Robot Ethics: Ethical, Legal, and User Perspectives in the Development and Application of Robotics and Automation

By Jim Torresen, Cecilia Laschi, Edson Prestes, Lydia E. Kavraki, Praminda Caleb-Solly, and Yueh-Hsuan Weng

We are witnessing the transition of robots from labs and industrial settings to home, work, and publicly accessible spaces where they interact with a diverse range of people in different contexts. This requires an increased focus on human–robot interaction (HRI), raising inherent ethical and legal issues. This *IEEE Robotics and Automation Magazine* special issue will enable readers to better understand the impact of different assessments and potential measures concerning robot ethics on robot design and deployment. The challenges presented also open up new directions for robotics and automation research.

The domain addressed by this special issue is sometimes referred to as covering ethical, legal, and social issues (ELSI). Being able to employ measures to address the implications and issues raised by ELSI is vital to making robots more acceptable and trustworthy and fundamental for responsible research and innovation. This special issue covers key aspects through concrete examples from ongoing research projects and applied work and case studies on legal considerations, application of relevant standards, ethical analysis, design principles, open source misuse, and more. This will be from an international perspective, with contributors representing the Global North and South and with emphasis on gender, cultural, and ethnic diversity. This special issue is related to the IEEE Robotics and Automation Society Technical Committee on Robot Ethics, with its co-chairs being among the guest editors of this special issue. We organize various events like workshops and tutorials. Authors of contributions to the IEEE ICRA 2024 Workshop on Robot Ethics—Ethical, Legal and User Perspectives in Robotics and Automation (organized 13 May 2024 in Yokohama, Japan) were encouraged to submit extended versions of their unpublished work to this special issue. We also welcomed other contributions. All submissions to the special issue underwent peer review like regular journal articles.

The main objective of the special issue is to raise awareness; prompt debate; and share knowledge about ethical, legal, and user/social perspectives for robot assistants operating in personal and public environments with humans. Views on challenges that are common and unique for robotics technologies compared with other fields were also welcome.

Mirroring the multidisciplinary nature of robot ethics, this special issue contains ten articles with a wide variety of topics related to ethical, legal, and user perspectives within robotics and automation. We think they provide an important overview of state-of-the-art research. They are appended in alphabetical order, sorted by the last name of the first author.

The first contribution in the special issue is an introduction by D. Araiza-Illan et al. of a roadmap for responsible robotics [A1]. It captures the outcomes of a Dagstuhl seminar held in September 2023, where researchers from robotics, computer science, social and cognitive sciences, and philosophy were gathered. The overall aim was to chart a path toward improving responsibility in robotic systems. The participants identified key priorities to guide future research and regulatory efforts. The roadmap outlines key values and questions needing to be addressed to advance responsible robotics. Thus, the resulting roadmap outlines actionable steps to ensure that robotic systems coevolve with human societies, promoting human agency and humane values rather than undermining them.

> “THE RESULTING ROADMAP OUTLINES ACTIONABLE STEPS TO ENSURE THAT ROBOTIC SYSTEMS COEVOLVE WITH HUMAN SOCIETIES, PROMOTING HUMAN AGENCY AND HUMANE VALUES RATHER THAN UNDERMINING THEM.”

T. Barros et al. then propose a robotic cell safety monitoring system that is applied to an industrial robotic cell [A2]. It enables real-time detection, analysis, and reasoning over safety norm violations in industrial HRI scenarios. It is developed based on the IEEE 7007-2021 standard, which provides a set of ontologies for the development of ethically

Digital Object Identifier 10.1109/MRA.2025.3619589
Date of current version: 12 December 2025

driven robotics and automation systems. A series of experiments, including tests in simulated and real-world robotic cell scenarios, are performed to validate the system's ability to identify violations, assign responsibilities, and support compliance with safety protocols, which helps to bridge the gap between ethical standards and practical robotic deployments in industrial automation.

The next contribution is by Menon et al., who propose a family of techniques for ethical hazard analysis of assistive robots [A3]. Users of such robots may be especially vulnerable as they often belong to demographics already marginalized by technology and thus exposed to a wider range of ethical hazards. Addressing these risks requires creativity, collaboration, and diverse perspectives. In light of this, the authors introduce X-HAZOP, a toolbox of structured, facilitated workshops designed to identify ethical hazards. Their findings from multiple workshops demonstrate that the use of X-HAZOP with suitably diverse groups of participants improves the creation of accessible descriptions of the robot, aids mutual understanding, and leads to an effective identification of a broad spectrum of ethical hazards.

In [A4], L. Righetti and V. Boulanin address the regulation of open source robotics systems, where the current policy of openness increases the inherent dual-use risks associated with research and innovation in robotics. The authors argue that it lowers barriers for developing and deploying robotics systems for military use and harmful purposes. Thus, they propose a roadmap focusing on four practices: 1) education in responsible robotics, 2) incentivizing risk assessment, 3) moderating the diffusion of high-risk material, and 4) developing red lines.

In contrast, C. Rigotti and E. Fosch-Villaronga address the sensitive topic of regulatory challenges surrounding machines offering sexual and emotional services [A5]. The article examines the adequacy of existing regulations to address the societal implications of the novel HRIs. Considering these questions and societal implications, the article specifically explores such machines' potential inclusion under the AI Act.

M. J. van der Schoor et al. set out to identify ethical, legal, and sustainability challenges when deploying service robots in and for cities [A6]. Their research is centered around the project "Robots and the City," which took place in the city of Brussels (Belgium). They investigated how service robots can aid in satisfying future potential needs in the delivery of public missions. Key challenges are identified, as well as measures to navigate them. The importance of integrating user perspectives to comply with ethical and legal standards is emphasized. The article follows up with an overview of the challenges associated with urban service robots and provides a list of recommendations for designers and developers. Finally, the impacts and feasibility of such measures are also discussed.

Soft robots represent a subgroup of robots that benefit from being analyzed separately since they present a series of unique characteristics defined by their soft and compliant nature. Thus, in [A7], S. Terrile et al. consider the ethical issues related to soft robotics and how the scientific community is trying to address them. Two areas are identified that present significant and pressing ethical challenges: HRI and environment–robot interaction. For each of these groups, the different applications and the corresponding ethical issues are explored, and possible future scenarios for soft robotics and their ethical components are discussed.

Velmurugan et al. analyze clinicians' perspectives on safety, ethical, and legal considerations for home-based physical rehabilitation robots [A8]. The authors highlight the urgent need for a multifaceted approach to address these challenges, emphasizing user-centered design, rigorous testing, comprehensive user training, and updates to regulatory frameworks. Their analysis underscores that only by combining these measures can home-based rehabilitation robots be deployed in a manner that is safe, effective, and equitable.

The next article, by Weng et al., addresses the integration of robots into daily life by bridging ethics and reality [A9]. Social robots operate in environments rich with cultural norms, emotions, and social cues, raising complex ethical, legal, and social implications related to privacy, trust, and safety. The authors argue that these challenges can be addressed by combining thought experiments with empirical research, creating a hybrid methodological approach. Thought experiments provide a systematic analysis of ethical dilemmas, while empirical methods validate and refine these frameworks in real-world contexts. The article particularly emphasizes the role of living labs as dynamic environments for embedding ethical design principles into robotics, ensuring that social robots are aligned with both ethical expectations and legal standards.

The final article in the special issue is by Yankee et al., who examine the impacts of design and behavior on the acceptance of anthropomorphic service robots [A10]. Using questionnaire responses from 146 participants taken from a publicly available dataset in affective computing in HRI, the authors analyze acceptance of service robots. After validating their framework, they observe significant relationships regarding anthropomorphism, transparency, liability, and morality. They find that neither transparent communication nor failures resulting in liability issues cause significant changes in acceptance. Similarly, no differences in acceptance are observed based on anthropomorphism. However, overtly immoral behavior by robots proves more harmful to acceptance than moral behavior is beneficial. These results highlight surprising and notable insights into how design and behavioral factors shape user perceptions of robots.

The guest editors would like to thank the reviewers for their efforts in reviewing the articles and the authors of the selected articles for their positive responses to the reviewers' comments and suggestions. Also, special thanks are given to Editor-in-Chief Prof. Yi Guo and the magazine's editorial office assistants for their support of this special issue. We hope you will find the selected articles of interest and that they represent a valuable contribution to the robot ethics research domain.

AUTHORS

Jim Torresen, University of Oslo, 0316 Oslo, Norway. E-mail: jimtoer@ifi.uio.no.

Cecilia Laschi, National University of Singapore, 117575 Singapore. E-mail: mpeclc@nus.edu.sg.

Edson Prestes, Federal University of Rio Grande do Sul, Porto Alegre, 91501-970, Brazil. E-mail: prestes@inf.ufrgs.br.

Lydia E. Kavraki, Rice University, Houston, TX 77251-1892 USA. E-mail: kavraki@rice.edu.

Praminda Caleb-Solly, University of Nottingham, NG8 1BB Nottingham, U.K. E-mail: praminda.caleb-solly@nottingham.ac.uk.

Yueh Hsuan Weng, Kyushu University, Fukuoka 819-0395, Japan, and Tohoku University, Sendai 980-8578, Japan. E-mail: weng.yueh.hsuan.647@m.kyushu-u.ac.jp.

APPENDIX: RELATED ARTICLES

[A1] D. Araiza-Illan et al., "A road map for responsible robotics," *IEEE Robot. Autom. Mag.*, vol. 32, no. 4, pp. 12–24, Dec. 2025, doi: 10.1109/MRA.2025.3620148.

[A2] T. Barros, C. Santos dos Reis, H. Constantinopolos, R. Maffei, and E. Prestes, "Managing safety and ethical norm violations in robotic industrial cells," *IEEE Robot. Autom. Mag.*, vol. 32, no. 4, pp. 25–33, Dec. 2025, doi: 10.1109/MRA.2025.3620101.

[A3] C. Menon, A. Rainer, P. Holthaus, S. Moros, and G. Lakatos, "X-HAZOP: A family of techniques for ethical hazard analysis of assistive robots," *IEEE Robot. Autom. Mag.*, vol. 32, no. 4, pp. 34–41, Dec. 2025, doi: 10.1109/MRA.2025.3590612.

[A4] L. Righetti and V. Boulanin, "Is open robotics innovation a threat to international peace and security?" *IEEE Robot. Autom. Mag.*, vol. 32, no. 4, pp. 42–50, Dec. 2025, doi: 10.1109/MRA.2025.3620110.

[A5] C. Rigotti and E. Fosch-Villaronga, "Sex robots and the AI act: Opening the regulatory discussion," *IEEE Robot. Autom. Mag.*, vol. 32, no. 4, pp. 51–56, Dec. 2025, doi: 10.1109/MRA.2025.3590611.

[A6] M. J. van der Schoor, S. E. Miri, A. Hüseynova and C.-M. Mörch, "Responsible urban robotics: Navigating ethical and legal challenges in cities," *IEEE Robot. Autom. Mag.*, vol. 32, no. 4, pp. 57–67, Dec. 2025, doi: 10.1109/MRA.2025.3615352 .

[A7] S. Terrile, L. Y. Lee, J. Ives, and J. Rossiter, "Gentle machines, tough questions: Ethics in soft robotics," *IEEE Robot. Autom. Mag.*, vol. 32, no. 4, pp. 68–76, Dec. 2025, doi: 10.1109/MRA.2025.3618084 .

[A8] V. Velmurugan, P. Holthaus, F. Amirabdollahian, and M. Dragone, "Clinicians' perspectives on safety, ethical, and legal considerations for home-based physical rehabilitation robots: Highlighting key themes," *IEEE Robot. Autom. Mag.*, vol. 32, no. 4, pp. 77–83, Dec. 2025, doi: 10.1109/MRA.2025.3619330.

[A9] Y.-H. Weng, D. Torabi, J. Torresen, Z. Dong, and Y. Hirata, "Bridging ethics and reality: Integrating thought experiments and empirical insights in robot ethics," *IEEE Robot. Autom. Mag.*, vol. 32, no. 4, pp. 84–90, Dec. 2025, doi: 10.1109/MRA.2025.3584352.

[A10] T. Yankee, N. R. Reddy, C. Thorpe, and S. Mondal, "Impacts of design and behavior on the acceptance of anthropomorphic service robots: Statistical modeling of post-experiment questionnaire responses," *IEEE Robot. Autom. Mag.*, vol. 32, no. 4, pp. 91–100, Dec. 2025, doi: 10.1109/MRA.2025.3590613.