The Empirical Turn in Robot Ethics: Reconciling Theoretical Thought Experiments with Practical Reality

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***Abstract*—** The inclusion of robots in daily life presents significant ethical, legal, and social implications (ELSI) that stem from their interactions with humans. Social robots are able to operate in environments that are rich in cultural norms, emotions, and social cues, leading to critical questions about privacy, trust, and safety. We explore the ways in which the interdisciplinary field of robot ethics can tackle these challenges using a hybrid methodological approach that incorporates thought experiments and empirical research. Ethical dilemmas can be systematically analyzed using thought experiments, and empirical methods can provide real-world insights to validate and refine these theoretical frameworks. In the paper, the use of living labs as dynamic environments for testing and integrating ethical design principles into robot design is emphasized, ensuring that robots comply with ethical expectations and legal standards.

I. Introduction

Robots, most notably those exhibiting social behaviors, increasingly transition from controlled research environments into actual everyday life. This transition inevitably comes with ethical, legal, and social implications (ELSI), particularly in relation to their interactions with humans. Robot ethics, an interdisciplinary field that explores the ethical implications of robotic technology, focuses on issues across diverse domains where robots interact with humans, such as elder care, medical assistance, rescue operations, and other services, with a growing emphasis on the impact of social robots.

In the context of social robots – i.e., autonomous robots that can interact with humans and other (social) robots based on socially accepted behaviors and rules – the need for control is reinforced. Social robots operate in environments where complex social cues, emotions, and cultural norms play an important role, raising questions about privacy, trust, and user safety. Moreover, the unpredictability of human responses and the diversity of social scenarios in which these robots act amplify ethical considerations, as unintended consequences can arise from these robots' interactions.

A key element in robot ethics is to approach these challenges with the correct methodology, as this field interrelates with both technical and humanistic disciplines, necessitating a balanced consideration of theoretical and empirical methods. Traditional ethical approaches alone, in particular thought experiments, may be insufficient in addressing emerging ELSI concerns, as they often focus too heavily on purely theoretical aspects and fail to capture the nuanced, real-world implications of robotic behavior and human-robot interaction (HRI). Thus, combining thought experiments with empirical research helps address both conceptual and practical challenges more holistically.

In this paper, we illustrate the importance of empirical experimentation in shaping robot ethics policies that are firmly grounded in real-world contexts. We also introduce a hybrid methodological approach that combines philosophical thought experiments with empirical validation in living lab settings, offering preliminary guidance for refining future empirical research methodologies.

II. Thought Experiments for Social Robots: Strengths and Limitations in Robot Ethics

Thought experiments are hypothetical scenarios used to explore the implications of principles or decisions by isolating specific variables within a controlled mental framework. As traditionally used in philosophy, they allow researchers to probe moral intuitions, test ethical theories, and clarify conceptual boundaries without real-world implementation. In the context of robot ethics, thought experiments help us imagine complex dilemmas that autonomous systems may encounter and analyze the normative principles that should guide their actions. Their value lies in enabling anticipatory reflection, particularly in contexts where deploying robots in the real world may be premature or risky. For instance, thought experiments can help clarify whether a care robot should prioritize a patient's autonomy or safety in conflicting situations, long before such robots are deployed at scale. As Allen et al. (2005) [1], and later Nyholm (2018) [2], have argued, these scenarios are indispensable for surfacing hidden ethical tensions in AI and robotic design.

One of the most widely cited thought experiments in this context is the "Trolley Problem," in which a robot must choose whether to actively intervene in a scenario that results in one person's harm to save several others. Thought experiments like the Trolley Problem have been adapted to AI and robotic applications, for example, in autonomous driving, to explore how machines might operationalize ethical decision-making [3].

While thought experiments are valuable in identifying theoretical problems, they also come with limitations. By their nature, thought experiments are abstract and lack the nuanced context of real-world scenarios. For instance, a robot's decision-making process is often influenced by technical constraints, environmental variables, and individual user differences, which are difficult to capture in hypothetical scenarios. More important still, thought experiments rarely accurately consider the numerous social factors that shape how people interpret and react to robot actions. Such influences may significantly alter perceptions of a robot's ethical decisions, suggesting that assumptions based on thought experiments alone may not universally apply. Hence, thought experiments have been questioned regarding their ability to provide evidence to substantiate the beliefs they inspire [4].

Against this background, empirical ELSI experiments can serve as a complementary approach to bridging the gap between theoretical exploration and real-world applications in robot ethics research. Thought experiments often inspire hypotheses that empirical studies can test, creating a synergistic cycle in which insights from empirical data refine thought experiments, ensuring they reflect realistic scenarios.

To create a more holistic approach, it is crucial to complement thought experiments with empirical methods. Empirical research provides concrete data on how users interact with and perceive social robots, helping to validate (or challenge) assumptions from thought experiments. By incorporating empirical insights, researchers can better anticipate the practical implications of deploying robots in different social environments. Together, these methodologies allow for a comprehensive and realistic evaluation of ethical challenges, making it possible to design social robots that are ethically sound, technically feasible, and aligned with user expectations in diverse situations. This integrated approach also provides a foundational structure for (upstream) policymaking to anticipate and address ethical concerns before social robots become widely integrated into society.

To translate the ethical dilemmas identified through thought experiments into practical insights, we turn to empirical research. The next section outlines how real-world studies can validate, refine, or challenge theoretical assumptions by situating ethical inquiry within lived HRI. This methodological continuity ensures that robot ethics is grounded in actual user experiences and technological constraints beyond philosophical debates.

III. Empirical ELSI Experiments for Social Robots: Regulatory Testbeds and Living Labs

Empirical experimentation plays an important role in the governance of social robots by enabling the collection and analysis of data to support or refute theories and to answer complex questions about human behavior and societal trends in the context of HRI [5]. While prior studies on the ethical design of robots have often primarily focused on high-level principles and guidelines, scholars have noted that such theoretical discussions often lack practical guidance for the design, development, and deployment of autonomous systems [6] [7].

Recent European research underscores the importance of empirical testbeds in refining legal and regulatory frameworks for robots. Calleja et al. (2022) argue that regulatory testbeds like those developed in the PROPELLING project can bridge the gap between rapidly evolving robotic technologies and lagging legal standards by generating empirical, policy-relevant data, demonstrating how experimentation, especially with wearable robots like exoskeletons, can inform evidence-based frameworks aligned with real-world risks [8]. Similarly, Fosch-Villaronga and Drukarch (2023) explain that current robot safety standards – specifically ISO 13482:2014 – fail to adequately account for user diversity (in sex, gender, age, health conditions), calling for intersectional updates to standards and testbeds to ensure inclusive and safe robotic systems [9].

As Weng et al. (2015) have previously emphasized, the Tokku Special Zone for Robotics Empirical Testing and Development has been instrumental for upstream policymaking, in particular regarding the validation of road traffic regulations in urban areas [10].

"Living labs," as a closely related concept, are collaborative, real-world testing grounds that support innovation by allowing new technologies to be developed and trialed in authentic settings [11] [12]. They are designed for naturalistic observation in context-rich environments. While participants do not typically stay overnight, the environment mimics real-world environments to support ecologically valid interaction scenarios. This makes them well-suited for studying ELSI issues in HRI, as the complexities of privacy, trust, and autonomy often unfold only in real-world interaction. As social robots increasingly move beyond public areas into semi-public and private spheres, regulators are confronted with the complex task of assessing a wide range of HRIs, many of which involve ELSI considerations. In this landscape, living labs can streamline empirical research efforts and support regulatory evaluation.

Living labs have proven to be a valuable approach, methodology, and environment for addressing various societal challenges [13]. Several studies have leveraged living labs to tackle social issues arising from the increasing senior population in modern society [14]. For example, the Robotics and Intelligent Systems Group (ROBIN) at the University of Oslo has extensively utilized living labs for empirical investigations involving social robots. In one collaborative project, for instance, they introduced the humanoid robot *Pepper* into a Dutch elderly care home to explore how design and behavior affect user expectations [15]. Additionally, ROBIN has conducted several studies at the *Diakonveien Omsorg+* senior living facility, including experiments with the service robot *TIAGo* focused on privacy-related sensors [16] and motion-walking velocity [17]. These examples highlight how living labs enable ethically grounded robotics by offering structured environments to test and refine various HRI scenarios throughout different stages of robot design and implementation. Below, we will outline two use cases in more detail, the Aobayama Living Lab and the IEEE P7017 Living Lab at Kyushu University.

IV. Use Case (1): Aobayama Living Lab, Tohoku University

To demonstrate how theoretical insights from robot ethics can be translated into concrete experimental protocols, we introduce two use cases that illustrate the practical application of our hybrid methodology. The first focuses on the Aobayama Living Lab, a research facility at Tohoku University dedicated to elder care and healthcare robotics. This lab exemplifies how controlled yet realistic settings can be used to test ethically sensitive design strategies, such as the use of "white lies," in ways that remain grounded in user interaction and normative reasoning. The facility serves as a hub for the research and development of nursing care robots, with the dual objective of exploring innovative solutions for the future in 2050 and practical solutions that can be implemented in the near future [18].

The Aobayama Living Lab is a 250 m² facility designed to simulate both nursing homes and at-home healthcare settings, as illustrated in **Figure 1**. This environment is also equipped with various types of healthcare robots, including electronic wheelchairs, robotic rollators, and wearable sensors. These devices can function independently or be integrated into coordinated systems to deliver a sequence of robot-assisted support tailored to different use cases. Additionally, the lab features AI speakers and motion capture systems to facilitate voice-based HRI and motion tracking. Leveraging this living lab, researchers developed a scenario where multiple robots collaborated to assist patients with their morning activities. This scenario included helping the patient get out of bed using an electronic bed, delivering a cup of water with a mobile robot, and accompanying them to the living room with a robotic rollator.

Figure 1. Overview of Aobayama Living Lab at Tohoku University

While the living lab provides an environment to evaluate the functionality of developed healthcare AI robots, it is equally important to inspire ethical consideration during interactions with these robots. Three primary areas of research can be conducted within the living lab environment: (i) Evaluating the usability and user governance of healthcare AI robots; (ii) Developing empirical methodologies on robot ethics and law that inform the requirements for designing trustworthy intelligent robots; and (iii) Promoting the ethical standardization of both robot design and legal frameworks. As a case study, this section introduces one of our ongoing research projects that examines the use of AI robot "white lie" deception.

One of the key ethical concerns explored in this study is determining when and how a healthcare AI robot can appropriately use deception, such as generating a "white lie," to enhance its ability to assist users in completing tasks, rather than disclosing the full truth. By leveraging the Aobayama Living Lab, it becomes possible to simulate various scenarios in which users interact with healthcare robots capable of utilizing deception within a controlled healthcare facility.

For instance, as illustrated in **Figure 2**, a user engages in treadmill gait training with the assistance of a walking assistive robot. The objective is to enable the robot to provide appropriate support and feedback to maintain the user's motivation while preserving their autonomy and sense of agency. To achieve this, in the experimental group, the robot dynamically adjusts the support ratio based on the user's subjective feelings and current performance. Additionally, the robot generates reports with a degree of intentional deception, designed to positively influence the user's motivation and future outcomes.

In contrast, the control group receives a fixed support ratio from the robot and is provided with progress reports that fully disclose the user's actual performance. By comparing the outcomes of both groups, this study aims to identify the "optimal" robot-supporting ratio. This approach could inform the development of an AI system capable of delivering "white lies" when necessary, ensuring that such deception remains transparent, beneficial, and non-harmful.

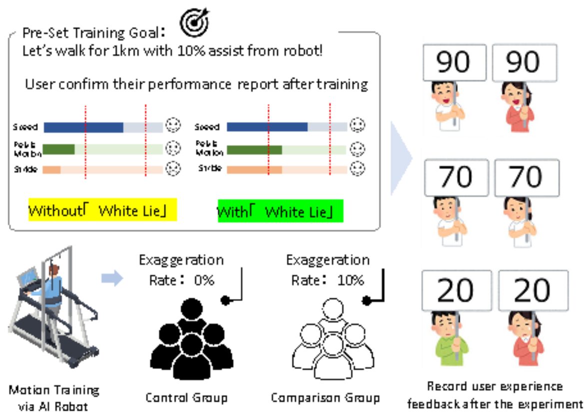

Figure 2. Case Study of Healthcare AI Robot Considering AI Deception

V. USE CASE (2): THE IEEE P7017 LIVING LAB, KYUSHU UNIVERSITY

The IEEE P7000 series are global socio-technical standards that help developers and stakeholders realize responsible development and use of AI systems and applications. The IEEE P7000 series covers broad topics around ethical considerations of AI governance, including Value-Based Engineering, AI Transparency, and Emulated Empathy. One of its ongoing standardization projects is called the IEEE P7017 Recommended Practice on Design-Centered HRI and Governance. To analyze ELSI hazards from daily HRI as well as investigate how robotic embodiment may impact ethical design, the IEEE P7017 Working Group decided to establish a living lab at Kyushu University in December 2023 (see **Figure 3** and **Figure 4**). The IEEE P7017 living lab is a 49 m² experimental facility used for supporting the Working Group's global ethics standardization activities with a focus on Legal Human-Robot Interaction (L-HRI). L-HRI is an advanced cross-cutting concept within HRI that integrates legal and ethical frameworks across the traditional distinctions of HRI, including social HRI (sHRI), physical HRI (pHRI), and social-physical HRI (spHRI). While existing HRI studies focus on social engagement (sHRI), physical contact (pHRI), or the integration of both social and physical cues (spHRI), L-HRI overlays these domains, embedding mechanisms to ensure compliance with social norms, legal standards, and regulatory requirements within the interaction design itself. The IEEE P7017 living lab allows researchers and working group members to conduct L-HRI-related scenario testing, ethical interface development, and human behavioral data collection for L-HRI. At this moment, its empirical experiments cover three main subgroups: anthropomorphic robots, privacy-sensitive robots, and healthcare robots. In this use case, we will mention how the IEEE P7017 living lab can be used in assisting empirical experiments on privacy.

Lutz et al. (2019) [19] provided a comprehensive scoping review of the literature on privacy and social robots, identifying several empirical studies that have investigated how robots are perceived in relation to privacy concerns. Key findings highlight the multifaceted nature of privacy issues in HRI, including concerns about data collection, surveillance, and the erosion of boundaries between public and private spaces. The study emphasizes the need for regulatory frameworks and ethical guidelines to address these privacy challenges effectively. This review serves as an important foundation for our study, indicating that while the field is still developing, there is a clear trend toward using empirical methods to explore these issues.

Figure 3. Overview of the IEEE P7017 Living Lab at Kyushu University

As part of the standardization activities for IEEE P7017, HRI experiments play a crucial role in refining draft versions of use cases. For instance, one use case documented in the IEEE P7017 Ethical Design Database focuses on privacy and data protection for the Japan-made social robot, LOVOT. A key question arising from this use case concerns the adequacy of ensuring users' perceived privacy through a simple on/off privacy protection switch. In this context, a living lab can be leveraged to assess users' privacy awareness when interacting with LOVOT, both with and without the switch enabled. During privacy perception tests, some users expressed a desire for robots to incorporate mechanisms for obtaining their privacy consent, which requires simulating and modeling consent conditions for compliance checking so that robots will be able to effectively communicate with humans about their privacy preferences.

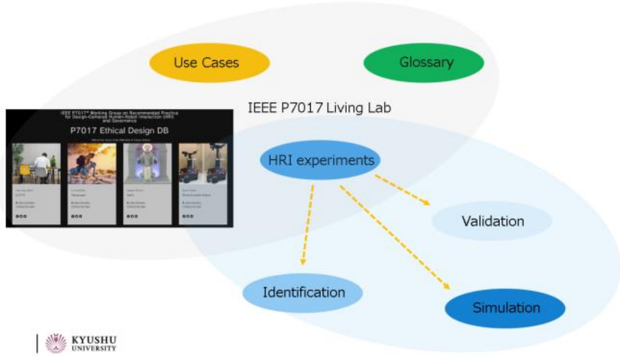

Figure 4. Overview of the IEEE P7017 Living Lab at Kyushu University

VI. Discussion

As illustrated by these two use cases, living labs serve as valuable testbeds for simulating such L-HRI scenarios. That being said, the integration of robots into human environments requires methodological approaches that address ethical concerns while remaining technically and practically feasible. Our proposed conceptual approach for ethical robot design integrates thought experiments with empirical research, leveraging the complementary strengths of both.

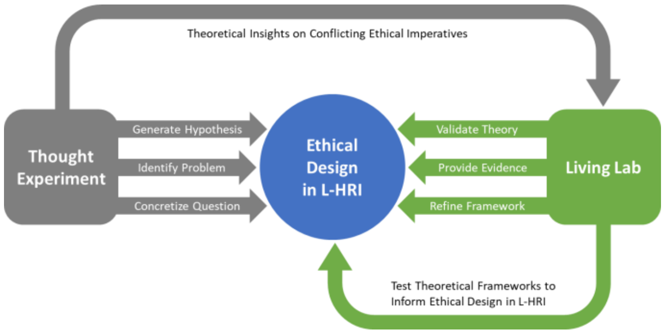

Figure 5. Methodological Concept Combining Thought Experiments and Empirical Research at Living Labs

Figure 5 illustrates this process, highlighting how the two methods collaborate through the central focus of ethical design in L-HRI: Thought experimentation serves as the starting point, enabling us to identify ethical dilemmas and formulate hypotheses by envisioning hypothetical scenarios where robots may encounter conflicting ethical imperatives. For instance, caregiving robots may need to balance patient autonomy with safety or prioritize harm reduction in scenarios such as the Trolley Problem. While these experiments facilitate anticipatory ethical reflection, their abstract nature often limits practical applicability. Living labs bridge this gap by grounding theoretical insights in practical, real-world interactions. By enabling observation and testing, empirical studies in living labs complement thought experiments, helping to prove, disprove, or improve theoretical insights gained through initial thought experimentation, to holistically inform ethical and legal standardization endeavors.

The proposed conceptual approach consists of the following iterative steps that integrate theoretical and empirical perspectives:

1. **Identify ethical dilemmas through thought experiments:** Normative reflection by creating hypothetical scenarios that involve potential moral conflicts in HRI (e.g., tension between privacy and safety, or autonomy and beneficence). These scenarios should be viewed through major ethical lenses (deontology, virtue ethics, consequentialism) and contextualized within plausible robotic use cases.

2. **Formulate hypotheses and design ethical goals:** From the thought experiments, derive hypotheses about user expectations, ethical risk points, or systemic design needs. Clarify what constitutes ethical success in each case (e.g., informed consent, fairness, emotional well-being).

3. **Translate scenarios into testable interactions:** Use living labs to simulate scenarios from thought experiments in ecologically valid settings. Design robot interactions or interfaces that operationalize the ethical goals identified earlier.

4. **Empirical testing and observation:** Conduct structured studies in the living lab. Unlike regular lab studies, living labs support diverse, naturalistic observation with embedded ELSI considerations. This setting allows researchers to observe not just reactions, but behavioral trends, adaptation, social feedback, and comparable data over time.

5. **Iterative ethical refinement:** Analyze user behavior and feedback. Refine ethical assumptions and the design based on empirical outcomes. Return to the thought experiment phase to reframe dilemmas if unexpected conflicts arise. Create feedback loops.

Compared to standard user studies, living labs provide a controlled but context-rich environment that enables sustained interaction over time, co-presence of multiple stakeholders, and direct engagement with ELSI features such as consent procedures, data protection protocols, and trust dynamics. This makes them particularly well-suited for ethical validation and regulatory prototyping.

To further illustrate this concept in a simplified manner, consider the design of a privacy-sensitive social robot intended for home use. The process begins with thought experimentation to explore ethical dilemmas, such as balancing safety monitoring with respect for personal boundaries. Empirical studies conducted in a living lab can then assess user responses to various data collection practices to find preferences for specific features or data processing methods. Participatory workshops involving, for example, users, designers, privacy experts, and technical specialists further refine these features and methods to align with (practical) ethical expectations and legal requirements.

By leveraging the complementary strengths of theoretical foresight and practical application, this hybrid approach ensures that robots are designed not simply to meet current ethical and legal standards but also to anticipate and adapt to emerging challenges. This methodological synergy is essential for the development of socially acceptable and ethically sound robots in human environments.

Nevertheless, it should be noted that empirical testing is not a panacea. Ethical reasoning often involves normative judgments that are not reducible to statistical trends or user preferences. What users prefer may not always align with what is morally justified. For instance, a robot's deceptive behavior (see the above-mentioned "white lie" in Section IV) might enhance user satisfaction, yet still raise moral objections from a deontological (and potentially consequentialist) perspective. Ethical dilemmas in HRI are deeply context-dependent and often resist resolution through empirical generalization alone. Therefore, while empirical research can illuminate user perceptions and inform ethically sensitive design, it must be coupled with normative analysis to ensure that robots not only meet expectations but also align with defensible moral standards.

VII. Conclusion

As the field of social robotics continues to advance, addressing its ELSI concerns remains a difficult challenge. Social robots operate at the intersection of novel technology and human interaction, which creates a plethora of unresolved issues that require (multidisciplinary) solutions. Social robots are meant to interpret and respond to diverse human behaviors, including emotions, cultural norms, and social cues. Further, human responses to robots are unpredictable and context-dependent, complicating the design of universally acceptable interaction protocols. This unpredictability extends to the ethical evaluation of robot behaviors, as cultural and individual differences lead to varying interpretations of what is considered "ethical" or "acceptable." Ethical evaluations of robots are shaped by deeply embedded cultural values and social norms, which vary significantly across global contexts. For instance, attitudes toward deception, data privacy, or even the attribution of agency to robots differ substantially between East Asian, Western, and other cultural traditions. This raises important questions about how empirical studies – often conducted in localized settings – can inform ethical robot design on a global scale. Thus, future empirical research must be culturally responsive, including cross-cultural comparative studies and participatory approaches involving diverse stakeholder groups. Without such considerations, there is a risk of designing robots that align with the values of one cultural context while alienating or conflicting with those of another.

The integration of robots into both private and public spaces amplifies these concerns, particularly regarding privacy. Robots collect sensitive data to function, including personal preferences, behavioral patterns, and biometric information. Living labs can be used for legal validation by testing hypothetical daily scenarios that may reveal gaps in current data protection regulations like the GDPR, such as the unique challenges posed by robot embodiment, which is a notable issue in the ethical standardization of L-HRI [20].

While combining thought experiments with empirical studies provides a more holistic approach, both methodologies still have limitations. Thought experiments are inherently abstract and may oversimplify real-world complexities, while empirical studies can be resource-intensive and context-specific, limiting their generalizability. Hence, bridging the gap between theoretical insights and practical applications remains an ongoing challenge. To address these challenges, initiatives like the IEEE P7017 Working Group and regulatory sandboxes can be utilized to facilitate standardization efforts, including a broad range of stakeholders, to ensure that standards are practical and globally applicable.

The complexity of robot ethics requires collaboration across different fields, including engineering, philosophy, law, psychology, and sociology. Building interdisciplinary research platforms and fostering communication between technical and humanistic experts facilitates more holistic ethical frameworks and practical solutions. Engaging users and other stakeholders in the design process ensures that robots meet real-world ethical expectations. Participatory methods such as co-design workshops, focus groups, and iterative prototyping should be integrated into the lifecycle of ethical robot design. These processes help identify potential ethical risks early in the design phase, reducing the probability of unintended consequences. Living labs and other regulatory sandboxes offer controlled environments for testing and refining ethical robot design in realistic settings. Expanding these initiatives globally and incorporating diverse social, cultural, and legal contexts will provide insights into the challenges of deploying robots across different environments. These platforms can effectively serve as testbeds to evaluate innovative governance models and compliance mechanisms for ethical design frameworks in L-HRI.

As robotic technologies evolve, new ethical dilemmas will arise. For example, advancements in humanoid robots and emotional AI may blur the boundaries between humans and machines, raising questions about identity, agency, and human-robot relationships. Proactive research approaches and policymaking are essential to address current and future issues before they become widespread. Against this backdrop, our proposed methodological approach, which integrates thought experimentation with empirical research, should be viewed as one of many steps toward advancing the field of robot ethics.

Importantly, while empirical validation enhances the practical relevance of ethical design, it should not be mistaken for normative justification. A robot feature that is widely accepted in user studies may still raise moral objections from certain cultural or philosophical perspectives. This reinforces the importance of coupling empirical data with careful ethical interpretation, resisting the temptation to universalize context-dependent findings.

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