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Human Interaction With Autonomous Delivery Robots: Navigating the Intersection of Psychological Acceptance and Societal Integration

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ABSTRACT

The rapid integration of autonomous delivery robots into urban environments presents a complex interplay of technological innovation and human factors. This paper explores the multifaceted challenges and opportunities in human-robot interaction (HRI) within the context of autonomous delivery systems. Through a comprehensive analysis of recent empirical studies and theoretical frameworks, we investigate the psychological constructs that influence human acceptance of delivery robots, including trust, perceived usefulness, and ease of use. The research also examines broader societal implications, such as potential impacts on employment, urban infrastructure, and social dynamics. By synthesizing these insights, we propose a framework for fostering effective human-robot collaboration in autonomous delivery, emphasizing user-centred design approaches, adaptive interaction strategies, and multi-stakeholder engagement. This study aims to contribute to the responsible development and integration of autonomous delivery technologies while ensuring alignment with human values and societal well-being.

Keywords: Autonomous delivery robots, Human-robot interaction, Trust in automation, Technology acceptance, Societal integration

INTRODUCTION

The integration of autonomous delivery robots marks a pivotal shift in urban logistics, necessitating a thorough examination of the psychological and societal factors influencing their acceptance. Trust emerges as a cornerstone in shaping human-robot relationships, with Hancock et al. (2021) emphasizing its multifaceted nature encompassing reliability, predictability, and transparency. Hoff and Bashir (2014) underscore that trust must be actively cultivated through consistent performance and clear communication.

The Technology Acceptance Model and its extensions, as discussed by Marikyan and Papagiannidis (2023), provide a framework for understanding the complex interplay of factors affecting robot adoption. The COVID-19 pandemic has accelerated this adoption, with Zeng et al. (2020) noting the increased demand for contactless delivery. However, Pani et al. (2020) highlight emerging challenges, including job displacement and privacy concerns.

As these systems become more prevalent, Alverhed et al. (2024) stress the importance of examining the factors influencing trust and acceptance across various domains. This research aims to contribute to the ongoing discourse on autonomous delivery systems by providing an in-depth analysis of these factors and exploring strategies to enhance trust and facilitate seamless integration into society.

METHODOLOGY AND LITERATURE REVIEW

Research Methodology

This study employs a systematic literature review to examine the psychological and societal factors influencing the acceptance and adoption of delivery robots. We conducted a comprehensive search of scholarly databases, including IEEE Xplore, ACM Digital Library, and ScienceDirect, focusing on publications from 2015 to 2024. Our search terms encompassed "delivery robots," "autonomous delivery," and "human-robot interaction."

Following the approach outlined by Booth et al. (2012), we selected relevant articles based on predefined inclusion criteria. The chosen literature underwent thematic analysis to identify key patterns and insights related to our research objectives.

Literature Review Findings

Our review reveals several critical themes in the current research landscape. The concepts of perceived usefulness and ease of use emerge as significant determinants of technology acceptance, aligning with the Technology Acceptance Model (TAM) proposed by Davis (Davis, 1989). Trust stands out as a fundamental aspect influencing the adoption of delivery robots. Hancock et al. (2021) (2018) highlight the multifaceted nature of trust, encompassing reliability, predictability, and transparency. Hoff and Bashir (2014) underscore the importance of consistent performance and clear communication in building and maintaining user trust. The COVID-19 pandemic has markedly accelerated the adoption of autonomous delivery systems. Zeng et al. (Zeng, Chen, & Lew, 2020) indicate a shift towards contactless delivery options, highlighting the potential benefits of delivery robots in terms of safety and efficiency. However, Pani et al. (2020) also point to emerging challenges, including concerns about job displacement and privacy.

Evolution of Autonomous Robots

The field of robotics has seen significant evolution over the past decades. Industrial robots pioneered the automation of manufacturing processes, paving the way for more sophisticated systems (2008). Service robots, designed to assist in various tasks, gained prominence in the early 2000s. Breazeal (2003). notes that social robots, aimed at human-like interactions, have been developing since the late 1990s. More recently, collaborative robots designed to work alongside humans have emerged, exemplified by systems like Rethink Robotics' Baxter (2016).

Delivery Robots: Current Landscape

The current landscape of delivery robots is diverse, with various systems tailored to different environments and use cases. Amazon's Scout (Statt, 2019) and FedEx's Roxo (2019) represent efforts by major logistics companies to automate last-mile delivery. Starship Technologies' robots have found application in campus and urban settings (2018). These systems demonstrate the ongoing efforts to integrate autonomous delivery into various contexts, each presenting unique challenges and opportunities for human-robot interaction.

User Engagement With Interactive Bots

Beyond delivery applications, interactive bots present intriguing possibilities for sustained user engagement. The EMO desktop bot (2019) exemplifies efforts to create emotionally resonant interactions through anthropomorphic design and responsive behaviors. Kervenoael et al. (2020) suggest that such design elements can foster a sense of social presence and connection with users. The success of interactive bots hinges on their ability to provide meaningful interactions and fulfil user needs. Rossi et al. (2017) emphasize that bots offering value, whether through companionship, entertainment, or task assistance, are more likely to maintain user interest over time. Ahmad et al. (2017). note that adaptive behaviours responding to individual user preferences play a crucial role in sustaining engagement during long-term interactions. As the field progresses, researchers and designers continue to explore novel approaches to enhance human-robot interactions. Advances in natural language processing, machine learning, and human-centered design promise to yield more sophisticated and engaging robotic systems in the future (2015).

This overview of the current research landscape provides a foundation for understanding the complex interplay of factors shaping the integration of delivery robots into society. As autonomous systems become increasingly prevalent, ongoing investigation into these psychological and societal dynamics will be crucial for ensuring successful adoption and positive human-robot relationships.

CURRENT HUMAN MINDSET TOWARDS DELIVERY ROBOTS

Acceptance and Trust

The integration of delivery robots into society hinges on public acceptance and trust. Research indicates that perceived usefulness, ease of use, and reliability significantly influence individuals' willingness to adopt these technologies. Hancock et al. (2021) (2024). emphasize the multifaceted nature of trust in human-robot interactions, highlighting the need for consistent performance and transparent communication users (2023). To foster acceptance, Kapser and Abdelrahman (2020) suggest focusing on user-friendly designs and clear articulation of benefits.

Safety Concerns and Risk Perception

Safety apprehensions and risk perceptions present significant barriers to widespread adoption. Pani et al. (2020) report that many individuals express concerns about potential accidents, malfunctions, and privacy breaches associated with autonomous delivery. Addressing these issues requires implementing robust safety features and establishing clear regulatory frameworks. Public education initiatives, as proposed by Dohler et al. (2017), can play a crucial role in mitigating risks and building confidence.

Anthropomorphism and Social Presence

The attribution of human-like characteristics to delivery robots can significantly impact user attitudes. Kervenoael et al. (2020) found that individuals who perceive robots as having social presence are more likely to engage positively with them. Incorporating anthropomorphic elements, such as expressive interfaces or voice communication, can enhance approachability. However, Leung et al. (2018) caution that a balance must be struck between anthropomorphism and functionality to maintain efficiency.

Trust-Building Through Human-Robot Interaction

Effective human-robot interaction is crucial for building trust. Kundinger et al. (2019) note that trust is influenced by a robot's appearance, behaviour, and communication style. Designing intuitive interfaces and incorporating adaptive behaviour that align with human expectations can foster more natural interactions. Ahmad et al. (2017). emphasize the importance of social cues in sustaining engagement during long-term interactions.

Ethical Considerations and Social Impact

The deployment of delivery robots raises significant ethical concerns, particularly regarding potential job displacement. Frey and Osborne (2017) project substantial workforce disruption in logistics and delivery sectors. Addressing these challenges requires comprehensive strategies for workforce transition and support. Acemoglu and Restrepo (2019). advocate for investing in reskilling programs and implementing fair labor practices to ensure equitable distribution of automation benefits. Furthermore, the environmental impact of delivery robots must be considered. Vepsäläinen (2022) highlights the need to evaluate and mitigate energy consumption and potential contributions to urban congestion.

In conclusion, the current human mindset towards delivery robots is shaped by a complex interplay of acceptance, trust, safety concerns, anthropomorphism, and ethical considerations. Addressing these factors through user-centered design, robust safety measures, effective public engagement, and proactive policies is crucial for the responsible integration of delivery robots into society.

ENHANCING HUMAN-ROBOT INTERACTION IN DELIVERY

User-Centered Design and Functionality

Improving human-robot interaction in delivery systems necessitates a strong emphasis on user-centered design and functionality. The development of delivery robots should prioritize intuitive interfaces, clear communication mechanisms, and robust navigation capabilities to ensure a positive user experience. Paterson et al. (2023) emphasize the importance of user-friendly interfaces that facilitate easy control and monitoring of the robot's status and location. Key considerations include:

1. Developing intuitive control systems that allow users to easily interact with and monitor the robot's operations (2017).
2. Implementing clear communication protocols, including visual and auditory cues, to effectively convey important information to users (2018).
3. Ensuring reliable navigation in complex environments, incorporating obstacle avoidance and adaptive path planning techniques (2020).

Addressing Societal and Ethical Concerns

Building public trust and acceptance of delivery robots requires a proactive approach to addressing societal and ethical concerns. DiLuoffo and Michalson (2021) stress the importance of transparent and responsible deployment to ensure data privacy, safety, and fairness. Key strategies include:

1. Engaging in public discourse and stakeholder collaboration to identify and address concerns related to privacy, security, and potential job displacement (2020).
2. Establishing clear regulations and guidelines for the operation of delivery robots in public spaces, ensuring compliance with legal and ethical standards (2018).
3. Promoting responsible innovation practices, such as conducting impact assessments and implementing ethical design principles (2018).

Collaborative Human-Robot Interaction

Collaborative human-robot interaction offers a promising approach to enhance the delivery experience. Khatib et al. (2021) suggest that leveraging the strengths of both humans and robots can improve efficiency, flexibility, and user satisfaction. Key elements of collaborative human-robot interaction include:

1. Designing robots capable of effective communication and coordination with human operators, utilizing natural language processing and gesture recognition (2015).
2. Implementing adaptive task allocation and dynamic role assignment based on the capabilities and preferences of both humans and robots (2017).
3. Developing trust-building mechanisms, such as explainable AI and transparency, to foster a sense of teamwork and shared goals (2020).

Continuous Learning and Adaptation

To ensure long-term success in human-robot interaction for delivery systems, it is crucial to incorporate continuous learning and adaptation capabilities. Argall et al. (2009) (2023) emphasize the importance of robots learning from their interactions with humans and the environment to improve performance and decision-making over time. Key aspects of continuous learning and adaptation include:

1. Implementing machine learning algorithms that allow robots to learn from user feedback, preferences, and behaviours (2019).
2. Developing adaptive control systems that enable robots to adjust their actions and strategies based on changing contexts and user needs (2018).
3. Incorporating self-monitoring and self-optimization mechanisms to ensure the robot's performance remains reliable and efficient over extended periods (2018).

In conclusion, enhancing human-robot interaction in delivery systems requires a multifaceted approach that focuses on user-centered design, addressing societal and ethical concerns, fostering collaborative interactions, and enabling continuous learning and adaptation. By prioritizing these key areas, stakeholders can develop delivery robots that are not only technologically advanced but also socially accepted and valued by the users they serve.

CHALLENGES IN HUMAN-ROBOT INTERACTION FOR DELIVERY SYSTEMS

Technical Challenges

Navigation and Obstacle Avoidance

One of the primary technical hurdles in deploying delivery robots is ensuring safe and efficient navigation in complex urban environments. Kang et al. (2022) highlight the need for robust perception, localization, and path-planning capabilities to handle dynamic obstacles and unpredictable human behaviors. Advanced sensor fusion techniques and adaptive control strategies are being developed to enhance navigation performance (2020). Kümmerle et al. (2014) emphasize the importance of sophisticated algorithms for handling varying terrains and real-time obstacle detection. Researchers are exploring the integration of computer vision and deep learning to create robots that can navigate safely in human-populated areas (2018).

Robustness and Reliability

Ensuring consistent performance of delivery robots under diverse conditions is crucial for their widespread adoption. Khalastchi and Kalech (2018) discuss the need for self-monitoring and fault detection mechanisms to maintain reliability over extended periods of operation.

Cybersecurity and Data Privacy

As delivery robots process sensitive information, robust cybersecurity measures are essential. Gebremichael et al. (2020) stress the importance of implementing secure communication protocols and encryption methods to protect against potential vulnerabilities.

Societal Challenges

Legal and Regulatory Frameworks

The deployment of autonomous delivery robots necessitates the development of comprehensive legal frameworks. Fosch-Villaronga and Millard (2019) discuss the need to address issues such as liability, insurance, and operating permissions to ensure responsible integration into public spaces.

Ethical Considerations

Winfield and Jirotka (2018) highlight the ethical questions raised by delivery robots, particularly regarding their decision-making processes in complex situations. Developing transparent and accountable ethical frameworks is crucial for building public trust (2020).

Economic Impact

The potential job displacement in the logistics sector due to automation is a significant concern. Acemoglu and Restrepo (2019) emphasize the need for proactive measures, such as reskilling programs, to address the economic impact on the workforce.

Infrastructural Challenges

Urban Environment Adaptation

Integrating delivery robots into existing urban infrastructure requires careful consideration. Law et al. (2023) discusses the need for adapting sidewalks, curbs, and building entrances to accommodate robot operation. Collaboration with urban planners and policymakers is essential for creating robot-friendly environments (2017).

Interoperability and Standardization

Bogue (2016) emphasizes the importance of developing common protocols and interfaces to ensure interoperability between different robotic platforms and existing logistics networks.

Readiness of Supply Chain and Logistics Networks

The successful deployment of delivery robots requires the readiness of supply chain and logistics networks to handle the increased complexity and automation. Adapting warehouse operations, inventory management, and order fulfilment processes is necessary to optimize the efficiency of robotic delivery systems (2020) (2024).

Human-Robot Interaction

Effective human-robot interaction (HRI) is crucial for the successful integration of delivery robots. Paterson et al. (2023) highlight the challenges in designing intuitive interfaces and communication channels. Research is focused on developing natural language processing and gesture recognition capabilities to enable more engaging interactions (2015). Trust-building is a critical aspect of HRI for delivery robots. Hancock et al. (2021) discuss the impact of robot appearance, behaviour, and communication style on user trust. Kervenoael et al. (2020) investigate the role of anthropomorphic design and social cues in fostering acceptance of delivery robots. The long-term success of delivery robots depends on their ability to learn and adapt. Argall et al. (2009) explore the integration of machine learning techniques to enable robots to improve their performance over time. Weld et al. (2019) discuss the potential of reinforcement learning and online learning approaches for creating adaptive robotic systems.

Opportunities and Future Prospects

Potential Benefits of Delivery Robots

The integration of delivery robots into urban environments presents numerous opportunities for enhancing efficiency, accessibility, and sustainability in last-mile logistics.

Increased Efficiency and Cost Reduction

Delivery robots have the potential to significantly streamline the delivery process and improve overall logistics performance. Alverhed et al. (2024) highlight the capacity of these systems to optimize routes, reduce labor costs, and enable round-the-clock operations, leading to substantial efficiency gains and cost reductions in last-mile delivery.

Enhanced Accessibility and Convenience

Lee and Hogan (2016) emphasize the potential of delivery robots to improve accessibility and convenience, particularly for underserved or remote areas. These autonomous systems can provide on-demand and flexible delivery options, enhancing the quality of life for individuals with limited mobility or access to traditional delivery services.

Environmental Sustainability

Wu et al. (2023) discuss the environmental benefits of adopting delivery robots, including reduced traffic congestion and lower emissions compared to traditional delivery vehicles. The use of electric-powered robots and optimized delivery routes can contribute significantly to minimizing the carbon footprint of last-mile delivery operations.

EMERGING APPLICATIONS AND USE CASES

Healthcare and Medical Supply Delivery

Kumar et al. delivery (2022) explore the crucial role delivery robots can play in healthcare and medical supply delivery, particularly in emergency situations or remote locations. These systems can efficiently transport medical supplies, medications, and diagnostic samples, ensuring timely and secure delivery in critical scenarios.

Food and Grocery Delivery

Kapser and Abdelrahman (2020) identify the food and grocery delivery sector as a promising application area for delivery robots. These autonomous systems can efficiently deliver fresh produce, prepared meals, and household essentials, offering convenience and flexibility to customers.

Emergency Response and Disaster Relief

Pizzuto (2023) discusses the potential deployment of delivery robots in emergency response and disaster relief scenarios. These systems can deliver essential supplies, food, and medical aid to affected areas, accessing hazardous or hard-to-reach locations while minimizing risks to human responders.

Future Research Directions

Advanced Human-Robot Interaction Techniques

Mavridis (2015) emphasizes the need for research focused on developing advanced human-robot interaction techniques, such as natural language processing and gesture recognition. Enhancing the naturalness and intuitiveness of human-robot communication is crucial for fostering trust and acceptance.

Collaborative Robotics and Human-in-the-Loop Systems

Musić and Hirche (2017) highlight the importance of exploring collaborative robotics and human-in-the-loop systems. Developing frameworks for effective task allocation, coordination, and shared decision-making can optimize the efficiency and flexibility of delivery operations.

Artificial Intelligence and Machine Learning Integration

Kober et al. (2013) discuss the potential of integrating artificial intelligence (AI) and machine learning (ML) techniques to enable delivery robots to adapt to dynamic environments and improve decision-making capabilities. These advancements can enhance the robustness, efficiency, and personalization of robotic delivery systems.

Aesthetic and Interactive Robot Design

The aesthetic and interactive design of delivery robots plays a crucial role in user acceptance and engagement. Zhang et al. (2022) note that anthropomorphic design elements can enhance the perceived friendliness of

robots. However, Roesler et al. (2023) caution that designers must balance human-like features with functionality to avoid the "uncanny valley" effect.

Transparent Human-Robot Interaction Platforms

Freedy et al. (2007) emphasize the importance of transparent human-robot interaction platforms in building trust and acceptance. Mobile apps and wearable devices can provide users with real-time updates and control over the robot's actions. Paci et al. (2023) suggest that these platforms should offer insights into the robot's decision-making processes and data usage to address user concerns and maintain transparency.

In conclusion, while the deployment of delivery robots presents various challenges, it also offers significant opportunities for increased efficiency, enhanced accessibility, and environmental sustainability. By addressing these challenges and investing in future research directions, stakeholders can unlock the full potential of delivery robots and shape a future where humans and robots collaborate seamlessly in the delivery sector.

CONCLUSION

The integration of delivery robots into urban landscapes represents a transformative shift in logistics and human-robot interaction. This review illuminates the intricate challenges and compelling opportunities inherent in this technological evolution. As we confront the complexities of user acceptance, technical constraints, and societal ramifications, a holistic approach becomes essential.

Our analysis underscores that successful implementation depends on addressing human factors in tandem with technological progress. User-centric design emerges as a cornerstone for building trust and acceptance. Concurrently, overcoming technical hurdles in navigation and obstacle avoidance demands innovative solutions. The potential of delivery robots to enhance efficiency, accessibility, and sustainability in urban logistics is substantial. Their promising applications in healthcare and emergency response point to a broader societal impact. However, responsible deployment must prioritize ethical considerations and inclusive design to ensure widespread acceptance.

Looking ahead, the focus should be on developing socially intelligent and adaptable robots through advanced interaction techniques and AI integration. Cross-sector collaboration is crucial for establishing comprehensive regulatory frameworks that balance innovation with public safety.

By tackling these challenges head-on and investing in responsible development, we can harness the full potential of delivery robots. This technological leap promises to revolutionize urban logistics and significantly enhance the quality of life for communities worldwide, marking a new era in human-robot coexistence.

REFERENCES

Acemoglu, D., & Restrepo, P. (2019). Automation and New Tasks: How Technology Displaces and Reinstates Labor. *Journal of Economic Perspectives, 33*(2), 3–30.

Ahmad, M., Mubin, O., & Orlando, J. (2017). Adaptive Social Robot for Sustaining Social Engagement during Long-Term Children–Robot Interaction. *International Journal of Human-Computer Interaction, 33*(2), 1–20.

Ahmad, M., Mubin, O., & Orlando, J. (2017). Adaptive Social Robot for Sustaining Social Engagement during Long-Term Children–Robot Interaction International Journal of Human-Computer Interaction. *International Journal of Human-Computer Interaction, 33*(2), 1–20.

Alverhed, E., Hellgren, S., Isaksson, H., Olsson, L., Palmqvist, H., & Flodén, J. (2024). Autonomous last-mile delivery robots: a literature review. *European Transport Research Review, 16*(4).

Argall, B., Chernova, S., Veloso, M., & Browning, B. (2009). A survey of robot learning from demonstration. *Robotics and Autonomous Systems, 57*, 469–483.

Bharadwaj, R., Swaisaenyakorn, S., & Parini, C. (2017). Impulse Radio-Ultra Wideband Communications for Localisation and Tracking of Human Body and Limbs Movement for Healthcare Applications. *IEEE Transactions on Antennas and Propagation, 65*(12), 7298–7309.

Bogue, R. (2016). Growth in e-commerce boosts innovation in the warehouse robot market. *Industrial Robot the international journal of robotics research and application, 43*(6), 583–587.

Booth, A., Papaioannou, D., & Sutton, A. (2012). *Systematic Approaches to a Successful Literature Review.* Sage Publications.

Breazeal, C. (2003). Toward sociable robots. *Robotics and Autonomous Systems*, 167–175.

Cha, E., Fitter, N., Kim, Y., Fong, T., & Matarić, M. (2018). Effects of Robot Sound on Auditory Localization in Human-Robot Collaboration. *HRI '18: Proceedings of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*, 434–442.

Davis, F. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly, 13*(3), 319–340.

DiLuoffo, V., & Michalson, W. (2021). A Survey on Trust Metrics for Autonomous Robotic Systems.

Dohler, M., Mahmoodi, T., Lema, M., Condoluci, M., Sardis, F., Antonakoglou, K., & Aghvami, H. (2017). Internet of skills, where robotics meets AI, 5G and the Tactile Internet. *European Conference on Networks and Communications (EuCNC)*, 1–5.

EMO PET. (2019). *EMO PET*. Retrieved from living.ai: https://living.ai/emo/

Fedex. (2019). *newsroom.fedex.com*. Retrieved from FedEx welcomes Roxo™, the FedEx SameDay Bot to the U. A. E: https://newsroom.fedex.com/newsroom/meis a-english/fedex-welcomes-roxo-the-fedex-sameday-bot-to-the-u-a-e.

Fosch-Villaronga, E., & Millard, C. (2019). Cloud robotics law and regulation. *Robotics and Autonomous Systems, 119*(c), 77–91.

Fosch-Villaronga, E., & Millard, C. (2019). Cloud robotics law and regulation: Challenges in the governance of complex and dynamic cyber–physical ecosystems. *Robotics and Autonomous Systems*, 77–91.

Freedy, A., DeVisser, E., Weltman, G., & Coeyman, N. (2007). Measurement of trust in human-robot collaboration. *2007 International Symposium on Collaborative Technologies and Systems*, (pp. 106-114). Orlando, FL, USA. DOI: 10.1109/CTS.2007.4621745.

Frey, C., & Osborne, M. (2017). The future of employment: How susceptible are jobs to computerisation? *Technological Forecasting and Social Change, 114*, 254–280.

Gebremichael, T., Ledwaba, L., Eldefrawy, M., Gerhard, H., Pereira, N., Gidlund, M., & Akerberg, J. (2020). Security and Privacy in the Industrial Internet of Things: Current Standards and Future Challenges. *IEEE Access*.

Hägele, M., Nilsson, K., & Pires, J. (2008). Industrial robotics. In *Springer handbook of robotics* (pp. 1385–1422).

Hancock, P., Kessler, T., Szalma, J., Kaplan, A., & Brill, J. (2021). Evolving Trust in Robots: Specification Through Sequential and Comparative Meta-Analyses. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 63*(7), 1196–1229.

Hoff, K., & Bashir, M. (2014). Trust in Automation: Integrating Empirical Evidence on Factors That Influence Trust. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 57*(3), 407–434.

Kang, J., Tariq, S., Oh, H., & Woo, S. (2022). A Survey of Deep Learning-Based Object Detection Methods and Datasets for Overhead Imagery. *IEEE Access, 10*, 20118–20134.

Kapser, S., & Abdelrahman, M. (2020). Acceptance of autonomous delivery vehicles for last-mile delivery in Germany – Extending UTAUT2 with risk perceptions. *Transportation Research Part C: Emerging Technologies, 111*, 210–225.

Kervenoael, R., Hasan, R., Schwob, A., & Goh, E. (2020). Building better robots: Leveraging human-robot interaction and perspectives. *Tourism Management, 78*.

Khalastchi, E., & Kalech, M. (2018). On Fault Detection and Diagnosis in Robotic Systems. *ACM Computing Surveys, 51*(1), 1–24.

Khalastchi, E., & Kalech, M. (2018). On Fault Detection and Diagnosis in Robotic Systems. *ACM Computing Surveys, 51*(1), 1–24.

Khatib, O., Sun, Q., Kang, S., Lara, S., & Tao, J. (2021). Human-in-the-loop robotic delivery: Opportunities and challenges. *n Proceedings of the 2021 IEEE International Conference on Robotics and Automation (ICRA)*, 2224–2230.

Kober, J., Bagnell, J., & Peters, J. (2013, September). Reinforcement learning in robotics: A survey. *International Journal of Robotics Research, 32*(11), 1238–1274.

Kumar, K., Prabakaran, D., Kumaran, R., & Yamuna, I. (2022). Privacy and Security of Smart Systems. In *Intelligent Green Technologies for Sustainable Smart Cities*.

Kümmerle, R., Ruhnke, M., Steder, B., Stachniss, C., & Burgard, W. (2014). Autonomous Robot Navigation in Highly Populated Pedestrian Zones. *Journal of Field Robotics, 32*(4), 565–589.

Kundinger, T., Wintersberger, P., & Riener, A. (2019). (Over) Trust in Automated Driving: The Sleeping Pill of Tomorrow? *Extended Abstracts of the 2019 CHI Conference* (pp. 1–6). ACM.

Law, W., Fan, K., Li, K., & Mo, T. (2023). Applied Design and Methodology of Delivery Robots Based on Human–Robot Interaction in Smart Cities. *EAI Endorsed Transactions on Smart Cities, 7*(2).

Lee, H., & Hogan, N. (2016). Essential considerations for design and control of human-interactive robots. *2016 IEEE International Conference on Robotics and Automation (ICRA)*. IEEE.

Leung, E., Paolacci, G., & Puntoni, S. (2018). Man Versus Machine: Resisting Automation in Identity-Based Consumer Behavior. *Journal of Marketing Research*, 818–831.

Marikyan, D., & Papagiannidis, S. (2023). Unified Theory of Acceptance and Use of Technology: A review. In S. Papagiannidis (Ed). In S. Papagiannidis, *TheoryHub Book*.

Mavridis, N. (2015). A review of verbal and non-verbal human–robot interactive communication. *Robotics and Autonomous Systems, 63*(1), 22–35.

Musić, S., & Hirche, S. (2017). Control sharing in human-robot team interaction. *Annual Reviews in Control, 44*, 342–354.

Paci, F., Pizzoli, J., & Zannone, N. (2023). A Comprehensive Study on Third-Party User Tracking in Mobile Applications. *A Comprehensive Study on Third-Party User Tracking in Mobile Applications*(97), 1–8.

Pani, A., Mishra, S., Golias, M., & Figliozzi, M. (2020). Evaluating public acceptance of autonomous delivery robots during COVID-19 pandemic. *Transportation Research Part D: Transport and Environment*.

Pani, A., Mishra, S., Golia, M., & Figliozzi, M. (2020). Evaluating public acceptance of autonomous delivery robots during COVID-19 pandemic. *Transportation Research Part D*.

Paterson, M., Hoffman, G., & Zheng, C. (2023). Introduction to the Special Issue on "Designing the Robot Body: Critical Perspectives on Affective Embodied Interaction". *ACM Transactions on Human-Robot Interaction*, 1–9.

Pizzuto, C. (2023). *Disaster robots: Revolutionizing emergency response with autonomous robots*. Retrieved from AI for Good: https://aiforgood.itu.int/disaster-robots-revolutionizing-emergency-response-with-autonomous-robots/

Roesler, E., Pickl, J., & Siebert, F. (2023). Investigating the Impact of Anthropomorphic Framing and Product Value on User Acceptance of Delivery Robots. *HCI in Mobility, Transport, and Automotive Systems*, (pp. 347–357).

Rossi, A., Dautenhahn, K., Koay, K., & Saunders, J. (2017). Investigating Human Perceptions of Trust in Robots for Safe HRI in Home Environments. *Conference: the Companion of the 2017 ACM/IEEE International Conference*, 375–376.

Siau, K., & Wang, W. (2020). Artificial Intelligence (AI) Ethics: Ethics of AI and Ethical AI. *Journal of Database Management*.

Simoni, M., Kutanoglu, E., & Claudel, C. (2020). Optimization and analysis of a robot-assisted last mile delivery system. *Transportation Research Part E, 142*.

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research, 104*, 333–339.

starship. (2018). *starship*. Retrieved from starship: https://www.starship.xyz/

Statt, N. (2019). *Amazon has made its own autonomous six-wheeled delivery robot*. Retrieved from theverge: https://www.theverge.com/2019/1/23/18194566/amazon-scout-autonomous-six-wheeled-delivery-robot

Thomas, J., & Harden, A. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Medical Research Methodology, 8*(45).

Ullman, D., & Malle, B. (2018). What does it mean to trust a robot? Steps toward a multidimensional measure of trust. *In Companion of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*, pp. 263–264.

Urbanic, R., Djuric, A., & Rickli, J. (2016). A Framework for Collaborative Robot (CoBot) Integration in Advanced Manufacturing Systems. *SAE International*.

Venkatesh, V., Morris, M., Davis, G., & Davis, F. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly*, 425–478.

Vepsäläinen, J. (2022). Energy Demand Analysis and Powertrain Design of a High-Speed Delivery Robot Using Synthetic Driving Cycles. *MDPI, 15*(6).

Weld, D., Vorvoreanu, M., Fourney, A., Nushi, B., Collisson, P., Suh, J.,... Horvitz, E. (2019). Guidelines for Human-AI Interaction. *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (pp. 1–13). ACM.

Winfield, A., & Jirotka, M. (2018). Ethical governance is essential to building trust in robotics and artificial intelligence systems. *Philosophical Transactions A The Royal Society*.

Winfield, A., & Jirotka, M. (2018). Ethical governance is essential to building trust in robotics and artificial intelligence systems. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*.

Wu, M., Yeong, C., Ming Su, E., Holderbaum, W., & Yang, C. (2023). A review on energy efficiency in autonomous mobile robots. *Robotic Intelligence and Automation*.

Xiao, X., Liu, J., Wang, Z., Zhou, Y., Qi, Y., Cheng, Q., Jiang, S. (2023). Robot Learning in the Era of Foundation Models: A Survey. *Robotics*.

Zeng, Z., Chen, P.-J., & Lew, A. (2020). From high-touch to high-tech: COVID-19 drives robotics adoption. *An International Journal of Tourism Space, Place and Environment, 22*(3), 724–734.

Zhang, S., Lin, X., Li, X., & Ren, A. (2022). Service robots' anthropomorphism: dimensions, factors and internal relationships. *Electron Markets, 32*, 277–295. doi:10.1007/s12525-022-00527-1

Zhang, Y., Sun, P., Yin, Y., Lin, L., & Wang, X. (2018). Human-like Autonomous Vehicle Speed Control by Deep Reinforcement Learning with Double Q-Learning. *2018 IEEE Intelligent Vehicles Symposium (IV)* (pp. 1251–1256). IEEE.