Workshop on Ubiquitous Mixed Reality: Unveiling Opportunities and Challenges

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Abstract

Mixed Reality (MR) increasingly gained importance over the last decade leading to the commercial breakthrough in recent years. Consequently, experts predict that users will spend considerable amounts of time in MR in the near future and possibly replace the smartphone. When MR becomes ubiquitous and will be used in everyday contexts as the smartphone, novel opportunities and challenges will arise that are unmatched by any other technology. In this one-day workshop, we will therefore discuss the opportunities of ubiquitous MR — such as an envisioned killer app — as well as the upcoming challenges, and gather guidelines and practices for the design and development of future MR applications that can be used in everyday contexts.

Keywords

Ubiquitous Mixed Reality, Virtual Reality, Augmented Reality

1 Introduction and Background

In recent years, Mixed Reality (MR) — a technology combining elements ranging from Virtual Reality (VR) to Augmented Reality (AR) — has increasingly gained significance across various domains, including healthcare, gaming, entertainment, education, training, and various research disciplines such as human-computer interaction (HCI) [12–16, 21, 26]. This trend is confirmed by the recent commercial development in immersive technologies, including Apple's release of the Vision Pro. Experts, therefore, predict that users will spend considerable amounts of time in MR in the near future [1, 22]. Hence, MR is assumed to be ubiquitous as smartphones and used during everyday activities [18, 30], such as walking, commuting, sitting at a restaurant, or just waiting [1, 31].

MR offers promising opportunities during these situations in public spaces or other everyday activities [25], e.g., working [11], watching movies [27], being immersed in a concert [3], playing

immersive games [4], or using MR while driving a car [24]. Thomas et al. [28], for example, presented a first-person shooter AR game that can be played outdoor. Knierim et al. [11] proposed a mobile office using multiple virtual screens that is not restricted to a physical location. These examples indicate MR technology enables users to do multitasking and perform a variety of tasks while doing common daily activities. Consequently, this technology offers a broad range of new opportunities that are unmatched by any other technology [10]. However, the immersive nature of MR also introduces risks that extend beyond those that are associated with other technologies such as smartphones [5, 8].

One challenge for MR revolves around ensuring the effective and safe coexistence of other people or objects surrounding the MR user [7]. The complexity of interactions within MR environments is accentuated when the sudden presence of a real person or object, not integrated into the virtual representation, becomes a variable. Even if potentially visible through MR, the high level of distraction caused by the immersive nature of MR applications can result in dangerous situations, e.g., overseeing obstacles such as vehicles [2] or playing games while driving a car [20]. While a large body of work has already investigated "smartphone zombies" whose attention is almost entirely absorbed by the smartphone while walking [23], MR exacerbates the challenges and introduces novel problems that need to be addressed before MR becomes an ubiquitous and everyday technology.

Consequently, this workshop contributes to the debate about the positive and negative implications of an envisioned future where ubiquitous MR is an integral part of our daily lives. To achieve this, we aim for an interdisciplinary workshop where we bring together scientists and industry attendees from various fields who investigate immersive technologies from different lenses. This allows to foresee the great opportunities on the one hand, but also problems and challenges of MR adoption and usage on the other. As envisioning and anticipating the future is one of the main tasks of science, this workshop targets to discover potentials and dangers of ubiquitous MR to explore invaluable opportunities, fascinating user experiences, best practices and guidelines, as well as legislation.

2 Workshop Mode

The workshop is planned as a one-day event and will be held as an in-person workshop. The schedule consists of paper presentations by the participants and interactive discussion sessions to

ensure active discussion among the participants and collaboratively elaborate on predefined topics.

2.1 Content

After welcoming the participants, we start the workshop with the individual presentations of the participants about the workshop paper in a Pecha Kucha style without an q&a. We plan with 6 minutes per paper. After a coffee break (30 minutes), discussion groups (small groups of 3 to 4 people) based on the participants' paper topics will be organized so that participants can actively discuss around the topic area (120 minutes). After a lunch break (60 minutes), the groups will conceptualize and sketch possible MR applications based on the previous discussion (90 minutes). After a 30-minute coffee break, the results of the discussion groups will be summarized and presented by the groups to all participants of the workshop (45 minutes). Finally, short and long-term collaborative plans will be discussed in the closing and wrap-up session (30 minutes).

2.2 Participants

We welcome participants from all fields of HCI and mixed reality— researchers, designers, practitioners, social scientists, psychologists, and philosophers — that are interested in immersive technologies such as MR/VR/AR. While we expect around 15-20 participants to allow an in-depth discussion, we are open to a larger audience. The workshop has no special requirements beyond curiosity about MR/VR/AR.

2.3 Schedule

While we are happy to adapt to the conference schedule, we propose to hold the workshop on Sunday, September 1st, from 09:00 to 17:00.

Welcome (09:00 – 09:15): Opening presentation to outline the workshop motivation and learning goals.

Individual presentations of the participants (09:15 – 10:15): Workshop paper presentations (12 minutes per paper incl. a q&a session). The coffee and lunch breaks can be used to ask questions and discuss the presented papers.

Coffee break (10:15 - 10:45)

Discussions and brainstorming in groups (10:45 – 12:15): Participants will discuss in small groups of 3-4 people for 120 minutes. The groups will be assigned in advance according to the paper topics. Participants will discuss and elaborate on predefined topics.

Group presentations (12:15 - 12:45): Participants will present their insights and findings from their discussion groups.

Lunch break (12.45 – 13:45)

Conceptualizing and Sketching in groups (13:45 – 15:15): Participants will discuss, conceptualize and sketch MR applications in small groups of 3-4 people for 90 minutes. The groups will be assigned in advance according to the previous discussion.

Coffee break (15.15 – 15:45)

Group presentations (15:45 – 16:30): Participants will present their insights and findings from their discussion groups.

Closing and wrap up (16:30 – 17:00): Workshop results, including best practices, and experiences from the workshop will be documented. Remaining open questions will be summarized and possible follow-up activities will be discussed.

3 Call for Participation

MR, characterized by the seamless integration of virtual and physical worlds across diverse contexts and devices, presents a paradigm shift in HCI. Experts predict that MR technology will become ubiquitous and will replace the smartphone in future. In case ubiquitous MR will be widely available and used in everyday contexts as we use the smartphone nowadays, it is crucial to think about opportunities and positive effects on the one hand, but also about challenges such as risks and dangers that need to be overcome on the other. This workshop aims to foster interdisciplinary discussions and collaborations to address the multifaceted challenges and opportunities associated with ubiquitous MR. The workshop will bring together researchers and practitioners to delve into the various facets of ubiquitous MR and its implications for society, technology, and beyond.

We invite researchers and practitioners to participate in the *Workshop on Ubiquitous Mixed Reality: Unveiling Opportunities and Challenges* on Sunday September 1st which will be co-located with Mensch und Computer (MuC) 2024 in Karlsruhe, Germany on September 1-4, 2024. Participants will have the opportunity to present their work, engage in discussions, and network with peers and experts in the field. We seek papers describing original research, work in progress, as well as novel applications and systems from all areas mixed reality, virtual reality and augmented reality used in everyday contexts. The workshop focuses on opportunities and challenges related to ubiquitous MR and provides a platform for discussions spanning the MR and HCI research communities.

3.1 Topics of interest include but are not limited to

- UX in ubiquitous MR
- Applications and use cases for ubiquitous MR
- Future trends and directions in ubiquitous MR research and development
- Technological infrastructure requirements for widespread MR deployment
- Altered realities and bodies (e.g., Avatars and Virtual Humans)
- Social acceptance of MR usage
- Ethical considerations and societal implications
- Privacy and security implications of ubiquitous MR

3.2 Submission Guidelines

We will have different submission formats and especially encourage students and PhD students to submit preliminary work in the Flashlight Paper format. The following formats can be submitted:

- Full Research Paper submissions should not exceed 8 pages (incl. references) and should make novel technical, empirical, or theoretical contributions to the field.
- Short Position Papers should not exceed 4 pages (incl. references) and should foster (interdisciplinary) discourse, arguing with a strong position
- Flashlight Papers should not exceed 3 pages (incl. references) and may present preliminary work, approaches and experimental designs, or first results.

- Presentation submissions (limited to an oral presentation) may be accepted on the basis of a submission of preliminary published work, that will not be included in the Workshop proceedings.

All submissions should be submitted in using the English Language and be formatted in the Long Paper format of MuC 2024 (ACM Double Column). It is mandatory that at least one of the authors of an accepted paper is present at the workshop during MuC 2024 to present the paper. For submission, please use the Conftool selecting the specific workshop track. All submissions (except presentation submissions) will be peer-reviewed and once accepted, the paper is published in the GI Digital Library.

4 Accepted Submissions

We accepted in total five papers that will be presented in the beginning of the workshop. All papers cover a variety of topics within the realm of MR ranging from public XR applications, human-robot interaction, and the design of user representations in MR and VR:

- Towards Connecting East and West German Cities Through Public XR [9]
- Virtually Real Robots: XR as a Proxy for Physical Human-Robot Interaction [6]
- Towards Enhanced User Representations for Handheld Mixed Reality [19]
- Towards Determining the Physical Characteristics that Induce the Proteus Effect [29]
- Investigating the Proteus Effect on Physiological Responses While Resting in VR [17]

5 Organizers

Martin Kocur is professor of Interactive Experiences at University of Applied Sciences Upper Austria in Austria. His research focuses on the design and creation of virtual avatars and digital humans in the context of VR, HCI, and games.

Alexander Kalus is a final year PhD student at University of Regensburg. He is interested in immersive technologies and how human perception can be utilized to create illusory experiences such as embodiment or weight illusions.

Valentin Schwind is professor of Human-Computer Interaction at the Frankfurt University of Applied Sciences. His research focuses on immersive user experiences, physiological and perceptual sensing, virtual avatars and gaming.

Niels Henze is professor for Media Informatics at the University of Regensburg. He is interested in using and understanding mixed reality to build better user interfaces. In particular, he is interested in connecting human-computer interaction with underlying psychological phenomena.

References

[1] Ronald T. Azuma. 2019. The road to ubiquitous consumer augmented reality systems. *Human Behavior and Emerging Technologies* 1, 1 (2019), 26–32. https://doi.org/10.1002/hbe2.113

[2] Stefania Barbieri, Gianna Vettore, Vincenzo Pietrantonio, Rossella Snenghi, Alberto Tredese, Mauro Bergamini, Sara Previato, Armando Stefanati, Rosa Maria Gaudio, and Paolo Feltracco. 2017. Pedestrian Inattention Blindness While Playing Pokémon Go as an Emerging Health-Risk Behavior: A Case Report. *J Med Internet Res* 19, 4 (01 Apr 2017), e86. https://doi.org/10.2196/jmir.6596

[3] Alejandro Beacco, Ramon Oliva, Carlos Cabreira, Jaime Gallego, and Mel Slater. 2021. Disturbance and Plausibility in a Virtual Rock Concert: A Pilot Study. In *2021 IEEE Virtual Reality and 3D User Interfaces (VR)*. 538–545. https://doi.org/10.1109/VR50410.2021.00078

[4] Elizabeth M. Bonsignore, Derek L. Hansen, Zachary O. Toups, Lennart E. Nacke, Anastasia Salter, and Wayne Lutters. 2012. Mixed Reality Games. In *Proceedings of the ACM 2012 Conference on Computer Supported Cooperative Work Companion* (Seattle, Washington, USA) *(CSCW '12)*. Association for Computing Machinery, New York, NY, USA, 7–8. https://doi.org/10.1145/2141512.2141517

[5] Martin Johannes Dechant, Martin Kocur, Christian Wolff, and Regan Mandryk. 2020. "Healthy" Deceits with Mixed Reality. In *CHI 2020 - Workshop on Exploring Potentially Abusive Ethical, Social and Political Implications of Mixed Reality Research in HCI*. 1–4. https://epub.uni-regensburg.de/45426/

[6] Enrico Guerra and Michael Prilla. 2024. Virtually Real Robots: XR as a Proxy for Physical Human-Robot Interaction. In *Mensch und Computer 2024 - Workshopband*. Gesellschaft für Informatik e.V., Bonn. https://doi.org/10.18420/muc2024-mci-ws06-204

[7] Jan Gugenheimer. 2016. Nomadic Virtual Reality: Exploring New Interaction Concepts for Mobile Virtual Reality Head-Mounted Displays. In *Adjunct Proceedings of the 29th Annual ACM Symposium on User Interface Software and Technology* (Tokyo, Japan) *(UIST '16 Adjunct)*. Association for Computing Machinery, New York, NY, USA, 9–12. https://doi.org/10.1145/2984751.2984783

[8] Jan Gugenheimer, Mark McGill, Samuel Huron, Christian Mai, Julie Williamson, and Michael Nebeling. 2020. Exploring Potentially Abusive Ethical, Social and Political Implications of Mixed Reality Research in HCI. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems (CHI EA '20)*. Association for Computing Machinery, New York, NY, USA, 1–8. https://doi.org/10.1145/3334480.3375180

[9] Daniel Görlich and Matthias Wölfel. 2024. Towards Connecting East and West German Cities Through Public XR. In *Mensch und Computer 2024 - Workshopband*. Gesellschaft für Informatik e.V., Bonn. https://doi.org/10.18420/muc2024-mci-ws06-203

[10] Ross Johnstone, Neil McDonnell, and Julie R. Williamson. 2022. When Virtuality Surpasses Reality: Possible Futures of Ubiquitous XR. In *Extended Abstracts of the 2022 CHI Conference on Human Factors in Computing Systems* (New Orleans, LA, USA) *(CHI EA '22)*. Association for Computing Machinery, New York, NY, USA, Article 6, 8 pages. https://doi.org/10.1145/3491101.3516396

[11] Pascal Knierim, Thomas Kosch, and Albrecht Schmidt. 2021. The Nomadic Office: A Location Independent Workspace Through Mixed Reality. *IEEE Pervasive Computing* 20, 4 (2021), 71–78. https://doi.org/10.1109/MPRV.2021.3119378

[12] Martin Kocur, Sarah Graf, and Valentin Schwind. 2020. The Impact of Missing Fingers in Virtual Reality. In *26th ACM Symposium on Virtual Reality Software and Technology* (Virtual Event, Canada) *(VRST '20)*. Association for Computing Machinery, New York, NY, USA, Article 4, 5 pages. https://doi.org/10.1145/3385956.3418973

[13] Martin Kocur, Florian Habler, Valentin Schwind, Paweł W. Woźniak, Christian Wolff, and Niels Henze. 2021. Physiological and Perceptual Responses to Athletic Avatars While Cycling in Virtual Reality. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI '21)*. Association for Computing Machinery, New York, NY, USA, Article 519, 18 pages. https://doi.org/10.1145/3411764.3445160

[14] Martin Kocur, Niels Henze, and Valentin Schwind. 2021. The Extent of the Proteus Effect as a Behavioral Measure for Assessing User Experience in Virtual Reality. In *CHI 2021 - Workshop on Evaluating User Experiences in Mixed Reality*. 1–3. https://doi.org/10.5283/epub.45543

[15] Martin Kocur, Melanie Kloss, Valentin Schwind, Christian Wolff, and Niels Henze. 2020. *Flexing Muscles in Virtual Reality: Effects of Avatars' Muscular Appearance on Physical Performance*. Association for Computing Machinery, New York, NY, USA, 193–205. https://doi.org/10.1145/3410404.3414261

[16] Martin Kocur, Philipp Schauhuber, Valentin Schwind, Christian Wolff, and Niels Henze. 2020. The Effects of Self- and External Perception of Avatars on Cognitive Task Performance in Virtual Reality. In *26th ACM Symposium on Virtual Reality Software and Technology* (Virtual Event, Canada) *(VRST '20)*. Association for Computing Machinery, New York, NY, USA, Article 27, 11 pages. https://doi.org/10.1145/3385956.3418969

[17] Martin Kocur and Valentin Schwind. 2024. Investigating the Proteus Effect on Physiological Responses While Resting in VR. In *Mensch und Computer 2024 - Workshopband*. Gesellschaft für Informatik e.V., Bonn. https://doi.org/10.18420/muc2024-mci-ws06-215

[18] Keiichi Matsuda. 2019. Hyper-Reality. http://hyper-reality.co/

[19] Vera Marie Memmesheimer, Sofie Magdalena Schwenkreis, and Achim Ebert. 2024. Towards Enhanced User Representations for Handheld Mixed Reality. In *Mensch und Computer 2024 - Workshopband*. Gesellschaft für Informatik e.V., Bonn. https://doi.org/10.18420/muc2024-mci-ws06-205

[20] Justin G Mignogna. 2017. Pokémon Go, Augmented Reality Games, and How the Insurance Industry Will Help Protect a Distracted Society from Becoming Even More Distracted. *Rutgers UL Rev.* 70 (2017), 675.

[21] Paul Milgram and Fumio Kishino. 1994. A Taxonomy of Mixed Reality Visual Displays. *IEICE Trans. Information Systems* vol. E77-D, no. 12 (12 1994), 1321–1329.

[22] Taiwoo Park, Mi Zhang, and Youngki Lee. 2018. When Mixed Reality Meets Internet of Things: Toward the Realization of Ubiquitous Mixed Reality. *GetMobile: Mobile Comp. and Comm.* 22, 1 (may 2018), 10–14. https://doi.org/10.1145/3229316.3229320

[23] Andrew Pressey, David Houghton, and Dogá Istanbulluoglu. 2023. The problematic use of smartphones in public: the development and validation of a measure of smartphone "zombie" behaviour. *Information Technology & People* ahead-of-print, ahead-of-print (01 Jan 2023). https://doi.org/10.1108/ITP-06-2022-0472

[24] Andreas Riegler, Andreas Riener, and Clemens Holzmann. 2020. A Research Agenda for Mixed Reality in Automated Vehicles. In *Proceedings of the 19th International Conference on Mobile and Ubiquitous Multimedia* (Essen, Germany) *(MUM '20)*. Association for Computing Machinery, New York, NY, USA, 119–131. https://doi.org/10.1145/3428361.3428390

[25] Somaiieh Rokhsaritalemi, Abolghasem Sadeghi-Niaraki, and Soo-Mi Choi. 2020. A Review on Mixed Reality: Current Trends, Challenges and Prospects. *Applied Sciences* 10, 2 (2020). https://doi.org/10.3390/app10020636

[26] Maximilian Speicher, Brian D. Hall, and Michael Nebeling. 2019. What is Mixed Reality?. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) *(CHI '19)*. Association for Computing Machinery, New York, NY, USA, 1–15. https://doi.org/10.1145/3290605.3300767

[27] Kata Szita, Wyatt Moss-Wellington, Xiaolin Sun, and Eugene Ch'ng. 2024. Going to the movies in VR: Virtual reality cinemas as alternatives to in-person co-viewing. *International Journal of Human-Computer Studies* 181 (2024), 103150. https://doi.org/10.1016/j.ijhcs.2023.103150

[28] Bruce Thomas, Ben Close, John Donoghue, John Squires, Phillip De Bondi, and Wayne Piekarski. 2002. First Person Indoor/Outdoor Augmented Reality Application: ARQuake. *Personal and Ubiquitous Computing* 6, 1 (Feb. 2002), 75–86.

[29] Elisa Valletta, Alexander Kalus, Johanna Bogon, and Niels Henze. 2024. Towards Determining the Physical Characteristics that Induce the Proteus Effect. In *Mensch und Computer 2024 - Workshopband.* Gesellschaft für Informatik e.V., Bonn. https://doi.org/10.18420/muc2024-mci-ws06-213

[30] Yu Wang, Raphael Johannes Schimmerl, Martin Kocur, and Philipp Wintersberger. 2023. Ubiquity of VR: Towards Investigating Ways of Interrupting VR Users to Obtain Their Attention in Public Spaces. In *Virtual Reality and Mixed Reality*, Gabriel Zachmann, Krzysztof Walczak, Omar A. Niamut, Kyle Johnsen, Wolfgang Stuerzlinger, Mariano Alcañiz-Raya, Greg Welch, and Patrick Bourdot (Eds.). Springer Nature Switzerland, Cham, 40–52.

[31] Sandro Weber, Linda Rudolph, Sven Liedtke, Christian Eichhorn, Daniel Dyrda, David A. Plecher, and Gudrun Klinker. 2022. Frameworks Enabling Ubiquitous Mixed Reality Applications Across Dynamically Adaptable Device Configurations. *Frontiers in Virtual Reality* 3 (2022). https://doi.org/10.3389/frvir.2022.765959