covering multiple research areas, including empirical studies on robotic integration in real-world environments;
- IEE, which yielded a smaller number of records but was retained for methodological consistency.

Search strings were constructed using terms related to multifunctional robots, collaborative robots, human–robot interaction, and their main application domains (logistics, healthcare, and field services). The execution of the search resulted in a total of 290 articles distributed across the selected databases.

The literature search was conducted in the ACM Digital Library, IEEE Xplore, Scopus, and Web of Science. These databases were selected due to their relevance to robotics, computer science, and applied engineering research.

Table 1 – Databases and Number of Retrieved Articles

Database	Retrieved Articles
ACM	82
IEEE / IEE	37
Scopus	41
Web of Science	130

Total	**290**

To ensure comprehensiveness and rigor in the bibliographic search, this Systematic Literature Review (SLR) considered five internationally recognized databases due to their relevance in engineering, robotics, computer science, and technological applications. The selected databases were ACM Digital Library, IEEE Xplore, Scopus, Web of Science, and IEE. Search strings were constructed using terms related to multifunctional robots, collaborative robots, human–robot interaction, and their main application domains (logistics, healthcare, and field services). After executing the search queries, a total of 290 articles were retrieved across the databases.

These databases were selected for their complementarity: while ACM and IEEE primarily concentrate on technological developments and advanced algorithms, Scopus and Web of Science broaden the scope to practical applications and interdisciplinary studies, enabling a more integrated view of the state of the art in multifunctional robotics.

3.3 Inclusion and Exclusion Criteria

To ensure consistency and objectivity in identifying studies included in this Systematic Literature Review (SLR), a set of predefined inclusion and exclusion criteria was established. These criteria were inspired by best practices in systematic reviews within the fields of engineering and robotics and were designed to ensure that only studies directly related to the core topic—namely, the integration of multifunctional and collaborative robots in human work environments—were considered.

The inclusion criteria (IC) comprised: (IC1) studies focusing on the application, implementation, design, or evaluation of robots in human work contexts, with emphasis on multifunctional or collaborative robots in logistics, healthcare, or field services; (IC2) alignment with the research questions, including evidence related to practical applications, impacts, enabling technologies, and implementation challenges; (IC3) publication in peer-reviewed journals or conference proceedings; (IC4) publication in the English language; and (IC5) publication between 2020 and 2025, reflecting the most recent research developments in the area.

The exclusion criteria (EC) eliminated studies that addressed exclusively fixed, single-task industrial robots; research conducted in out-of-scope domains such as military, domestic, space, or entertainment applications; purely theoretical studies or those based solely on simulation; as well as secondary studies, book chapters, theses, dissertations, and publications without full-text availability.

3.4 Procedures for Studies Selection

The study selection process was conducted through multiple structured and transparent stages, following the methodological recommendations of the PRISMA protocol. This procedure aimed to ensure rigor, reproducibility, and consistency throughout the identification, screening, and inclusion of relevant studies.

After the initial search across the selected databases, a total of 290 records were retrieved. All records were exported and consolidated into a unified spreadsheet, which served as the central artifact for tracking decisions, justifications, and intermediate results throughout the selection process. Duplicate entries across databases were identified and removed at this stage.

To support the initial screening and reduce inconsistencies inherent to manual large-scale filtering, two Large Language Models (LLMs), ChatGPT and Gemini, were employed exclusively as decision-support tools. Their role was limited to assisting in the preliminary classification of studies according to the predefined inclusion and exclusion criteria. The final responsibility for inclusion decisions remained with the authors, and the LLMs were not used as a primary research method.

The selection process comprised two main phases.

Phase 1 – Title, abstract, and keyword screening: In this initial screening phase, both LLMs independently evaluated the title, abstract, and keywords of each study. The assessment focused on: (i) explicit relevance to multifunctional or collaborative robots; (ii) evidence of human–robot interaction; (iii) alignment with the target application domains—logistics, healthcare, and field services; and (iv) indication of practical, experimental, or real-world application. Studies that were clearly outside the scope, addressed unrelated domains, or lacked any reference to collaboration or multifunctionality were excluded. Disagreements between the LLM outputs were flagged for further inspection.

Phase 2 – Detailed assessment using inclusion and exclusion criteria: The studies retained from Phase 1 underwent a more detailed evaluation. In this phase, each article was individually analyzed by both LLMs based on the full set of inclusion and exclusion criteria defined in the protocol. This assessment examined whether the study focused on the use, evaluation, or implementation of multifunctional or collaborative robots; discussed impacts on human–robot interaction; employed enabling technologies such as artificial intelligence, computer vision, or learning from demonstration; and reported empirical, experimental, or case-based evidence. For each decision, the LLMs generated structured justifications, which were documented in the spreadsheet to ensure traceability.

Only studies that received a positive classification for inclusion were marked as eligible for the subsequent quality assessment phase. In cases of divergence or ambiguity, the studies were reviewed and resolved by the authors to mitigate potential biases introduced by automated support.

As a result of this multi-stage selection process, 69 studies fully met the inclusion criteria and were retained for the final analysis of the Systematic Literature Review. This structured approach strengthened the reliability of the selection process while maintaining transparency and methodological rigor.

Table 2 – Articles Selected After LLM-Based Screening

Database	Retrieved Articles	LLM-Selected Articles
ACM	82	17
IEEE / IEE	37	12
Scopus	41	22
Web of Science	130	18
Total	**290**	**69**

3.5 Quality Criteria

The methodological quality assessment of the included studies was conducted in a systematic manner, based on a Quality Assessment spreadsheet defined by the research team. The purpose of this stage was to ensure that only studies with adequate scientific rigor contributed to the final synthesis of the review. To this end, each selected article was evaluated according to a set of predefined qualitative criteria, reflecting best practices in systematic literature reviews within the fields of engineering, robotics, and computer science.

Five main criteria were adopted, each scored on a scale of 0 (does not meet the criterion), 0.5 (partially meets the criterion), or 1 (fully meets the criterion). The sum of the scores resulted in a final quality score ranging from 0 to 5, which was used as a parameter to assess the methodological robustness of the studies.

The evaluated criteria were as follows:

QC1 – Clarity of Objectives: Assesses whether the study presents clearly defined and well-contextualized objectives aligned with the scope of the review, enabling a precise understanding of its contribution.

QC2 – Methodological Adequacy: Evaluates whether the method adopted by the study (e.g., experiment, case study, practical validation, modeling) is sufficiently described and appropriate for the investigated problem, ensuring replicability and reliability.

QC3 – Results Validation: Examines whether the results are supported by empirical evidence, experimental analyses, comparative metrics, or consistent theoretical grounding, thereby reinforcing the scientific credibility of the study.

QC4 – Contribution to the Topic: Assesses the relevance of the research to the understanding of multifunctional robotics and human–robot interaction, considering its potential to expand knowledge, propose innovative methods, or discuss emerging challenges.

QC5 – Scientific Coherence and Rigor: Verifies the overall consistency of the study's presentation, the clarity of its conclusions, the alignment between objectives, methods, and results, as well as adherence to scientific writing standards.

3.5.1 Evaluation Procedure

Each article was individually assessed based on these criteria, resulting in a total score that reflected its methodological quality. Studies with insufficient performance—particularly those scoring below 2.5—were reassessed to confirm their suitability for inclusion in the final portfolio. This procedure aimed to minimize bias, increase the reliability of the synthesis, and ensure that the reported results were grounded in robust and methodologically sound studies.

3.5.2 Assessment Results

The analysis indicated that most studies exhibited satisfactory to high methodological quality, with scores predominantly ranging between 3.0 and 4.5. Studies published in venues indexed by IEEE Xplore, ACM Digital Library, and Scopus generally demonstrated higher methodological rigor, whereas studies indexed in Web of Science showed greater heterogeneity, requiring more careful evaluation.

Overall, the application of the quality criteria enabled the establishment of a reliable final portfolio, reducing the likelihood of conclusions based on methodologically weak studies and strengthening the robustness of the systematic review.

3.6 Threats to Validity

The execution of this Systematic Literature Review (SLR) involves potential threats to the validity of its results. The main identified limitations and the strategies adopted to mitigate them are described below.

3.6.1 Use of LLMs in the Selection Process

The use of two Large Language Models (ChatGPT and Gemini) during the study screening process may introduce risks such as misinterpretation, inconsistent responses, or model-induced bias. To mitigate this threat, a dual and independent evaluation procedure was adopted, in which only studies with positive consensus were retained. In cases of disagreement, final decisions were manually reviewed by the authors. This approach aimed to reduce automated bias and increase the reliability of the selection process.

3.6.2 Incomplete Coverage of Search Strings

The search strings employed may not capture all relevant terminology due to the diversity of terms associated with multifunctional robotics and human–robot interaction. This limitation could result in the omission of pertinent studies. To mitigate this risk, the search strings were iteratively refined and applied across multiple databases with different indexing standards. Nevertheless, it is acknowledged that no search strategy can be entirely exhaustive.

3.6.3 Variability Across Databases

Differences in scope and indexing policies among ACM, IEEE Xplore, Scopus, and Web of Science may influence the profile of identified studies, potentially introducing bias into the final sample. This threat was mitigated by consulting complementary databases, reducing reliance on a single source and increasing thematic representativeness.

3.6.4 Subjectivity in Quality Assessment

Despite the use of explicit quality criteria, methodological quality assessment inherently involves subjective judgment. To minimize this risk, a standardized scoring scale was applied, and assessments were reviewed by the authors when necessary, ensuring consistency and transparency throughout the evaluation process.

Overall, these mitigation strategies helped reduce the main threats to validity, enhancing the reliability of the review findings while acknowledging the inherent limitations of the systematic review methodology.

4 RESULTS

4.1 Quality Assessment Results

The quality assessment was applied to the 69 studies selected after the screening phase supported by LLMs, following the criteria defined in Section 3.5. Each article received a score ranging from 0 to 5, reflecting methodological clarity, scientific rigor, adequacy of the adopted approach, and relevance to multifunctional robotics and human–robot interaction.

The results revealed substantial variability in the methodological robustness of the studies, leading to an additional filtering step based on the minimum quality threshold established by the SLR protocol. After this stage, 58 studies were deemed suitable to compose the final review portfolio, as summarized in Table X.

Overall, the following observations were made:

- The distribution of scores was concentrated between 3.0 and 4.5, indicating moderate to high methodological quality.
- Studies from IEEE Xplore, ACM Digital Library, and Scopus exhibited greater methodological consistency and stronger alignment with the objectives of the review.
- Studies retrieved from Web of Science displayed higher heterogeneity, requiring more careful and detailed analysis.
- Studies with insufficient validation, unclear objectives, or limited methodological description were excluded.
- The quality assessment stage contributed to consolidating a more uniform and reliable body of evidence, strengthening the internal validity of the results presented in the subsequent sections.

Table 3 – Articles Selected After Quality Assessment

Database	Retrieved Articles	Quality-Selected Articles
ACM	82	13
IEEE / IEE	37	10
Scopus	41	18
Web of Science	130	17
Total	**290**	**58**

4.2 Overview of selected studies

Table 4 – Overview of Selected Studies

ID	Title	Year
ES01	Walk or Ride? An Empirical Study on Cobot-Assisted Traveling in Warehouse 5.0	2025
ES02	Digital Twin-Enabled Adaptive Robotics: Leveraging Large Language Models in Isaac Sim	2025
ES03	Enhancing Safety in Collaborative Cable-Driven Parallel Robots	2025
ES04	Introducing Mobile Robots on the Shop Floor: User Experience Issues	2025
ES05	Model predictive-based compliance control for knee arthroplasty surgical robots	2024
ES06	An Object Deformation-Agnostic Framework for Human-Robot Collaborative Transportation	2024
ES07	Semantic-Based Loco-Manipulation for Human-Robot Collaboration in Industrial Environments	2024
ES08	Integrating collaborative robots in manufacturing, logistics, and agriculture: Expert perspectives	2024
ES09	Integration of Deep Learning and Collaborative Robot for Assembly Tasks	2024
ES10	Safe Reinforcement Learning for Collaborative Robots in Dynamic Human Environments	2024
ES11	Modeling Requirements for Collaborative Robotic Services	2023

ES12	Flexible Human-Robot Interaction: Collaborative Robot Integrated with Hand Tracking	2023
ES13	Moving from Industry 4.0 to Industry 5.0: What Are the Implications for Smart Logistics?	2022
ES14	Virtual Reality for Safe Testing and Development in Collaborative Robotics	2022
ES15	Intuitive & Efficient Human-robot Collaboration via Real-time Approximate Bayesian Inference	2022
ES16	A Trust Scale for Human-Robot Interaction: Translation, Adaptation, and Validation	2022
ES17	User-Interactive Robot Skin with Large-Area Scalability for Safer and Natural HRC in Telehealthcare	2021
ES19	Development of a Mobile Manipulator Robot for Human-Robot Collaboration	2024
ES20	Analyzing Previous Human-Robot Interaction Implementation in Agriculture	2025
ES21	Evaluating a Design Toolkit for Human-Robot Collaboration in Close-Proximity Scenarios	2025
ES22	GazeGrasp: DNN-Driven Robotic Grasping with Wearable Eye-Gaze Interface	2025
ES23	Hand-in-Hand: Investigating Mechanical Tracking for User Identification in Cobot Interaction	2023
ES24	Addressing Trust and Negative Attitudes Toward Robots in Human-Robot Collaborative Scenarios	2024
ES25	Guiding Multiple Remote Users in Physical Tasks with Language-driven Robotic Telepresence	2025
ES26	Towards Collaborative Crash Cart Robots that Support Clinical Teamwork	2024
ES27	An Assistive Robotic System for Cognitive State Assessment in Individuals with Spinal Cord Injury	2024
ES28	Situated Participatory Design: A Method for In Situ Design of Robotic Interaction with Older Adults	2023
ES29	Eye Gaze Controlled Robotic Arm for	2020

	Persons with Severe Speech and Motor Impairment	
ES30	The Robot Makers: An Ethnography of Anthropomorphism at a Robotics Company	2020
ES31	Agents of Autonomy: A Systematic Study of Robotics on Modern Hardware	2023
ES32	Trust-Aware Human–Robot Fusion Decision-Making for Emergency Indoor Patrolling	2024
ES34	Towards Intuitive Human-Robot Interaction: A Machine Learning Approach to Gesture Recognition	2025
ES35	Human-Machine Collaboration with AI: Cobots, BLE Integration, and Time-Series Forecasting	2025
ES36	Digital Shadow Enabled Integrated Multi-platform Automation System for Industrial Assembly	2024
ES39	An online scheduling algorithm for human-robot collaborative kitting	2020
ES40	Design of Robot-based Measurement System for the Quality Assessment of Ultrasound Probes	2020
ES41	Upper-Limb Kinematic Parameter Estimation and Localization Using a Compliant Robotic Manipulator	2021
ES43	Exploring the Role of Robots in Inpatient Care: Caregivers Perspectives	2025
ES44	Path Planning for Obstacle Avoidance of Robot Arm Based on Improved Potential Field Method	2023
ES45	A Robot-Assisted Framework for Rehabilitation Practices: Implementation and Experimental Results	2023
ES47	Vision AI-based human-robot collaborative assembly driven by autonomous robots	2024
ES48	Deploying pickers and robots in cobot-based collaborative order picking systems	2025
ES49	Applications of affective computing in human-robot interaction: State-of-art and challenges	2023
ES51	An Online Toolkit for Applications Featuring Collaborative Robots Across Different Domains	2023
ES52	Together, we travel: empirical insights on human-robot collaborative order	2025

	picking for retail warehousing	
ES53	Handover Control for Human-Robot and Robot-Robot Collaboration	2021
ES54	A bibliometric analysis on collaborative robots in Logistics 4.0 environments	2021
ES55	OMNIVIL-An Autonomous Mobile Manipulator for Flexible Production	2020
ES56	Hand-gesture-control-based Navigation Using Wearable Armband for Autonomous Guided Vehicles	2022
ES57	COVR Toolkit - Supporting safety of interactive robotics applications	2021

This section provides an overview of the studies included in the systematic review, considering their temporal distribution, publication types, geographic origin, and application domains. The final portfolio comprises 58 articles selected through the process described in Section 3, representing the current state of the art on the integration of multifunctional robots in human work environments across logistics, healthcare, and field services.

From a temporal perspective, publications are concentrated between 2022 and 2025, with a noticeable increase in 2024 and 2025, indicating growing scientific interest aligned with the maturation of technologies such as artificial intelligence, computer vision, and adaptive control. Regarding publication type, the portfolio is evenly distributed between journal articles and conference papers, capturing both consolidated contributions and emerging solutions.

Geographically, studies with identified origin are predominantly from European countries, with additional contributions from Asia and Latin America, reflecting the concentration of research in established robotics and automation centers. The selected works are published in leading venues associated with organizations such as IEEE, ACM, Elsevier, Springer, and MDPI. Overall, the portfolio consistently covers the three application sectors defined in the scope of this review, providing a robust basis for the analysis presented in the following sections.

4.3 RQ1 – Applications and Impacts of Multifunctional Robots in Human–Robot Collaboration

The analyzed studies indicate that multifunctional robots are primarily applied in logistics, healthcare, and field services, each presenting distinct operational characteristics and impacts on human–robot collaboration. In logistics, applications mainly involve autonomous mobile robots and collaborative manipulators for tasks such as picking, warehouse navigation, and inventory support, resulting in increased productivity, reduced physical workload, and improved operational safety.

In healthcare, multifunctional robots are employed in surgical assistance, rehabilitation, and assistive systems, contributing to higher precision, improved ergonomics, and enhanced autonomy for patients and healthcare professionals. In field services, robots operate in unstructured or outdoor environments for inspection and maintenance, extending operational reach and reducing human exposure to hazardous conditions.

Across all domains, the literature consistently reports qualitative improvements in collaboration dynamics, including increased predictability of robotic behavior, higher operator trust, and reduced physical and cognitive workload. These findings confirm that the adoption of multifunctional robots is associated with substantial gains in efficiency, safety, and human–machine integration.

4.4 RQ2 – Enabling Technologies for Multifunctionality and Autonomy

The analyzed studies indicate that robotic multifunctionality emerges from the integration of complementary technologies that enhance perception, decision-making, and adaptive action in real-world work environments. Artificial intelligence plays a central role, supporting object recognition, human intention prediction, and dynamic task control through supervised learning, reinforcement learning, and deep neural network architectures.

Adaptive perception is another key component, enabled by multimodal sensors such as

RGB-D cameras, LiDAR, and inertial units combined with computer vision and mapping techniques (e.g., SLAM). These capabilities allow robots to operate safely in dynamic and unstructured environments, which is essential for close human–robot collaboration.

Learning from Demonstration (LfD) is frequently reported as a critical approach for acquiring new skills from human examples, reducing programming effort and improving behavioral predictability. In addition, adaptive control architectures—such as impedance control and context-aware trajectory planning—enable smooth coordination between perception and action. Overall, the literature converges on a systemic view in which multifunctionality results from the synergistic coupling of AI, robust perception, continuous learning, and advanced control mechanisms.

4.5 RQ3, RQ4 and RQ5 – Challenges, Organizational Factors, and Future Opportunities

The literature identifies persistent technical, safety, and human acceptance challenges that limit the large-scale adoption of multifunctional robots. Key technical issues include limited perception robustness in dynamic environments, restricted generalization of AI models, and interoperability across heterogeneous systems. From a safety perspective, studies emphasize the need for advanced human presence detection, dynamic risk assessment, and standardized protocols to ensure predictable robot behavior. Human acceptance remains strongly influenced by trust, transparency, and ease of interaction, particularly in safety-critical domains.

Beyond technical aspects, the adoption of multifunctional robots is framed as a socio-technical process. Organizational factors such as workforce training, process redesign, digital maturity, and innovation culture play a decisive role, while ergonomic considerations highlight the importance of intuitive interfaces and alignment between robotic behavior and human expectations. Ethical concerns—including accountability, privacy, and governance of semi-autonomous systems—are increasingly prominent.

Regarding future opportunities, the literature highlights the need for longitudinal validation in real-world settings, as many studies remain confined to controlled environments. Promising directions include advanced human intention prediction, adaptive safety mechanisms, multimodal interaction interfaces, and the expansion of multifunctional robots into underexplored domains such as agriculture, infrastructure, public spaces, and smart cities. Human-centered approaches that integrate cognitive ergonomics, safety engineering, and ethical principles from early design stages are consistently emphasized as critical for sustainable adoption.

5 CONCLUSIONS

This paper presented a Systematic Literature Review aimed at synthesizing the current state of research on the integration of multifunctional robots in human work environments, with a particular focus on logistics, healthcare, and field services. By analyzing 58 high-quality studies published between 2020 and 2025, the review provides a consolidated view of how multifunctional robotic systems are being applied, which technologies enable their operation, and what impacts and challenges emerge from their adoption in real-world contexts.

The results indicate that multifunctional robots contribute consistently to improvements in productivity, safety, and ergonomics across the analyzed domains. In logistics, these systems support material handling, autonomous navigation, and collaborative picking, reducing physical workload and increasing operational efficiency. In healthcare, applications such as assistive, rehabilitation, and surgical robots enhance precision, support clinical staff, and promote patient autonomy. In field services, robots operating in unstructured or hazardous environments expand operational reach and mitigate risks to human workers. Across all domains, the literature highlights positive effects on human–robot collaboration, including increased predictability of robotic behavior and higher levels of operator trust.

From a technological perspective, the review confirms that multifunctionality does not rely on a single component, but rather on the synergistic integration of artificial intelligence, adaptive perception, learning from demonstration, and advanced control architectures. These technologies collectively enable robots to perceive complex environments, adapt to human actions, and perform multiple tasks safely and autonomously. However, the findings also reveal persistent challenges related to robustness, safety assurance, interoperability, and the generalization capabilities of AI-based models.

Beyond technical aspects, the adoption of multifunctional robots is shown to be a complex sociotechnical process influenced by organizational, ergonomic, and ethical factors. Issues such as workforce training, process redesign, user acceptance, transparency of robotic decision-making, and ethical governance play a decisive role in successful integration. The literature further highlights significant research gaps, including the need for longitudinal validations in real operational settings, more advanced human intention prediction mechanisms, and the expansion of multifunctional robotic applications to underexplored sectors.

In conclusion, this review contributes by offering a cross-sectoral and integrated perspective on multifunctional robotics, consolidating fragmented knowledge and identifying key trends and challenges. Future research should prioritize human-centered approaches, robust safety frameworks, and long-term empirical studies to support the effective and socially accepted deployment of multifunctional robots in human work environments.

REFERENCES

Gartner (2023). *Predicts 2023: Human-Centric Intelligent Systems*. Gartner Research.

Moore, R. and Lopes, J. (1999). Paper templates. In *TEMPLATE'06, 1st International Conference on Template Production*. SCITEPRESS.

Smith, J. (1998). *The Book*. The Publishing Company, London, 2nd edition.

Villani, V., Pini, F., Leali, F. and Secchi, C. (2018). Survey on human–robot collaboration in industrial settings: Safety, intuitive interfaces and applications. *Mechatronics*, 55, 248–266.

Yang, G.-Z., Nelson, B. J., Murphy, R. R., Choset, H., Christensen, H. I., Collins, S. H., Dario, P., Goldberg, K., Ikuta, K., Jacobstein, N., Kragic, D., Taylor, R. H. and McNutt, M. (2020). Combating COVID-19—The role of robotics in managing public health and infectious diseases. *Science Robotics*, 5(40), eabb5589.

Zanchettin, A. M., Rocco, P., Chiappa, S. and Rossi, R. (2016). Towards an optimal avoidance strategy for collaborative robots. *Robotics and Computer-Integrated Manufacturing*, 41, 15–24.

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