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1st Workshop on Prototyping Cross-Reality Systems

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ABSTRACT

Cross-Reality (CR) systems offer different levels of virtuality to their users, enabling them to either transition along the reality-virtuality continuum or collaborate with each other across different manifestations. Many Augmented (AR) and Virtual Reality (VR) systems are inherently cross reality since the amount of augmentation of the physical world (AR) or the influence of the physical environment (VR) varies over time. However, traditional prototyping approaches often focus on one specific manifestation, and so are less feasible for prototyping cross-reality systems. In this workshop, we aim to discuss current challenges, solutions, and opportunities that arise from prototyping CR systems and their interactions. We offer attendees a balanced mix of presentation and interactive sessions, including (provocative) research positions and video demonstrations of existing CR prototyping tools. Ultimately, the workshop aims to start a discussion inside the ISMAR community about the current challenges and novel concepts around prototyping CR systems.

Index Terms: Human-centered computing—Mixed / augmented reality; Human-centered computing—Virtual reality; Human-centered computing—Collaborative interaction; Human-centered computing—Interface design prototyping

1 INTRODUCTION

With Augmented (AR) and Virtual Reality (VR) technologies, users can enrich their physical reality with digital information using AR or immerse themselves into entirely virtual worlds using VR. Although complimentary, both AR and VR belong to the same reality-virtuality continuum that Milgram and Kishino introduced in 1994 [6]. They primarily differ in the degree of virtuality they offer to users. In recent years, the boundaries between these technologies have become increasingly blurred with new hardware allowing users to transition along the reality-virtuality continuum. For example, the Oculus Quest 2 head-mounted display can be used to view immersive VR content, and, at the same time, supports AR experiences with a video see-through mode. Various systems have also been developed that enable users to collaborate with others at different points on the continuum. For example, in the MagicBook [1], users in AR could collaborate with others in VR and together transition along the reality-virtuality continuum. We refer to these applications as cross-reality systems as they are not limited to one particular point on the continuum. Many AR and VR systems can be understood as inherently cross-reality systems as the amount of augmentation of the physical world using AR or the influence of the physical environment using VR vary over time.

While the research area of cross-reality systems has become more popular in recent years, with first workshops discussing the topic (cf., international workshop on cross-reality interaction [8]), methods for prototyping these systems have received less attention. Developing prototypes that enable immersive cross-reality experiences is often

time-consuming and requires both software and hardware prototyping expertise. In particular, cross-reality hardware prototypes (e.g., [3–5]) have a high barrier to entry as they require technology (e.g., displays, projectors, sensors), engineering (e.g., electrical engineering, software development), and design expertise (e.g., rapid prototyping). Furthermore, traditional prototyping approaches are often limited to one type of interface and they do not provide means to transition on the reality-virtuality continuum or switch between users. This may result in the need to create at least two separate AR/VR systems to prototype the CR experience.

In our workshop, we combine the expertise of a variety of research domains related to CR to generate and discuss novel approaches for CR prototyping tools. We discuss current prototyping approaches applicable to the field of CR and introduce toolkits that support the CR prototyping process with different levels of expertise. We aim to start a discussion on new approaches that are shaped by requirements coming from related domains to get insight into what a proper prototyping toolkit needs to provide in its feature set. We initiate this discussion by introducing current research, such as our *VRception* toolkit [2] for prototyping CR experiences completely in VR and *XRDirector* [7] which supports cross-reality prototyping with multiple designers in VR or AR. Without the need for additional hardware, these systems provide a way to generate virtual prototypes that give user’s a first impression of the CR experience.

2 WORKSHOP PREFERENCES

Preferred date for the workshop. We would like to offer our workshop on Monday, the 17th of October, but could also do Friday. The workshop is planned as a full-day workshop.

Presentation mode. We plan to offer our workshop in a hybrid format, meaning we will offer both online and in-person participation for our attendees. However, if the available physical space is limited, we can offer our workshop online only.

Whether workshop materials should be published in the proceedings. We would like to have the accepted workshop papers published in the ISMAR 2022 adjunct proceedings and will ensure that authors follow the IEEE Computer Society VGTC format for their submissions.

3 THEMES AND TOPICS OF INTEREST

Brief description on research issues that the workshop will address. Our workshop focuses on the unique challenges and opportunities that arise from prototyping cross-reality systems. We argue that the nature of VR and AR (being grounded in a physical environment and adding virtual content) is inherently cross-reality. However, there exists a spectrum of challenges, where on the one hand both realities might be tightly connected (e.g., adding a virtual text on a physical object) and on the other hand, there might be friction between different types of interfaces (e.g., interacting with a non-immersed AR user while being immersed in VR). We aim to focus on these challenges and discuss what unique properties of CR systems result in the demand for new prototyping tools.

In our workshop, we include both software and hardware prototyping of these systems, to encourage the community to tackle the

lack of research into CR prototyping. Hardware prototyping, in particular, has received some attention in previous research (e.g., [3, 10]). The main emphasis of the workshop will be on video and hands-on demonstrations of different prototyping tools during an interactive session, allowing attendees to get insights and experience with these tools.

Reasons why the workshop is of interest to the conference participants. Prototyping is the core of every development cycle and CR comes with a unique set of prototyping challenges. In this workshop, we will discuss with participants what specific challenges they are facing prototyping for CR and additionally include authors of potential solutions for these individual challenges.

Participants can learn about novel tools and methods that allow them to prototype cross-reality systems. During the workshop, participants can get hands-on experience with different prototyping tools and methods in an interactive session. Moreover, they can meet and discuss with researchers in the field, which could lead to exciting collaborations.

Reasons why the workshop is timely and relevant for ISMAR 2022 With the recent rise of interest in CR technology, a more diverse population of content creators and developers (e.g., designers, researchers, and engineers) are working on developing CR applications and experiences. However, current tools for prototyping often fail to meet the demands of being cross-reality focused. This workshop aims to gather people from different communities of researchers and content creators at ISMAR 2022. With its strong technical direction, we think that ISMAR is the perfect venue to start this type of multi-disciplinary discussion and build upon the existing experience of years of designing and engineering CR systems.

Over the last decade, the human-computer interaction community has built various prototyping tools for mixed reality, including a few tools for cross-reality systems. In our workshop, we aim to introduce these tools and provide a forum for researchers and practitioners interested in getting to know them. We believe that sharing prototyping tools and experiences for cross-reality systems can be particularly valuable for the VR/AR communities as published papers usually do not discuss the challenges experienced by researchers.

4 FORMAT OF THE WORKSHOP

We plan the workshop in a hybrid format, supporting both people attending in person or online. Overall, the workshop aims for a balance between presentations and interactive sessions.

We plan for two keynotes that are scheduled at the end and the beginning of the workshop. For the opening keynote, we plan to invite a local keynote speaker to present in person at the conference. For the closing keynote, we recruited Adalberto Simeone from KU Leuven, Belgium (<https://www.adalsimeone.me>). Adalberto is an Assistant Professor in the Department of Computer Science at the KU Leuven. His research lies in the intersection of 3D Interaction and Virtual Reality with Human-Computer Interaction. Adalberto is one of the organizers of the first workshop on cross-reality interaction [8] and has contributed various cross-reality systems in previous years, such as *Substitutional Reality* [9].

For authors, we have planned two sessions, one for short papers and one for posters and video presentations. For the short paper presentations, we plan for a joint moderated discussion of multiple related papers. For the posters and video presentations, we aim for an open space discussion in which authors get a physical or virtual space allocated and workshop attendees can freely wander around.

9:00 AM Opening Keynote (20 min + 10 discussion)

9:30 AM Paper Presentations (5 min per paper + discussion pool: one discussion for multiple papers + coffee breaks)

12:00 PM Lunch Break (45 min)

12:45 PM Interactive Session with Posters and Video Demonstrations in an Open Space (60 min)

1:45 PM Coffee Break (15 min)

2:00 PM Brainstorming / Discussion of Future Directions (60 min)

3:00 PM Coffee Break (15 min)

3:15 PM Closing Keynote (15 min + 10 discussion)

5 CALL FOR PARTICIPATION DOCUMENT

We invite researchers, practitioners, and designers to participate in the first workshop on prototyping for cross-reality (CR) systems. The aim of the workshop is to bring together a community of researchers, practitioners, and designers who are interested in prototyping for cross-reality interactions and systems.

5.1 Workshop Contributions

Topics of interest include, but are not limited to:

- Cross-Reality Prototyping Challenges
- Hardware and/or Software Cross-Reality Prototypes
- CR User and Bystander Interaction
- CR Design Principles
- Evaluation of Cross-Reality Experiences and Systems
- Cross-Reality Prototyping Tools (low/medium/high fidelity)
- Privacy and Security in Cross-Reality Systems
- Application Domains Benefiting from Cross-Reality Systems

We invite a variety of submissions: short papers (2-4 pages), posters (format: A1 or A0), video demonstrations (max. 5 minutes), and research statements (between 200 and 500 words long).

Short Papers We invite papers of two to four pages in length, excluding references. Submissions should follow the IEEE Computer Society VGTC format for their submissions. Authors could discuss previously published results, present work-in-progress, lay out a (provocative) position based on the current cross-reality research field, or discuss their (10-year) vision within the cross-reality and prototyping field. Each paper will be allocated a dedicated slot in the program for their talk. This will be followed by a panel-like discussion, in which we provide a shared space to discuss several related papers at once.

Posters We invite people interested in attending the workshop to submit posters that follow similar topics as for the short paper submissions. Compared to short papers, posters are expected to present a less substantial contribution and are discussed in an open space to foster networking.

Video Demonstrations We are looking for implementations and evaluations of novel and interesting concepts or systems related to CR prototyping and cross-reality interaction. Video demos can be up to 5 minutes (ideally between three to five minutes), and will also be presented in an open space together with the poster submissions.

Research Statements We invite people interested in attending the workshop to share their opinion about a specific workshop-related topic. Research statements should be between 200 and 500 words.

5.2 Submission Format and Dates

All short paper submissions should be formatted as ISMAR Conference Proceedings papers (IEEE Computer Society TVCG format described <https://ismar2022.org/conference-submission-guidelines>). All submissions must be accessible and electronically submitted via EasyChair. Accessible means that images must be described with alt text

or narration and videos should be captioned. For a full list of accessibility considerations please refer to <https://ismar2022.org/journal-accessible-submission-guide>. Videos should be encoded as an MP4 using the H.264 codec. Posters should be submitted as PDF.

- Submissions deadline: July 11th, 2022 (Monday)
- Acceptance notifications: August 8th, 2022 (Monday)
- Camera-ready versions: August 31st, 2022 (Wednesday)
- Workshop day: October 17th or 21st, 2022 (Monday/Friday)

6 ORGANIZERS

The following researchers are involved in organizing the workshop:

Uwe Gruenefeld is a postdoc researcher in human-computer interaction at the University of Duisburg-Essen, Germany. He is fascinated by a wide range of topics around AR and VR. His research has mainly focused on visualizing out-of-view objects, passive haptics, usable security, and cross-reality systems (www.uwe-gruenefeld.de).

Jonas Auda is a Ph.D. candidate at the University of Duisburg-Essen, Germany. His research focuses on enhancing the experiences and interaction opportunities within virtual environments. Therefore, he utilizes emerging technologies like drones, electrical muscle stimulation, or brain-computer interfaces. His current research covers natural locomotion, haptic feedback, and collaboration in VR as well as cross-reality systems (www.jonasauda.de).

Florian Mathis is a Ph.D. candidate at the University of Glasgow and the University of Edinburgh. His research is in human-computer interaction, usable security and privacy, and VR. He is interested in exploring how VR studies can facilitate the implementation and evaluation of novel forward-looking prototypes (www.fmathis.com).

Mohamed Khamis is a Reader/Associate Professor at the University of Glasgow. His research is at the intersection of ubiquitous computing and user-centered privacy and security. He is interested in understanding the implications of ubiquitous sensors, including XR sensors, on people's privacy and security, and in developing novel user-centered security and privacy-enhancing systems (www.mkhamis.com).

Jan Gugenheimer is an Assistant Professor at the Institute Polytechnique de Paris. His research focuses around upcoming social challenges for mixed reality technology and how to embed XR into the fabric of our daily lives (www.gugenheimer.com).

Sven Mayer is an assistant professor for HCI at the LMU Munich. He uses machine learning tools to design, build, and evaluate future human-centered interfaces in his research. This allows him to focus on hand- and body-aware interactions in a variety of contexts, such as mobile scenarios, augmented and virtual reality, with special attention to building hardware and software prototypes (www.sven-mayer.com).

Michael Nebeling is an Assistant Professor at the University of Michigan where he directs an HCI research group focused on XR. His lab developed a number of XR authoring tools with support for rapid prototyping using multi-device interaction techniques and supporting cross-reality interfaces (www.michael-nebeling.de).

Mark Billingham is Director of the Empathic Computing Laboratory, and Professor at the University of South Australia in Adelaide, Australia, and also at the University of Auckland in Auckland, New Zealand. He conducts research on how virtual and real worlds can be merged, publishing over 650 papers on Augmented Reality, Virtual Reality, remote collaboration, Empathic Computing, and related topics. In 2019 he was given the ISMAR Career Impact Award in recognition for lifetime contribution to AR research and commercialization (www.empathiccomputing.org/team/mark-billinghurst).

7 POTENTIAL PROGRAM COMMITTEE MEMBERS

For the review process of our workshop, we decided to take a collaborative approach in which the workshop organizers take on the role of the program committee and the authors of submissions are asked to provide external reviews for two other submissions. We expect a larger number of workshop submissions from early career researchers, so we want to provide an opportunity for them to gain reviewing experience, while maintaining a fair balance of senior and junior reviewers for each submission.

8 AUDIENCE

We expect around 15 to 30 attendees in our workshop at ISMAR 2022. However, we are able to adapt our program if we receive a larger number of submissions, and want to have more presentations.

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