THE SECOND JOINT WORKSHOP ON CROSS REALITY

A PREPRINT

Nanjia Wang*

University of Calgary Calgary, Canada nanjia.wang1@ucalgary.ca

Yue Li

Xi'an Jiaotong Liverpool University Suzhou, China yue.li@xjtlu.edu.cn

Francesco Chiossi

LMU Munich Munich, Germany francesco.chiossi@um.ifi.lmu.de

Fabian Pointecker

University of Applied Sciences Upper Austria Wels, Austria fabian.pointecker@fh-hagenberg.at

Lixiang Zhao

Xi'an Jiaotong-Liverpool University Suzhou, China lixiang.zhao17@student.xjtlu.edu.cn

Daniel Zielasko

Trier University
Trier, Germany
zielasko@uni-trier.de

ABSTRACT

The 2nd Joint Workshop on Cross Reality (JWCR'24), organized as part of ISMAR 2024, seeks to explore the burgeoning field of Cross Reality (CR), which encompasses the seamless integration and transition between various points on the reality-virtuality continuum (RVC) such as Virtual Reality (VR), Augmented Virtuality (AV), and Augmented Reality (AR). This hybrid workshop aims to build upon the foundation laid by the inaugural JWCR at ISMAR 2023, which successfully unified diverse CR research communities. The workshop will address key themes including CR visualization, interaction, user behavior, design, development, engineering, and collaboration. CR Visualization focuses on creating and displaying spatial data across the RVC, enabling users to navigate and interpret information fluidly. CR Interaction delves into natural user engagements using gestures, voice commands, and other advanced techniques to enhance immersion. The study of CR User Behavior and Experience investigates how users perceive and interact within these hybrid environments. Furthermore, CR Design and Development emphasizes creating effective CR applications using innovative processes and tools, while CR Collaboration examines methods for fostering teamwork in mixed reality settings.

Keywords Cross-Reality · Mixed Reality · Virtual Reality · Augmented Reality · Augmented Virtuality · Spatial Computing

1 Introduction

Cross Reality (CR) Auda et al. [2023] is an emerging technology that focuses on the concurrent usage of or the transition between multiple systems at different points on the reality-virtuality continuum (RVC), including Virtual Reality (VR), Augmented Virtuality (AV), and Augmented Reality (AR). CR has gained significant attention in recent years due to its potential for revolutionizing various research and industry areas where users need to comprehend and explore spatial data and its relevant information in different forms Chiossi et al. [2022]. It is expected that in the near future, more CR applications will arise to allow users to transition along the individual stages of the RVC or to collaborate in-between these stages to use their distinct advantages and mitigate their potential problems.

^{*}Use footnote for providing further information about author (webpage, alternative address)—not for acknowledging funding agencies.

1.1 Themes and Topics of Interest

Last year, the 1st Joint Workshop on Cross Reality Liang et al. [2023] held in conjunction with the IEEE ISMAR 2023 brought together the community of CR researchers from five separate workshops on individual CR topics. The workshop drew a lot of attention where participants established the research area further. There were over 50 participants joined the 1st JWCR in person with over 20 participants joined online. This is a follow up workshop to explore the new challenges, solutions, and opportunities in the field of CR and provide a comprehensive overview of the related research on the design of interactive techniques for effective CR visualization, interaction, collaboration, user experience, behavior and engineering. We are particularly interested in blurring the lines between and merging the virtual and physical worlds to support users in understanding data in different forms. The workshop provides a forum for researchers from VR/AV/AR/MR, visualization, HCI, and related fields to present their technical and systems papers that introduce new approaches, ideas, discussions, and applications.

Topics of Interest

The field of Cross Reality (CR) is a rapidly evolving area of research that encompasses various aspects of technology and human interaction. CR integrates and transitions between multiple systems on the reality-virtuality continuum, including Virtual Reality (VR), Augmented Reality (AR), and Augmented Virtuality (AV). This convergence of real and virtual worlds opens up numerous possibilities for innovation in how we perceive, interact with, and utilize digital information in our daily lives and professional activities.

CR research covers a broad spectrum of topics, aiming to enhance user experiences and functionalities across different reality-virtuality interfaces. The integration of virtual and physical environments presents unique challenges and opportunities in design, interaction, and application development. Researchers and practitioners are exploring new methodologies and technologies to create more immersive, interactive, and effective CR systems.

Key areas of interest include, but are not limited to, the following:

- Cross Reality environment design: virtuality and reality
- Computational and Adaptive Cross Reality Systems
- Visual representations in cross-reality systems
- Cross Reality transitions across multiple interfaces
- Cross Reality interaction
- Multimodal interaction, perception, and cognition
- Real-world tool use and tangibles as input to CR systems
- Collaborative Cross Reality immersive analytics
- Collaboration across the reality-virtuality continuum
- Cross Reality user experience
- · Cross Reality user behavior
- · Cross Reality tools, frameworks, and APIs
- Testing Cross Reality systems
- Design guidelines for Cross Reality applications
- Evaluation of Cross Reality experiences and systems

Researchers in these areas are encouraged to contribute their insights and findings to advance the state of CR technology and its applications. By addressing these topics, we aim to foster a deeper understanding of CR and its potential to transform various domains, including education, healthcare, industry, and entertainment.

1.1.1 CR Visualization

CR Visualization refers to the ability to create and display abstract or inherently spatial data along the RVC. The visual representations of a Cross-Reality system offer different degrees of virtuality to users and enable users to seamlessly move back and forth across the reality-virtuality continuum.

1.1.2 CR Interaction

CR Interaction allows users to naturally and intuitively engage with real and virtual objects and environments. CR enables various forms of interaction, including hand gestures, voice commands, haptic feedback, and eye-tracking. Advanced interaction techniques for object manipulation, locomotion, and spatial interaction enhance the level of immersion and interactivity in CR experiences, enabling users to seamlessly perform complex tasks and interactions.

1.1.3 CR User Behavior and Experience

CR User Behavior and Experience are concerned with how users perceive, process andrespond to visual information in CR environments. CR technology enables users to immerse themselves in virtual or augmented reality spaces, allowing them to interact with and seamlessly transition between virtual and physical environments and objects.

1.1.4 CR Design, Development, and Engineering

CR Design, Development, and Engineering are concerned with processes, methods, frameworks, and tools that increase the effectiveness and efficiency of design and development teams tasked with creating CR applications and systems. Testing and evaluation are a substantial part of these processes. Additionally, there are still many open challenges in enabling end users, such as developers, domain experts, and users with minimal programming experience, to craft, program, and tailor CR applications and experiences according to their goals, interests, needs, and abilities. There is a growing interest in utilizing authoring tools powered by Generative AI for prototyping CR applications.

1.1.5 CR Collaboration

CR Collaboration is an area of growing interest, as it allows users to work together in real and virtual environments using different interaction techniques and interfaces with different degrees of virtuality. Collaborative CR experiences have the potential to enhance local, remote, and hybrid communication, foster creativity, and improve decision-making in various domains such as design, training, and education.

1.1.6 CR Applications

CR Applications have the potential to enhance the effectiveness and efficiency of real-life tasks in diverse industries. However, there needs to be more empirical evidence to support claims made about the advantages of serious CR; namely, more CR applications need to demonstrate their benefit in solving real-life tasks and be evaluated by empirical studies with the respective user group.

1.2 Workshop Format

This will be a half-day to a full-day workshop with a mixture of invited keynote speeches, presentations of short position papers, and panel discussion on topics derived from the position papers. Position papers will each be presented for ten minutes, while thirty to sixty minutes will be allocated for the group discussion activity. It will be a hybrid event supporting both face-to-face and online participation. A discord channel will be created, enabling people to discuss the workshop topic both before and after the ISMAR event.

1.3 Workshop Contributions

We welcome position paper submissions from 2-4 pages long, excluding references. All paper submissions must be in English. Paper quality versus length will be assessed according to a contribution-per-page judgment. All submissions will be accepted or rejected as workshop papers. All accepted papers will be archived in the IEEE Xplore digital library. Detailed submission and review guidelines are available on the workshop website: https://cross-realities.org/2024/

1.4 Audience

Based on the statistics of the 1st JWCR at ISMAR 2023, we are expecting 15 to 20 submissions with paper presentations at the workshop. An additional 20 to 30 participants will join the panel discussion with presenters.

1.5 Important Dates

We encourage all interested researchers and practitioners to note the following important dates for the 2nd Joint Workshop on Cross Reality (JWCR'24):

• July 26, 2024: Papers submission deadline

• August 9, 2024: Notification of acceptance

• August 26, 2024: Camera-ready submission deadline

• October 25, 2024: Workshop date

1.6 Call for Participation

We are pleased to invite you to the 2nd Joint Workshop on Cross Reality (JWCR'24), held in conjunction with ISMAR 2024. Cross Reality (CR) is an emerging technology that enables concurrent usage and transitions between multiple systems across the reality-virtuality continuum (RVC), including Virtual Reality (VR), Augmented Virtuality (AV), and Augmented Reality (AR). This technology has garnered significant attention for its potential to revolutionize research and industry by allowing users to explore and comprehend spatial data in diverse forms.

Following the success of the inaugural JWCR at ISMAR 2023, which united the CR research community from five separate workshops, this year's workshop aims to further explore new challenges, solutions, and opportunities in the field. We seek to provide a comprehensive overview of research on interactive techniques for effective CR visualization, interaction, collaboration, user experience, behavior, and engineering. Our goal is to blur the lines between the virtual and physical worlds, enhancing users' ability to understand and manipulate data across different forms.

1.7 Organizers

Nanjia Wang is a Ph.D. student at the SEER lab (https://seriousxr.ca/) under the supervision of Dr. Frank Maurer. His work focuses on single-user cross-reality (CR) applications Wang and Maurer [2022]. His research goal is to exploit the potential benefits of single-user CR applications, including the ability to transition between spaces on the Milgram's Reality Virtuality Continuum (RVC) that are most suitable for specific tasks Aigner et al. [2023], Wang et al. [2020]. Nanjia is a member of the 1st Joint Workshop on Cross Reality program committee.

Yue Li received her PhD degree from the University of Nottingham in 2020 with the Postgraduate Award. She is an Assistant Professor at Xi'an Jiaotong-Liverpool University (https://imyueli.github.io/). Her research interest is in the field of HCI, with particular emphasis on Cross Reality technologies and their use in cultural heritage and education Ch'Ng et al. [2020], Xu et al. [2024], He et al. [2024].

Francesco Chiossi (www.francesco-chiossi-hci.com is a PhD researcher at LMU Munich with a background in applied cognitive science. He focuses on implicit measures of user behavior and context, such as electrodermal activity Chiossi et al. [2023a] and EEG Chiossi et al. [2023b], as an implicit input to design and evaluate physiologically adaptive systems across the reality-virtuality continuum Chiossi et al. [2024].

Fabian Pointecker received his Master's degree in Human-Centered Computing from the University of Applied Sciences Upper Austria and is a member of the program committee of the 1st Joint Workshop on Cross Reality. His research interests are visualization and transition techniques in the area of CR (https://hive.fh-hagenberg.at/). He is currently focusing on visual transition techniques that allow the user to seamlessly move along Milgrams's Reality Virtuality Continuum.

Lixiang Zhao is a Ph.D. student at VACT lab in Xi'an Jiaotong Liverpool University (https://lixiangzhao98.github.io/), supervised by Dr. Lingyun Yu. His research focuses on Scientific Visualization (SciVis) and HCI. His work is dedicated to design and evaluate the spatial interaction techniques Zhao et al. [2023] and visualization techniques Li et al. [2023] within CR and VR environments, tailored to specific scientific domains including astronomy and biomedicine.

Daniel Zielasko is currently a postdoctoral researcher at the HCI Group at the University of Trier. He received his Ph.D. in 2020 at the Virtual Reality and Immersive Visualization group at RWTH Aachen University for studying desk-based Virtual Reality. He received his Master's degree in Computer Science in 2013 at RWTH Aachen University.

He focuses on the integration of VR technologies into existing professional workflows and collaborates with neuroscientists, archaeologists, and psychologists in various interdisciplinary projects such as the EU Flagship Project, "The Human Brain Project (HBP)," and the SMHB (Supercomputing and Modeling for the Human Brain). His special interest is the prevention of cybersickness Zielasko et al. [2024] and the development of convincing and innovative 3D user interfaces Wang et al. [2024], Zielasko et al. [2017].

References

- Jonas Auda, Uwe Gruenefeld, Sarah Faltaous, Sven Mayer, and Stefan Schneegass. A scoping survey on cross-reality systems. *ACM Comput. Surv.*, 56(4), oct 2023. ISSN 0360-0300. doi:10.1145/3616536. URL https://doi.org/10.1145/3616536.
- Francesco Chiossi, Johannes Zagermann, Jakob Karolus, Nils Rodrigues, Priscilla Balestrucci, Daniel Weiskopf, Benedikt Ehinger, Tiare Feuchtner, Harald Reiterer, Lewis L. Chuang, Marc Ernst, Andreas Bulling, Sven Mayer, and Albrecht Schmidt. Adapting visualizations and interfaces to the user. *it Information Technology*, 2022. doi:10.1515/itit-2022-0035.
- Hai-Ning Liang, Hans-Christian Jetter, Frank Maurer, Uwe Gruenefeld, Mark Billinghurst, and Christoph Anthes. 1st joint workshop on cross reality. In *IEEE ISMAR 2023*. IEEE, October 2023. doi:10.13140/RG.2.2.21577.52322.
- Nanjia Wang and Frank Maurer. A design space for single-user cross-reality applications. In *Proceedings of the 2022 international conference on advanced visual interfaces*, pages 1–5, 2022.
- David Aigner, Nanjia Wang, David Kielmayer, Jürgen Steiner, Julian Hochpöchler, Christoph Heinzl, Daniel Roth, Frank Maurer, and Christoph Anthes. Cardiac visualisation along the rv-continuum-a high-fidelity pilot study. In 2023 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct), pages 675–680. IEEE, 2023.
- Nanjia Wang, Amir Aminbeidokhti, and Frank Maurer. Individual and collaborative cross-reality immersive analytics-initial ideas. In XR@ ISS, 2020.
- Eugene Ch'Ng, Yue Li, Shengdan Cai, and Fui-Theng Leow. The effects of vr environments on the acceptance, experience, and expectations of cultural heritage learning. *Journal on computing and cultural heritage (JOCCH)*, 13 (1):1–21, 2020.
- Ningning Xu, Yue Li, Xingbo Wei, Letian Xie, Lingyun Yu, and Hai-Ning Liang. Cubemuseum ar: A tangible augmented reality interface for cultural heritage learning and museum gifting. *International Journal of Human–Computer Interaction*, 40(6):1409–1437, 2024.
- Shuqi He, Haonan Yao, Luyan Jiang, Kaiwen Li, Nan Xiang, Yue Li, Hai-Ning Liang, and Lingyun Yu. Data cubes in hand: A design space of tangible cubes for visualizing 3d spatio-temporal data in mixed reality. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, pages 1–21, 2024.
- Francesco Chiossi, Yagiz Turgut, Robin Welsch, and Sven Mayer. Adapting visual complexity based on electrodermal activity improves working memory performance in virtual reality. *Proceedings of the ACM on Human-Computer Interaction*, 7(MHCI):1–26, 2023a.
- Francesco Chiossi, Changkun Ou, Carolina Gerhardt, Felix Putze, and Sven Mayer. Designing and evaluating an adaptive virtual reality system using eeg frequencies to balance internal and external attention states. *arXiv* preprint *arXiv*:2311.10447, 2023b.
- Francesco Chiossi, Uwe Gruenefeld, Baosheng James Hou, Joshua Newn, Changkun Ou, Rulu Liao, Robin Welsch, and Sven Mayer. Understanding the impact of the reality-virtuality continuum on visual search using fixation-related potentials and eye tracking features. In *Proceedings of MobileHCI 2024*. ACM, 2024. doi:10.1145/3676528.
- Lixiang Zhao, Tobias Isenberg, Fuqi Xie, Hai-Ning Liang, and Lingyun Yu. Metacast: Target-and context-aware spatial selection in vr. *IEEE Transactions on Visualization and Computer Graphics*, 2023.
- Jiayin Li, Lixiang Zhao, Hai-Ning Liang, and Lingyun Yu. Immerview: Adaptive multi-view layout for immersive situated visualizations. In 2023 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct), pages 108–112. IEEE, 2023.
- Daniel Zielasko, Ben Rehling, and Gregor Domes. The progression of cybersickness after exposure. 2024.
- Nanjia Wang, Daniel Zielasko, and Frank Maurer. User preferences for interactive 3d object transitions in cross reality-an elicitation study. In *Proceedings of the 2024 International Conference on Advanced Visual Interfaces*, pages 1–9, 2024.
- Daniel Zielasko, Benjamin Weyers, Martin Bellgardt, Sebastian Pick, Alexander Meibner, Tom Vierjahn, and Torsten W Kuhlen. Remain seated: towards fully-immersive desktop vr. In 2017 IEEE 3rd workshop on everyday virtual reality (WEVR), pages 1–6. IEEE, 2017.