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Failing Forward: Design and Deployment Lessons from Real-World Human-Robot Interaction

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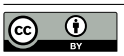
Abstract

As the technology readiness level of robotic systems increases, these systems interact with real users in realistic application contexts at increasing scale. In such real-world HRI, failures and unexpected outcomes are common, and these can provide valuable lessons for the design and evaluation of future HRI systems. Building on two recent workshops—the HRI 2025 workshop on Human-Robot Interaction in Extreme and Challenging Environments and the RO-MAN 2025 workshop on Real-World HRI in Public and Private Spaces: Successes, Failures, and Lessons Learned—this half-day workshop invites researchers and practitioners to share their design and deployment lessons drawn from across the spectrum of real-world HRI. The interactive sessions follow a taxonomy of the key phases during field deployment and major factors at play, inviting attendees to review the experimental design of their own research or example projects to identify potential challenges and share related experiences. This discussion will refine the initial taxonomy, which we plan to release as an open-source tool to empower researchers and practicioners in their design and deployment of real-world HRI.

CCS Concepts

• **Computer systems organization → Robotics**; • **Human-centered computing → Human computer interaction (HCI)**.



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real-world HRI, failures, methodology, social robotics, field robotics

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1 Motivation

Within the HRI community, there is an increasing emphasis on adopting a paradigm shift that focuses on real-world contexts – where uncertainty and unpredictability challenge traditional research paradigms [1, 3]. This enables robots to be deployed in real-world applications to support humans, where these robots either directly interact with users, such as serving as receptionists, tour guides, home assistants, or companions, or execute tasks under an operator's remote supervision and control, such as in space or underwater explorations. As robots face these uncertainties, complexities, and dynamics in such challenging deployment contexts, failures can arise from human, robot, task, environment, interaction, or scaling aspects. This workshop continues the trajectory of PubRobFails [2] and ExactingHRI [4], uniting their communities under a shared focus on real-world deployment challenges and learning from failures across diverse contexts. We invite researchers, designers, and practitioners to reflect critically on the technical, social, and organizational challenges of deploying robots in public, private, and extreme environments. We encourage open discussion of both

successes and failures, including stories that rarely make it into traditional conference sessions – those involving unexpected breakdowns, messy real-world data, and valuable lessons learned. This workshop offers a platform to explore what happens when robots meet reality, and how the HRI community can grow by sharing not only what works, but also what does not. Embracing a culture of "failing forward", we aim to transform setbacks into stepping stones for progress, fostering a culture of error, acknowledgement, and transparency that can unlock the full potential of HRI research.

As discussions in the PubRobFails and the Exacting HRI workshops revealed, robotic systems face both predictable failures (e.g., battery depletion, network loss) and unpredictable ones (e.g., crowds swarming a robot, operator overload, stakeholder conflicts). Minor oversights in planning or communication can propagate into major execution breakdowns, often driven more by human factors, participants, bystanders, or team members, than by the robot itself. Participants also emphasized the importance of redundancy, safety buffers, and recovery time, as well as recognizing that failure analysis extends beyond operation into data interpretation and reporting. These failures occur across domains, whether a service robot in a shopping mall, a teleoperated robot in a nuclear plant, or an assistive robot in healthcare. Building on these, we explore:

- Technical, human, organizational, and environmental factors that cause deployment challenges.
- Strategies for anticipating and mitigating failures.
- Methods for analyzing failures and turning them into actionable design insights.
- Cross-domain lessons: What can different environments teach social and field robotics?
- Ethical, safety, privacy, and governance considerations.

Topics of interest include (but are not limited to):

- Human unpredictability, stakeholder alignment, and cultural/social factors.
- Robust perception and planning under uncertainty.
- Error detection, recovery, prevention, and trust repair.
- Long-term, in-situ evaluation and data quality challenges.
- Governance, safety, privacy and ethical frameworks.

2 Organizers

- Leimin Tian is a senior scientist and the leader of the HRI team at CSIRO Robotics. She focuses on developing robots that incorporate social-emotional intelligence to enhance communication and collaboration.
- Ana Kirschbaum is a postdoctoral researcher and leads a research group at the Cologne Cobots Lab, focusing on interdisciplinary HRI research. She is particularly interested in understanding group interactions in public spaces.
- Caterina Neef is a postdoctoral researcher at the SARAI (Socially Assistive Robotics with AI) research group. Her research focuses on the development and deployment of social robots and virtual agents in medical and care domains, employing user-centered design and participatory methods to ensure their added value in real-world settings.
- Mary Ellen Foster is a Senior Lecturer in the School of Computing Science at the University of Glasgow. Her research aims to develop artificial embodied characters that are able to engage in natural face-to-face conversation with human partners. Her research interests include human-robot interaction, social robotics, and multimodal interactive systems.
- Sara Cooper is a biomedical and robotics research engineer, working as a research scientist on assistive robotics at the AI institute of the Spanish National Research Council (IIIA-CSIC). She has worked at PAL Robotics and Honda Research Institute Japan, contributing to the development and deployment of social robots in schools and healthcare applications.
- Frauke Zeller is Chair and Professor in Design Informatics, and co-director of the Institute for Design Informatics (IDI) at the University of Edinburgh. Situated in both Edinburgh College of Art and the School of Informatics of Edinburgh University, IDI champions interdisciplinary research and participatory methods for innovation design. Frauke's research focuses on designing and deploying social robotics for and in real-world situations people would not expect robots in; and as such has long-standing experience with both failures as well as unexpected outcomes.
- Manuel Giuliani is a Professor for Geriatric Robotics at Kempten University of Applied Sciences. His research interests include assistive robotics, human-robot interaction, social robotics, natural language processing, multimodal fusion, multimodal output generation, augmented and virtual reality interfaces, and embedded cognitive robot architectures.
- Alexander Eberhard is a research associate at the Cologne Cobots Lab. His research focusses on embodied conversational agents and the influence of non-verbal behavior.
- Oliver Chojnowski is a research associate and Ph.D. candidate at the Cologne Cobots Lab. His research focuses on non-verbal behavior generation of social robots and virtual agents in real world contexts.
- Nils Mandischer is a postdoctoral researcher at the Chair of Mechatronics, University of Augsburg. His research evolves around estimating and evaluating capabilities of people and use these as basis for self-adaptation in human-robot collaboration. The methods are applied to the fields of assisted work and neurorehabilitation.
- Utku Norman is a postdoctoral researcher at the Institute for Technology Assessment and Systems Analysis (ITAS). His research explores how robots can be responsibly integrated into everyday settings such as kindergartens and eldercare, supporting joint activities and aligning with human values.
- Jan Ole Rixen is a postdoctoral researcher at Human-Computer Interaction and Accessibility lab at Karlsruhe Institute of Technology. His ethnographical research is focused on real-world deployment of socially assistive robots in the context of daycares. Here, he is especially interested in how socially assistive robots can enhance the autonomy of disabled children inside the daycare context.
- Pamela Carreno-Medrano is a lecturer at Monash Robotics. Her research interests lie at the intersection of HRI, human-centred and embodied AI, and human-centred design. Her work focuses on developing autonomous, intelligent agents (virtually and/or physically embodied) that can adequately interact with humans in both short- and long-term scenarios.

- Nick Hawes is the director of the Oxford Robotics Institute. His research focuses on long-term autonomy for mobile robots; information-processing architectures and software engineering for intelligent systems; the integration of AI planning techniques into a variety of robot systems; and the use of semantic and spatial knowledge to enable robots to reason about the possibilities for action in their worlds.
- Dana Kulić is a leading expert in robotics, specialising in human-robot interaction and intelligent systems. She is Professor and Director of Monash Robotics. Her work focuses on developing autonomous systems that interact naturally with humans and learn from user feedback.

3 Workshop Overview

This half-day workshop[1] follows a taxonomy of real-world HRI, developed based on the PubRobFails [2] and ExactingHRI [4] workshops, as well as the HRI study life cycle tool [5]. The taxonomy structures real-world HRI into design, evaluation, analysis, and reporting phases, and highlights common challenges and failure points across them. As detailed in Table 1, the workshop opens with a short introduction to the taxonomy and an ice-breaking activity. The participants are then organized into group discussion sessions following the taxonomy, during which they present short stories of deployment challenges and failures from their experience. In this discussion, they both critique the taxonomy on its applicability and coverage, such as missing factors or methods, as well as discuss design and methodological revisions that would benefit their presented examples. This allows the groups to work on guidelines focusing on themes such as technical/environmental failures, human factors, ethics/governance, and data/evaluation.

Table 1: Tentative Program

Time	Activity	Potential Topics
08:45-09:00	Taxonomy overview	Welcome and overview to the real-world HRI taxonomy by organizers
09:00-09:15	Ice-breaking: Meme challenge	Interactive activity where participants share or create memes (images, sketches, or captions) that capture the gap between expected robot performance and the messy reality of deployments
09:15-09:45	Phase 1: Design	Research questions & hypothesis; physical, social, locational, temporal, informational context; robot & sensor choice
09:45-10:15	Phase 2: Evaluation	Quantitative, qualitative, and mixed methods; recruitment and data collection; mitigation and toubleshooting; participant and stakeholder management
10:15-10:45	Break	Morning tea
10:45-11:15	Phase 3: Analysis	Data cleaning and processing; annotation; statistical analysis
11:15-11:45	Phase 4: Report	Data / code open-sourcing and benchmarking; Follow-up studies; Publication
11:45-12:15	Summary	Closing remarks by organizers

[1]Workshop website: https://sites.google.com/monash.edu/failfowardhri2026/

4 Target Audience and Recruitment

This workshop is intended for HRI researchers, roboticists, designers, UX professionals, as well as those working in application domains such as healthcare, disaster response, industrial inspection, service robotics, and public-space deployments—anyone who deploys robots in the wild and faces the complexities of real-world interaction. This workshop will be held in person only: given the sensitive and reflective nature of the discussions, particularly around failure, lessons learned, and behind-the-scenes realities, a shared physical space is essential to foster open, candid, and constructive conversations. Recruitment will be through relevant mailing lists (e.g., HRI, ICRA, IROS), social media, professional networks, and direct outreach to both academic and industry partners with experience in field deployments. We will invite all participants to write a short paper outlining their deployment stories submitted via EasyChair. They will also be encouraged to prepare a poster based on the paper. Where participants consent, the papers and posters will be published on the workshop website or via arXiv.

5 Outcomes

Our workshop will serve as a platform that allows researchers to openly discuss their experiences, including failures and the lessons they learned from them. Our goal is to create a collaborative space for sharing experiences, addressing challenges, and developing innovative approaches to tackle failure in research, promoting transparency, resilience, and innovation. The workshop will generate both practical resources and community-level benefits:

- Documentation and tools: Checklists, guidelines, and a practical toolkit for planning, executing, and analyzing real-world HRI deployments.
- Cross-domain synthesis: A taxonomy of deployment failures that spans social, public, and extreme environments.
- Community building: A strengthened community of practice across social and field robotics, normalizing the sharing of failures and lessons.
- Future impact: A foundation for recurring workshops and collaborations on real-world HRI challenges.

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