

FutureEcologies: Towards Mixed Reality Cross-Device Ecologies for The Future of Work

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FutureEcologies: Towards Mixed Reality Cross-Device Ecologies for The Future of Work

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ABSTRACT

In this workshop, we will review and discuss opportunities and challenges on the intersection of cross-device computing, mixed reality, and the future of work. The way work and collaboration are organized is fundamentally changing, and in this workshop, we will explore how mixed reality in the context of cross-device computing can address some of the challenges for the newly emerging paradigms for work. The goal of this workshop is to bring together academic researchers and practitioners working on (i) the future of work, and (ii) mixed-reality ecologies to explore new conceptual, technical, and design visions for novel work in this space. Through this workshop, we aim to produce a synthesis article outlining how mixed reality ecologies can mediate and support new modes of future work.

CCS CONCEPTS

• **Human-centered computing** → **HCI theory, concepts and models.**

KEYWORDS

Mixed Reality, Augmented Reality, Cross-Device Computing, Future of Work

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1 INTRODUCTION

The way people are working and collaborating is fundamentally changing [9, 10, 12]. This shift of moving to a distributed, online, and often nomadic work model across spaces, time zones, and roles has been dramatically accelerated by the world-wide epidemic. This technological and societal disruption has created a wide range of problems and challenges around how to organise and orchestrate information, communication, and collaboration across such diverse and changing practices [12]. From online meetings, full conferences, collaboration with code or complex 3D models, to brainstorm or design activities: all have moved to a distributed hybrid context with both offline and online participants.

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This shift in work practices implies an increasing reliance on technology and devices to mediate and orchestrate such complex cross-cutting practices, information space, and collaboration methods. To support complex user multiplicity, hybrid working scenarios, and multi-device information flows, the field of 'Cross-Device Computing' [1, 3] has proposed new taxonomies, principles, and technical infrastructure. However, most of this work is heavily based on 'screen-based' interfaces, with limited support for new forms of immersive interfaces and devices. It is currently not clear how mixed-reality interfaces [2, 7, 11] (in the form of both wearable and handheld VR/AR) can be included and supported by such cross-device systems and infrastructures that are aimed at providing seamless, distributed and collaborative interactive systems.

2 OBJECTIVES

The goal of this workshop is to bring together researchers and practitioners from industry and academia working on the topics of (i) future of work and remote work practices, (ii) cross-device computing, and (iii) collaborative mixed reality, to flesh out a new vision for how such immersive technologies can be leveraged to mediate and support newly emerging modes of work. Through this workshop we aim to establish a consortium of people interested in this intersection between work practices and cross-device computing, outline steps for future work and collaborations, and co-author a synthesis article with open challenges and opportunities in this domain.

The workshop is organised around four main themes:

- (1) **Modes of work and collaboration** – Documenting open challenges and opportunities in shifting modes of work and collaboration.
- (2) **Role of Mixed-Reality** – Build a better understanding of how mixed-reality technologies can facilitate complex hybrid work practices and collaboration scenarios.
- (3) **Integrate immersive experiences in Cross-Device Computing** – Discuss the role of immersive mixed reality technology in the wider cross-device spectrum.
- (4) **New Concepts and Vocabulary** – Outline new conceptual models, vocabulary, and infrastructural requirements for supporting cross-devices immersive scenarios.

3 PARTICIPATION

Our goals is to bring together 20-30 participants from academia and industry that are interested in the role of immersive or cross-device technology for work practices, or who are interested in operationalising new technological possibilities to new modes of work. We will launch an open call for participation but will also personally invite key researchers who are currently active in these domains.

The aim is to gather a group of interdisciplinary researchers with diverse experience about the social, technical, and organizational aspects of the future of work. We have opted to not work with short workshop papers, but will ask potential participants to submit a 1-page motivation or position statement outlining their reasons and motivations to participate in this workshop.

4 WORKSHOP FORMAT AND ACTIVITIES

4.1 Workshop format: Fully Virtual

We will organise this workshop in a fully virtual format (i.e., all participants will join through an online video call). This will make it easier for participants to join the workshop given the varying degrees of lock-downs and restrictions during the Covid-19 pandemic. We will use digital tools to coordinate workshop activities: (i) the workshop website for resources, agenda, position papers, etc., (ii) Zoom for the video conference and break-out rooms, and (iii) Miro digital whiteboard to prepare workshop material before the workshop and collect inputs during the workshop.

4.2 Before the Workshop

We will setup a website and distribute a call for position or motivation statements in all relevant communities. In addition to being listed on the ISS 2021 website, we will announce the Call for Participation at popular mailing lists and calendars (e.g., ACM, CHI-announcements, Interaction-Design.org, WikiCFP) and social media (e.g., Twitter, Facebook). The calls will be posted on the workshop website, along with other details about the workshop. Furthermore, we will directly contact researchers and practitioners who are likely to be interested in the workshop and write to relevant institutions, projects or activities. We will continue our efforts of promoting the workshop and getting in touch with potential participants during the period leading up to the workshop deadline.

4.3 During the Workshop

We propose a one-day 5 hour workshop, with short breaks every hour, that combines various collaborative activities aimed at creating a starting point to outline a clear research agenda.

4.3.1 Step 1: Preparation for Workshop. – Before the workshop, all participants will submit a short form with 4 key challenges and 4 key enabling technical infrastructures or ideas. We will collate these before the workshop and use them as a starting point in our discussions. We will use the digital platform *Miro* to prepare material for the workshop, and facilitate participation during the workshop. All participants will also send a 1-minute short video clip introducing themselves and their interests in the workshop. These introductions will be compiled into a single video for participants to watch before the workshop starts.

4.3.2 Step 2: Keynote. – We will invite a keynote speaker on the topic of mixed reality multi-device computing or key challenges in the future of work to inspire discussions during the workshop.

4.3.3 Step 3: Kick-off Session. – We will then start discussions, collecting problems and challenges. This will be partially based on the pre-workshop submissions from all participants, and the inspiration from the keynote talk. Through facilitated conversations and

break-out groups, we will unpack the challenges and opportunities of mixed reality and cross-device computing when addressing the changing practices of work.

4.3.4 Step 4: Mapping out Design Space. – An important part of the workshop will be the in-depth unpacking of the design space, mapping out important dimensions, components, challenges, and opportunities when considering mixed reality – and cross-device computing in particular – for the changing and evolving work practices. We will use the Miro digital whiteboard to map out, revise, and iterate over these dimensions.

4.3.5 Step 5: Planning Next Steps, Collaborations, and Wrap-up. – We synthesise key outcomes of the workshop, and plan out the next steps for the synthesis paper. For everyone interested in the joint paper, we will split part of the paper into actionable work packages. Furthermore, we will outline other opportunities to collaborate: other papers coming out of the workshop, joint grants, and further workshops. We will conclude with a general discussion, reflection, and wrap-up.

4.4 After the Workshop

Materials produced during the workshop will be posted on the workshop web site (<https://future-ecologies.com/>). We will continue to maintain the site to serve both the participants and the broader community developing around this topic.

5 PUBLICATION VENUE AND OUTCOMES

Our final goal is to produce a full paper at ACM CHI, TOCHI, or similar, where we outline an overview of the challenges and opportunities for novel cross-device technology for the future of work. This workshop is a first step towards this goal and will bring together relevant academic researchers and industry experts. During the workshop, we will share these overarching goals and invite participants to contribute to this paper.

6 ORGANISERS

The organisers have extensive previous experience in organising workshops within the space of cross-device computing, as they were the main organisers of the 'Cross-Surface' and 'HCI.Tools' workshops series that ran from 2015-2017 and were collocated with ACM CHI and ITS/ISS [4–6, 8] that lead to a position paper in ACM Interactions [3] and was the basis for a full ACM CHI paper on the principles, taxonomy and technical realization of cross-device computing [1].

Steven Houben is Assistant Professor in Physical Computing at Eindhoven University of Technology (TU/e). His work is on Tangible and Physical Computing that blends and integrates data, interactions, and interfaces into real-world applications on digital health, education, industry 4.0, and knowledge work. He has co-organised 6 workshops at CHI, ISS and CSCW covering a breadth of topics on technical and social aspects of collaborative or cross-device computing work.

Nicolai Marquardt is Associate Professor in Physical Computing at the University College London. At the UCL Interaction Centre he works on projects in the research areas of cross-device

computing, prototyping toolkits, and physical user interfaces. Nicolai received the ACM ISS 10-year Impact Award for his work on Proxemic Interactions. He previously organised over 10 workshops at ACM CHI, ISS, and other conferences, and is co-author of two textbooks — *Sketching User Experiences Workbook* (Morgan Kaufmann 2011) and *Proxemic Interactions: From Theory to Practice* (Morgan & Claypool 2015).

6.1 Contact Details

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7 RELEVANCE TO ISS

This workshop addresses societal and technological issues around how interactive surfaces and space unlock new modes of work. Based on prior experiences of organising the Cross-Surface workshops [5, 6] twice at ISS, we believe ACM ISS'21 to be the most relevant venue for discussions around cross-device ecologies, mixed reality and the future of work.

REFERENCES

- [1] Frederik Brudy, Christian Holz, Roman Rädle, Chi-Jui Wu, Steven Houben, Clemens Nylandsted Klokmose, and Nicolai Marquardt. 2019. Cross-device taxonomy: Survey, opportunities and challenges of interactions spanning across multiple devices. In *Proceedings of the 2019 chi conference on human factors in computing systems*. 1–28.
- [2] Barrett Ens, Joel Lanir, Anthony Tang, Scott Bateman, Gun Lee, Thammathip Piumsomboon, and Mark Billinghurst. 2019. Revisiting collaboration through mixed reality: The evolution of groupware. *International Journal of Human-Computer Studies* 131 (2019), 81–98.
- [3] Steven Houben, Nicolai Marquardt, Jo Vermeulen, Clemens Klokmose, Johannes Schöning, Harald Reiterer, and Christian Holz. 2017. Opportunities and challenges for cross-device interactions in the wild. *interactions* 24, 5 (2017), 58–63.
- [4] Steven Houben, Nicolai Marquardt, Jo Vermeulen, Johannes Schöning, Clemens Klokmose, Harald Reiterer, Henrik Korsgaard, and Mario Schreiner. 2016. Cross-Surface: Challenges and Opportunities for 'bring your own device' in the wild. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*. 3366–3372.
- [5] Steven Houben, Jo Vermeulen, Clemens Klokmose, Nicolai Marquardt, Johannes Schöning, and Harald Reiterer. 2015. Cross-surface: Workshop on interacting with multi-device ecologies in the wild. In *Proceedings of the 2015 International Conference on Interactive Tabletops & Surfaces*. 485–489.
- [6] Steven Houben, Jo Vermeulen, Clemens Klokmose, Johannes Schöning, Nicolai Marquardt, and Harald Reiterer. 2016. Cross-surface: Challenges and opportunities of spatial and proxemic interaction. In *Proceedings of the 2016 ACM International Conference on Interactive Surfaces and Spaces*. 509–512.
- [7] Kangsoo Kim, Mark Billinghurst, Gerd Bruder, Henry Been-Lirn Duh, and Gregory F Welch. 2018. Revisiting trends in augmented reality research: A review of the 2nd decade of ISMAR (2008–2017). *IEEE transactions on visualization and computer graphics* 24, 11 (2018), 2947–2962.
- [8] Nicolai Marquardt, Steven Houben, Michel Beaudouin-Lafon, and Andrew D Wilson. 2017. HCITools: Strategies and Best Practices for Designing, Evaluating and Sharing Technical HCI Toolkits. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*. 624–627.
- [9] Christina Moore. 2016. The future of work: What Google shows us about the present and future of online collaboration. *TechTrends* 60, 3 (2016), 233–244.
- [10] Caleece Nash, Mohammad Hossein Jarrahi, Will Sutherland, and Gabriela Phillips. 2018. Digital nomads beyond the buzzword: Defining digital nomadic work and use of digital technologies. In *International Conference on Information*. Springer, 207–217.
- [11] Maximilian Speicher, Brian D. Hall, and Michael Nebeling. 2019. *What is Mixed Reality?* Association for Computing Machinery, New York, NY, USA, 1–15. <https://doi.org/10.1145/3290605.3300767>
- [12] Jaime Teevan and SJ Brent Hecht. 2020. The New Future of Work: Research from Microsoft into the Pandemic's Impact on Work Practices. (2020).