Virtual, Augmented, and Mixed Reality for Human-Robot Interaction (VAM-HRI)

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ABSTRACT

The 7*th* International Workshop on Virtual, Augmented, and Mixed Reality for Human-Robot Interaction (VAM-HRI) seeks to bring together researchers from human-robot interaction (HRI), robotics, and mixed reality (MR) to address the challenges related to mixed reality interactions between humans and robots. Key topics include the development of robots capable of interacting with humans in mixed reality, the use of virtual reality for creating interactive robots, designing augmented reality interfaces for communication between humans and robots, exploring mixed reality interfaces for enhancing robot learning, comparative analysis of the capabilities and perceptions of robots and virtual agents, and sharing best design practices. VAM-HRI 2024 will build on the success of VAM-HRI workshops held from 2018 to 2023, advancing research in this specialized community. This year's website is located at https://vam-hri.github.io.

CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**.

KEYWORDS

robotics, human-robot interaction, VR, AR, MR

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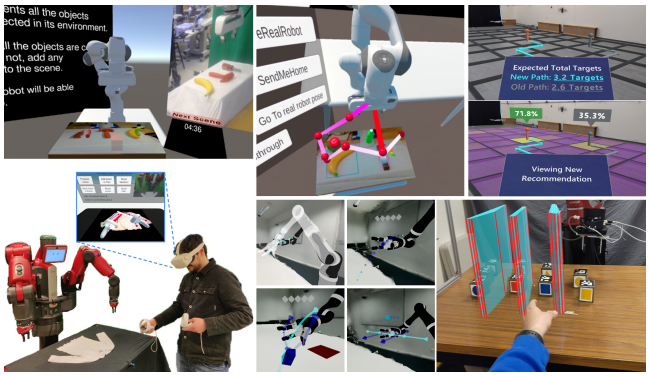

Figure 1: Recent advances in HRI using mixed reality technologies. Top left and top middle: a virtual reality interface for a *correcting robot errors* framework [25, 26]. Top right: an AR interface for providing explainable decision-support for human-robot search tasks [7, 18]. Bottom left: a virtual reality framework for human-robot collaboration in cloth folding [24]. Bottom middle: MR visualization of AI-enhanced robotic control [12, 14, 15]. Bottom right: AR-projected barriers for inducing legible motion during human-robot shared space collaboration [19] (used with authors' permission).

1 BACKGROUND

Effective collaboration between humans and robots requires a shared understanding of beliefs, desires, and intentions [13, 17]. This is especially important in mixed human-robot teams working on tasks that require safety, efficiency, and ease-of-use, as emphasized in the *Roadmap for U.S. Robotics* [3].

Recent advancements in HRI have tackled this challenge using various methods, including haptic feedback [10, 11], explicable task plans [5], verbalization of intentions in natural language [1] and explicit and implicit adaptation mechanisms [8]. Moreover, VAM technologies have been utilized to improve communication and mutual understanding between humans and robots [26], engendering a clearer understanding of a robot's state [6, 13] and failures [25] in users. Virtual, augmented, and mixed reality also helps mediate human-robot interaction by providing a shared virtual medium in which a user may signal their intent through visual cues [13].

Recent advancements have significantly enhanced the feasibility and promise of this approach. For example, a multitude of systems have been developed to visualize trajectories of mobile robots [2, 9, 16, 20, 21], with results suggesting that humans prefer to interact with a robot when it presents its intentions directly as visual cues. However, a majority of current work presents passive, non-interactive systems with limited bi-directional interaction between the human and the robot. Moreover, these systems have utilized a static mixed reality perspective, as they rarely consider the changing context of their environment while projecting information. Therefore, it is our hope that this workshop foster future developments in VAM-HRI that address these challenges.

Thanks to the recent developments in augmented and virtual reality hardware, HRI researchers now have access to more mixed reality environments, richer sensor information, and diverse interaction modalities. Accordingly, this has led to a surge of interest in this exciting research area, as evidenced by the high attendance at VAM-HRI 2018 – 23 (among the most attended workshops at HRI) and the substantial number of relevant papers presented at HRI and other top robotics conferences. In Figure 1 we illustrate some of the recent work in this area (including work from the organizing committee), demonstrating the novel innovations within this research field.

The VAM-HRI workshop focuses on technologies that improve how users understand, control, and interact with robots through immersive visualizations and interfaces, which are crucial for the pursuit of "HRI in the real world."

2 TARGET AUDIENCE

The 7^{th} International Workshop on Virtual, Augmented, and Mixed Reality for Human-Robot Interaction aims to create a forum for researchers within the HRI community to come together and exchange ideas. The focus is on sharing and discussing research involving the development of interactive mixed-reality agents, the use of virtual reality in creating interactive robots, the design of innovative mixed-reality interactions, and the investigation of how humans perceive these agents. The inaugural VAM-HRI Workshop, held at HRI 2018 and documented in [23] and [22], drew a diverse group of over 75 participants, representing academia, industry, and government sectors from regions spanning the Americas, Africa, Europe, Asia, and Oceania. Subsequently, we adopted an online-only format for the 4^{th} and 5^{th} VAM-HRI Workshops, significantly increasing accessibility and participation to over a hundred attendees. We plan to employ a hybrid model for the upcoming 7^{th} VAM-HRI Workshop in 2024. This approach aims to maintain the advantages of online accessibility while fostering in-person connections among attendees who can be physically present. We anticipate a similar level of interest and attendance as in previous years.

3 TOPICS

The workshop welcomes contributions across a wide range of topics, including but not limited to *virtual/augmented/mixed reality* for: intention communication; behavior explanation; robot testing and diagnostics; HRI human-subject experimentation; efficient data representation; language grounding; natural language generation; robot control and teleoperation; HRI architectures; Computational modeling within HRI; expanding social interactions; ethical implications; and identification of novel HRI problems that can benefit from emerging VAM technologies.

4 FORMAT AND ACTIVITIES

While we encourage all participants to join the workshop in person, the organizing committee will prepare for the possibility of both in-person and hybrid conference formats. The VAM-HRI 2024 workshop will include the following components: (1) An invited academic or industry keynote with Q&A; (2) six minute lightning talks followed by Q&A for certain selected paper submissions; and (3) a poster session for all accepted paper submissions, including those who delivered lightning talks. For hybrid accommodations, remote participants will be able to participate via video conference. As a result, the authors will be able to interact with other participants online and in-person during the poster sessions. Lightning talks will also be recorded to be viewed online. Throughout the afternoon, we are planning to have multiple VR and AR headsets with different demos available for in-person participants, with the goal of providing exposure to VAM technology and tools that can be incorporated into future work.

Tentative Workshop Schedule

02:00 – 02:15	Intro
02:15 – 03:00	Invited Keynote Talk
03:00 – 03:50	Lightning Talk Group 1
03:50 – 04:10	Coffee Break
04:10 – 05:00	Lightning Talk Group 2
05:00 – 05:50	Poster Session
05:50 – 06:00	Wrap-up and Closing Remarks

5 PARTICIPANTS, SELECTION AND DOCUMENTATION

The call for submissions will be shared on relevant email lists and websites, including the workshop's dedicated site. We welcome 4-6 page papers on new work and 2-4 page extended abstracts (including references) of ongoing work. Each paper will receive at least two reviews. Accepted papers will be presented as a poster and/or as lightning talks, which will be made available on the workshop website.

Previous iterations of this workshop have utilized OpenReview, allowing submissions to be publicly available. As was done for prior VAM-HRI workshops, the organizers plan to write a paper on summarizing lessons from the workshop, identifying trends of the subfield, and highlighting the emerging work in VAM-HRI [4].

6 ORGANIZING TEAM

Maciej K. Wozniak is a Ph.D. student in the Robotics, Perception and Learning Division at KTH Royal Institute of Science supervised by Patric Jensfelt and Andre Pereira. He has previously served as an organizer of VAM-HRI 2023. His research is focused how use robots and VR/AR to efficiently represent and interact with 3D dynamic environment.

Max Pascher is a Ph.D. student at the University of Duisburg-Essen, supervised by Stefan Schneegass and a member of the Research Unit for Inclusive Human-Robot Interaction (IHRI) at TU Dortmund University, led by Jens Gerken. His research focuses on multi-modal intent Communication and interaction designs for AI-enhanced assistive human-robot collaboration.

Bryce Ikeda is a Ph.D. student in the Computer Science Department at the University of North Carolina at Chapel Hill. He is a member of Interactive Robotics and Novel Technologies (IRON) Laboratory, led by Prof. Daniel J. Szafir. He previously served as an organizer of VAM-HRI 2023. His research focuses on improving the design and development of visual programming and debugging tools by utilizing the immersive properties of augmented reality technology.

Matthew B. Luebbers is a Ph.D. student in the Department of Computer Science at the University of Colorado Boulder, and a researcher in the Collaborative AI and Robotics (CAIRO) Lab, led by Prof. Bradley Hayes. He has previously served as an organizer of VAM-HRI 2023. His research focuses on methods for establishing shared mental models between human and robot teammates using augmented reality.

Ayesha Jena is a Ph.D. student in Robotics and Semantic Systems (RSS), within the Department of Computer Science of the Faculty of Engineering at Lund University, supervised by Elin Anna Topp. Her research areas are currently focused on Human-Robot Interaction, Cognitive Robotics, and Artificial intelligence.

7 STEERING COMMITTEE

For VAM-HRI 2024, the Steering Committee will continue to ensure the workshop's high standards and quality.

Daniel J. Szafir is an Assistant Professor in the Computer Science Department at the University of North Carolina at Chapel Hill. His work focuses on investigating the interplay between robotics and virtual, augmented, and mixed reality technologies, crafting new tools that make robot programming easier, more efficient, and enjoyable, and enhancing human-robot coordination through shared control.

Cynthia Matuszek is an Associate Professor in the Computer Science and Electrical Engineering Department at the University of Maryland, Baltimore County. She focuses on the problem of grounded language acquisition: extracting semantically meaningful representations of human language by mapping those representations to the noisy, unpredictable physical world in which robots operate. She combines robotics, natural language processing, and machine learning to build systems that non-specialists can instruct, control, and interact with intuitively and naturally.

Andre Pereira is multidisciplinary researcher at the Division of Speech, Music and Hearing at KTH Royal Institute of Technology. His work focuses on Artificial Intelligence, Human-Robot Interaction, Extended Reality and Game Design. He creates autonomous embodied intelligent systems that can socially interact, in real-time, with humans throughout extended periods.

Jivko Sinapov is an Assistant Professor in the Computer Science Department at Tufts University and leads the Multimodal Learning, Interaction, and Perception Lab. The goal of the MuLIP lab is to enable robots to operate autonomously in human-inhabited environments through learning and interaction using multiple sensory modalities.

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