# Robots for Public and Social Spaces - Design for Intent Communication, Collaboration and Acceptance

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## ABSTRACT

Intent communication is crucial for human-robot interactions, allowing robots to understand and respond to human intentions and enabling humans to comprehend potentially autonomous robots' intentions. Social robots have become increasingly popular in various fields, from healthcare to education, due to their ability to interact with humans naturally and intuitively. Enabling seamless communication between robots and humans is a key challenge in developing effective social robots. This workshop explores the intersection of intent communication and user experience in social robotics, with a focus on human-centered human-robot interaction. The workshop aims to bring together researchers, developers, and practitioners from academia and industry to discuss recent advances in intent communication and user experience design in social robotics. Participants can present their research, share experiences, and engage in interactive discussions with other attendees. The workshop provides a forum for collaboration and knowledge exchange to advance the state-of-the-art in social robotics and HRI. This is the second iteration of the RoboX workshop at MuC.

## 1 INTRODUCTION

The field of robotics has evolved, with robots now being used for various tasks in different contexts, including social interactions with humans. Domestic robots can help with home upkeep [6], and more special-purpose robots can aid in rescue operations [26]. Research has investigated features such as gaze, head movements, nodding [23], and body orientation [33] to improve the naturalness of robot behavior in social situations. Although social robots are not yet a common sight in everyday interactions, the trend of integrating robots into various services and enabling them to engage in social interactions is on the rise, thanks to technological advancements.

Adoption and acceptance of technology depend on technical capabilities, design, contextual requirements, and social factors. In social interaction with robots, the entire user experience matters as much as their utility in a specific use case. Therefore, investigating the various aspects that can impact human-robot interaction and taking into account new use cases from both a technological and design perspective is crucial.

Signaling intent has been found to improve trust, acceptance, and situational awareness in human-robot interaction and collaboration [13, 30]. The topic of signaling intent between humans and robots is well-studied in the field of HRI. Intent communication can occur in two ways: Robot-to-Human or Human-to-Robot [21]. The direction of communication influences the modality used, and multiple forms of communication are possible. The development of effective strategies for intent communication will remain a crucial aspect of HRI as robots become more integrated into our daily lives. Moreover, the design choices of robots must also consider the ability of humans to understand the robots' intentions to lead to more seamless interaction and ultimately improve the overall user experience.

This workshop examines how intent communication impacts the user experience and social interaction with social robots. Social robots are autonomous or semi-autonomous robots that interact and communicate with humans while adhering to human-established behavioral norms [4]. The workshop seeks to encourage comprehensive discussions related to this topic and engage both researchers and practitioners interested in robotics.

## 2 INTERACTING WITH ROBOTS

Human interaction with robots can be direct or happen through indirect encounters. In the scope of this workshop, we are especially


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interested in interaction with social robots, or when robots are taking public roles e.g. in public places or as service robots.

## 2.1 Interacting with Social Robots

Social robots provide an interesting viewpoint to the future, where we (expectantly) interact with increasingly complex technology, and where technology is even deeper entwined into our everyday life. Social robots present one possibility to ease the user experience of interaction with complex technology, and a wide set of potential research directions are possible.

Social robots are robots that are able to communicate and interact with people according to the social and cultural structures associated with the role they are given by designers [4]. Social robots can proactively engage with humans to accomplish specific tasks, utilizing natural human-like communication mechanisms such as speech, gestures, and eye gaze [9]. Whereas robots can appear in many shapes for different human-robot interaction tasks, humanoid robots are generally preferred for social use cases. For instance, the Pepper robot, which today is popular in different research experiments, is designed to resemble humans in its shape and outlook. Approaches leveraging anthropomorphism have been identified as a fruitful direction to improve human acceptance of robots [40].

Likeness to humans however goes beyond facial and bodily features. As robots are not merely digital representations but have a dynamic physical shape, their behavior has very tangible aspects, including postures and gestures that are interpreted by the surrounding humans. Including emotional expressions in robots is another challenge for social robotics. For instance, research on robots for civic engagement emphasizes that the robot should express its purpose clearly, and showing emotions can be a supportive element [19]. The emotional expression can be communicated by facial expressions [17], but also by the robot's movement, such as the flying patterns of a drone [11].

## 2.2 Robots in Public Spaces

In addition to interaction with robots in controlled and confined environments, such as in industrial settings, robots are now being deployed to many public spaces such as streets, shopping malls [24], or museums. Robots can also be part of a larger service design solution. For instance, a rescue robot can function as an element within a larger emergency services concept. In these kinds of examples, robots can be seen to be taking public roles, where they inevitably interact with people. With the increase in deployment of robots into these types of scenarios [39], it can be expected that this will form the context for a large proportion of future human-robot interactions.

**Figure 1: Humanoid robots are often used in social robot experiments, for instance here as with wearing accessories [16].**

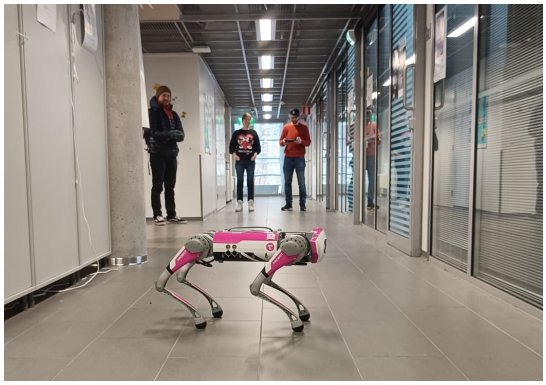

**Figure 2: Robot dogs are emerging for different types of tasks.**

In a study where robots on the street asked for help from passersby, Weiss et al. found people were willing to provide guidance to the robot, indicative of a high level of social acceptance [36]. Salvini et al. [29], highlight the numerous factors that may affect human acceptance of robots in public roles, calling for a viewpoint that is wider than user-centered. With a focus on autonomous delivery robots, Abrams et al. developed a theoretical model for social acceptance [1], and introduced the concept of 'Existence Acceptance' for autonomous systems. Different form factors of robots. For instance, dog-shaped robots, as seen in figure 2, can be used in search and rescue tasks.

When robots in public roles become more common, it can be expected that new etiquette and social practices are formed by interacting with robots, as tends to happen with emerging technology use, in general [27]. Appropriate and context-sensitive behavior codes are an important part of human interaction, and correspondingly, a robot using correct etiquette is more comfortable to interact with. For instance, in the context of a museum guide robot, it has been reported that people preferred a robot that performed an appropriate greeting to one which did not [15].

Cultural factors, such as manners and etiquette, are also factors that influence people's perceptions of robots. Moreover, as with graphical user interface design [25], robot interaction design needs to consider if the possible alternative cultural interpretations of the robot's behavior. Inconsiderate designs may give grounds for misunderstandings and awkwardness in the human-robot interaction.

# 3 INTENT COMMUNICATION

In Robot-to-Human communication, visual methods like lights and projections are common [3, 7, 32, 34], while Human-to-Robot methods can include pointing and motion [20, 22]. A user study by Walker et al. [35] found that explicit information about timing led to better performance and user preference in AR. Auditory cues in HRI serve various purposes, including making the robot's behavior more transparent [2, 8], assisting in localization [12], and representing distance [5]. Multimodal signals, such as audio-visual modalities, are used in real-world and mixed-reality settings[18, 28]. However,

audio-visual signaling methods are vulnerable to noise in a loud or visually dynamic setting [22]. Haptic feedback is used in HRI to signal various robot behaviors [10, 14]. Multimodal communication, which utilizes different modalities perceived through different channels, is preferred as it is less taxing on cognitive ability and adds flexibility in signaling [37, 38]. Shrestha et al.[31] investigated the use of visual and auditory cues in signaling intended robot motion trajectory, and found that using both indicators together resulted in better user experience in certain scenarios. Additionally, Lemasurier et al.[22] observed that non-audio-visual multimodal signaling methods, such as haptic feedback, are less susceptible to noise in dynamic settings. Overall, visual, auditory, and haptic communication methods are commonly used in HRI, with some studies exploring multimodal signaling methods.

## 4 THE WORKSHOP AREAS OF INTEREST

This workshop brings together researchers, designers, and practitioners working in human-robot interaction to explore intent communication, user experience, and social robots. Participants will showcase existing cases, discuss new possibilities, and engage in collaborative discussions. We welcome submissions from various disciplines, such as HCI, computer science, design, psychology, and social science. The papers can present, e.g., concepts, designs, prototypes, user studies, interaction techniques or use scenarios, or be position papers addressing the workshop theme. We welcome work on the topics related, but not limited, to the following topics:

- verbal and non-verbal communication with robots
- multimodal communication with robots
- interaction with social robots (e.g., in public spaces)
- interaction with robots in cross-cultural contexts
- accessible interaction with robots and inclusive HRI design
- emotions and affect with robots
- conducting field studies with robots(e.g., in public spaces)
- simulation of human-robot interaction
- transfer of learnings from other domains (e.g., automated driving, mobility)

## 5 ORGANIZATION OF THE WORKSHOP

### 5.1 Pre-workshop Actions

The call is distributed through various HCI channels and organizers' networks, and advertised e.g. at the CHI'23 conference in Hamburg in April 2023. Workshop papers are submitted through Easy Chair. The call and all essential information about the workshop are shared on the workshop web page, https://laplandrobotics.com/muc_workshop.

### 5.2 The Workshop

The workshop will begin with an invited talk, followed by thematic sessions for accepted papers. After lunch, two interactive group sessions will be held, where participants will work together. In the first session, groups will visit four posters illustrating different robot scenarios, and discuss and add points. In the second session, groups will ideate a social human-robot interaction scenario using miniature objects. The workshop concludes with a facilitated discussion. Participants can bring demos to present during a coffee break. The workshop is a follow-up to RoboX 2022 at MuC, and the interactive tasks from the previous workshop are shown in Figure 3. The 2023 workshop will have different group tasks. The workshop papers can be accessed through the GI Digital Library, with the authors' agreement.

**Figure 3: Group work sessions in action in RoboX 2022 MuC workshop: tasks with posters and low-fi prototyping materials.**

### 5.3 Impact and Post-workshop Actions

As an outcome, the workshop papers will be published through the opportunity provided by the conference organizers. To increase visibility, social media postings are done through the organizers' institutes' social media channels. A special issue (on social robots) in the IEEE Pervasive Magazine (one of the workshop organizers is part of the magazine's editorial board) is planned with selected papers from the workshop.

## 6 ORGANIZERS

**Jonna Häkkilä** is a professor at the University of Lapland, Finland, Faculty of Art and Design. She conducts research at the cross-section of design and technology, and is interested in the user experience design of futuristic topics in human-computer interaction. She leads Lapland User Experience Design research group (LUX), and is U. Lapland PI for Lapland Robotics project.

**Khaled Kassem** is a PhD student at TU Wien, Artifact-based Computing and User Research unit. His research interests include intent communication and human-robot interaction.

**Emma Kirjavainen** is a PhD student at the University of Lapland, Faculty of Art and Design, working on design and user experience with robots. She works as a project manager at Lapland Robotics project, funded by ERDF.

**Johannes Kraus** is a Postdoc in Human Factors at Ulm University. His research interests are trust aspects of human-technology interaction, human-robot interaction, and human-vehicle interaction. He is currently working on a publicly funded project on mobile robots in public spaces.

**Florian Michahelles** is a full professor of ubiquitous computing at TU Wien. His main focus is to explore the potential of technology in aiding humans in their tasks and activities while ensuring that the human user remains in control. Florian's research centers

around the development of proactive services that integrate computing capabilities to enhance user experience.

**Heiko Müller** is a Senior Researcher at the University of Oldenburg and OFFIS - Institute for IT in Oldenburg. His research interests lie on soft and shape changing robotics as well as prosocial behaviour between humans and robots.

**Bastian Pfleging** is Professor for Ubiquitous Computing and Smart Systems at TU Bergakademie Freiberg, Germany. With a background in computer science, his expertise is in the fields of human-computer interaction, and specifically automotive user interfaces. He co-organized various conferences and workshops in the field of HCI and AutomotiveUI.

**Norman Seyffer** is a researcher at TU Bergakademie Freiberg, Germany and works on technical and interactive challenges related to mobile delivery robots.

**Kai Erik Trost** is researcher at HDM Stuttgart, Germany. His current research activities focus on empirical research and ethical aspects of mobile robots.

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