Designing Tools for Collaboration: A Critical and Intentional Approach

Collaboration with people, in space and over time, forms the basis for some of the most meaningful and memorable interactions in work and life. Technology has helped us collaborate across distances and at scales that go far beyond what was possible only a few decades ago, yet there are persistent challenges that make the experience of technology-mediated interaction feel inferior when compared to working with people in real life. **As a designer and human-computer interaction (HCI) researcher**, I draw from a multi-disciplinary understanding of what makes our interactions meaningful and how technology shapes these interactions to design new tools and ecosystems for collaboration. To achieve this, I primarily work with the technologies of **Spatial Computing** and **Generative AI**—both of which have demonstrated immense potential to change the way we work and live for better and for worse. With the latter seeming more *probable* to many by the day, **we have a responsibility to take a more critical and intentional stance when designing with these technologies, and *"commit to a possible, by means of resisting the probable"*** [1]. Through my work, I turn insights from the diverse fields of Science & Technology Studies, Social and Cognitive Sciences, Computer-Supported Cooperative Work, and Philosophy into action by designing tools for use in the immediate future, that serve as concrete representations of the *possible*. In my academic and industry research experience, I have used this approach to design new systems for collaboration across space, and over time.

Supporting Collaboration Across Space

The Problem: Each day, hundreds of millions of people interact with family, friends, and colleagues while separated by vast distances. Audio and video communication on mobile devices and laptops is widely available, and goes a long way towards supporting remote collaboration, but the richness of the resulting experience is far from the spatial and embodied nature of sharing spaces in real life together.

The *Probable*: The people who can afford Augmented and Virtual Reality (AR/VR) headsets and work in contexts that allow for their use will use them to interact with high-resolution avatars of their collaborators. The vast majority of people who cannot afford or use such devices will be excluded and left to make do with video, audio, and text.

The *Possible*: By focusing on widely available devices like mobile phones and tablets, and maximizing their potential for spatial computing, we can create systems that enable people to share and interact with three-dimensional representations of each other's real selves and spaces. Such systems could be integrated with mobile video calls, as well as headset-based communication, enabling transitions across these modalities based on the devices a person might have access to, and the needs of interaction in the moment.

My dissertation work has been an exercise in insisting on this possibility and helping realize it through design. The first step towards this was the DualStream project [2], where I explored the powerful design possibilities of modern mobile devices. Many recent smartphones and tablet computers have front-facing and rear-facing cameras, with the ability to capture 3D information about oneself and one's surroundings. By leveraging mobile devices' abilities to track their own position in space, and display 3D content as if it were present in one's real space in AR, I created a mobile spatial communication system—DualStream—that enables people to (1) share and interact with representations of each other that look and move the way we do in real life, and (2) share and blend each others' spatial environments to create a shared context for collaboration.

Headset-based systems often showcase their utility through scenarios of remote assistance in the field, and personal connection despite distance. While compelling, these scenarios draw upon and contribute to specific kinds of sociotechnical imaginaries of spatial computing, that upon close analysis, reveal a future that is only in reach for a select and privileged few [3]. Headsets also restrict the freedom of technological coupling, and place barriers to an intersubjective understanding of collaborative work, both of which are essential elements that help people construct meaning during embodied interaction [4]. In contrast, systems like DualStream can help bring spatial and embodied interaction to many of the contexts where we already use mobile phones. We can achieve truly remote spatial assistance—for example, between a person whose car has broken down, and their friend a few cities away (Figure 1, bottom)—and help people share personally-meaningful spaces and moments.

Over the years, I have evaluated the idea of mobile spatial collaboration across a wide range of contexts. I have conducted successful pilot experiments where I used DualStream to interact with friends and colleagues across different cities and countries. In order to gain a better understanding of the dynamics of mobile spatial communication, I conducted a comprehensive,

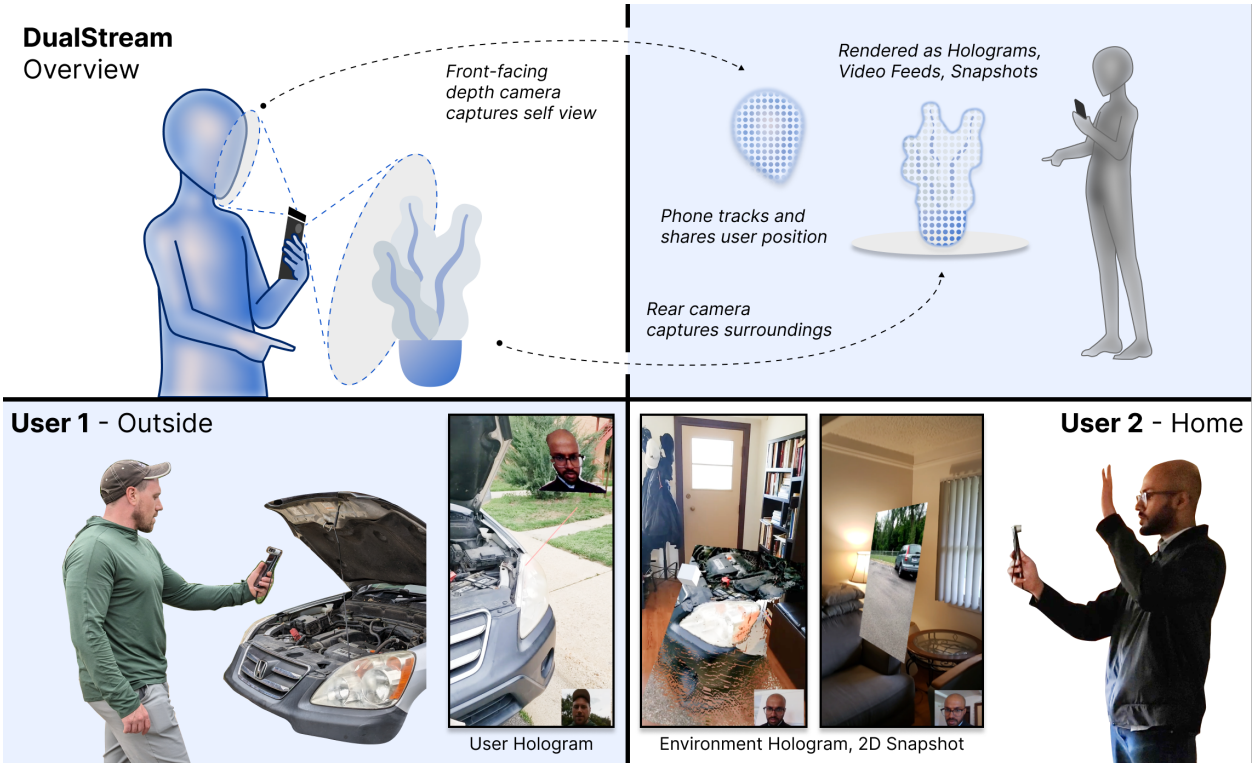

Figure 1: An Overview of the DualStream Project: (Top) By capturing 3D information from both front and rear-facing cameras, we can create representations of oneself and one's environment for spatial interaction via Mobile AR. (Bottom) Images from a real-world deployment of DualStream in the context of remote assistance. Both users can see each other as moving 3D holograms, and the remote user can view and point to a real-time 3D scan of the car engine.

lab-based study where pairs of participants completed a spatial collaboration task using mobile video and mobile AR [5]. I led a mixed-methods analysis to understand how people make sense of space and interact with remote collaborators across each medium. While video calls help participants "be on the same page" more directly at times, we show how AR calls enable both onsite and remote collaborators to engage with the space and each other in embodied ways that closely resemble in-person interaction. This study is among the first in-depth analyses of mobile spatial collaboration, and helps lay the groundwork for future design that combines the modalities of mobile video and AR to create new tools that help people make the most of the spatial capabilities of everyday devices.

This work was funded by Ericsson Research, and I was able to further expand upon these ideas with a focus on real-world implementation during an internship with the Digital Spatial Representations team. At Ericsson, I developed technical prototypes of network-adaptive spatial collaboration, where one's representation in the shared space seamlessly moves between different levels of fidelity to ensure an optimal communication experience despite changes in network bandwidth and quality. This work was aligned with an internal project about holographic communication to which I contributed intellectual property in the form of key frameworks and prototypes. Taken together, this thread of research shows how we can use intentional design to question the dominant imaginaries of spatial computing, and demonstrate the concrete possibility of widely available spatial collaboration using everyday devices.

Supporting Collaboration Over Time

The Problem: The modern workplace is one characterized by fragmentation. Navigating the timeline of everyday work usually involves frequent switching between project threads and moving in and out of meetings. At their best, meetings are key sites of collaboration and organizational memory, however, as their volume continues to increase, they are being increasingly scrutinized and seen as ineffective.

The *Probable*: Large Language Models (LLMs) can already create effective summaries of meetings, helping people keep track

of progress in case they miss meetings. Taking this further, people have begun to send AI note-takers or even 3D avatars to attend meetings in their stead and give them a personalized summary at a later time. As a result, these tools minimize real human interaction in the name of efficiency, and might further contribute to unsustainable working conditions.

The *Possible*: Instead of replacing human interaction, we can use Generative AI to design tools that better support the intricacies of real work. By enabling people and teams to actively make sense of the digital traces of their interactions over time—meeting recordings, messages, shared documents—we can design tools to scaffold the extensive temporal work that people undertake each day.

Working with the Intentional Meetings group at Microsoft Research Cambridge, I led a project exploring the potential for mutual benefit that exists between the concepts of temporal work and Generative AI [6]. While the design of many new AI-powered tools has been driven by the emergent capabilities of each new model, we took a different approach, one that is more grounded in a long history of prior research in the allied fields of organizational science, routine dynamics, and cognitive science. We focused on the importance of temporal work, a concept that *"... involves negotiating and resolving tensions among different understandings of what has happened in the past, what is at stake in the present, and what might emerge in the future"* [7]. We conducted an exploratory qualitative analysis of a series of real-world team meetings, and discovered that team members engage in extensive amounts of temporal discussions spanning different timescales, with connected acts of looking back and ahead. Building upon prior attempts at visualizing temporal work in psychology and organizational science, we devised a new framework that takes the concepts of "objective" time (as determined by clock and calendar) and "subjective time" (the mental operations of looking back and ahead) and turns them into two-dimensional fields that reveal areas for further design.

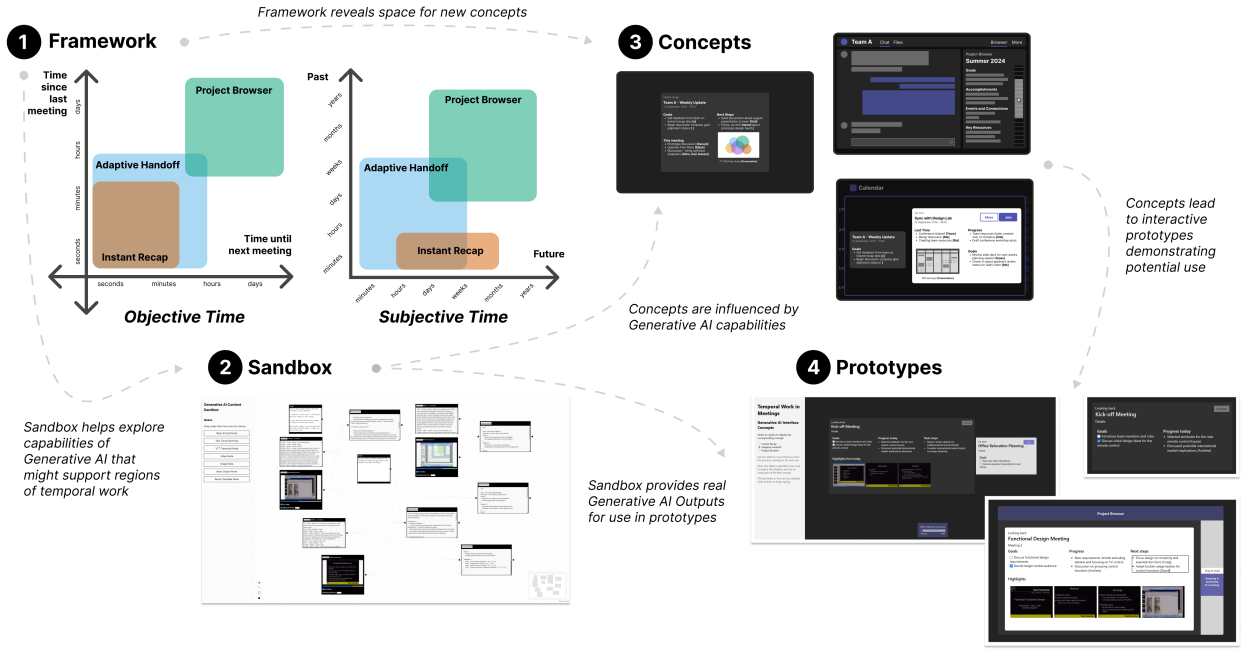

Figure 2: A Process for Designing Interfaces that Support Temporal Work with Generative AI: (1) The spaces of Objective and Subjective time help reveal possibilities for design, (2) the Content Sandbox helps build a stronger understanding of Generative AI capabilities, (3) together, these help conceptualize new design ideas, (4) which are then developed into interactive prototypes.

This framework helped us begin conceptualizing ideas for designing interfaces that might support temporal work at different points in the project lifecycle. To ensure that these designs were informed by a strong understanding of current capabilities of Generative AI, I designed and developed the "Generative AI Content Sandbox", a prototyping tool that offers a node-based environment to experiment with prompting strategies involving various combinations of textual information (meeting transcripts, chat information) and visual information (meeting recordings, slides). Equipped with the Framework and the Sandbox, I designed three unique interactive prototypes that support temporal work at very different points of the meeting and project lifecycle—Instant Recaps, Adaptive Handoff interfaces, and Project Browsers. We used these interactive prototypes

to present our ideas to various stakeholders in the product team behind Microsoft Teams, and the overall process we followed helped us demonstrate real utility together with technical promise.

This thread of work brings together multiple approaches to present a process for thoughtful design when working with Generative AI. In parallel to my main project on temporal work across meetings, I worked closely with the team to explore how Generative AI interfaces can meaningfully support people in preparing for meetings [8], and how in-meeting interactions can be better guided by team goals [9]. These research projects provide a valuable blueprint for future work that begins with and centers a deep understanding of real-world practices, and crafts tools to explore the promise of emerging technologies in a more intentional manner.

Looking back, looking forward

In his 1973 book "Tools for Conviviality" [10], the philosopher Ivan Illich warned against the creation of *Radical Monopolies*, where *"a major tool rules out natural competence ... imposes compulsory consumption and thereby restricts personal autonomy"*, and where *"independent action has been paralyzed for so long that the ability for it seems to have atrophied, and when simple alternatives seem beyond the reach of imagination"*. When considering the most worrying implementations of Spatial Computing and Generative AI today, we may well be facing the beginnings of a radical monopoly on human interaction and thought. The good news is that we are still at the beginning, and have the time to positively shape the course of these technologies away from such a monopoly. To achieve this, my work focuses on the intentional design of tools and the intentions behind their use, as a way to insist on *possible* ways of meaningful collaboration, borrowing language from the philosopher of science Isabelle Stengers [1]. Moving forward, I plan to continue these efforts along two key directions:

Expanding the ecosystems for spatial and temporal collaboration: As Spatial Computing and Generative AI technologies become increasingly prevalent in the coming years, significant research and design efforts will be needed to solve pressing challenges around remote and hybrid collaboration, and to identify appropriate forms of AI inclusion into everyday work practices. In my future work, I will continue to expand on the thread of Mobile Spatial Collaboration by deploying and studying how such systems can enhance the functioning of real-world teams. I will also conduct research into building connected ecosystems for spatial collaboration, where teams can engage in effective cross-reality communication using a mosaic of devices that span the continuum between traditional computers and immersive headsets. My ongoing work with the SpaceConnector project [11] is a first step towards this aim, and focuses on helping teams transition across the collaborative seams of time, place, and content. To secure funding for this research, I will look to agencies like NIST and NSF that have historically supported work in this area through programs on the Future of Work, Cyberphysical Systems, and AI Standards and Innovation. I will also seek out industry-academic collaborations with partners in the tech industry including Ericsson and Microsoft. By further exploring the potential of everyday devices for spatial computing, building robust, cross-device systems for group work, and considering the thoughtful inclusion of Generative AI capabilities into such systems, I will continue to use design to demonstrate possible futures where meaningful forms of collaboration can flourish.

Building a community for critical and intentional design: In his call for a *"Critical Technical Practice"* [12], the computer scientist and humanities professor Phil Agre described, as a condition for its success, a need to have *"a split tendency—one foot planted in the craft work of design and the other foot planted in the reflexive work of critique"*. I have attempted to bridge this divide in my work, and am very motivated to build a community that embodies the split tendency—with designers and technologists who seek to take a critical approach to the ideas they put out in the world, along with sociologists and critical theorists who seek to take their insights and turn them into action through design. I am uniquely placed to support both these kinds of researchers—my own journey is an example of the former, and I have extensive experience in teaching design and development to people from a wide range of non-technical backgrounds. While collaboration, Spatial Computing, and Generative AI are the main themes of my research, I have also worked on projects across diverse areas and technologies, focusing on data visualization literacy [13], accessibility [14], tangible interfaces for learning [15], and tools for musical collaboration [16]. There will likely be many more emerging technologies and new domains that can benefit from critical and intentional design efforts, and I am excited to help grow a community that is prepared to realize these possibilities.

References

[1] Isabelle Stengers. "The Insistence of Possibles." In: *PARSE Journal* (2017). Ed. by Anders Hultqvist, Dave Beech, and Valérie Pihet. DOI: 10.70733/w8eviuefu210.

[2] **Rishi Vanukuru**, Suibi Che-Chuan Weng, Krithik Ranjan, Torin Hopkins, Amy Banic, Mark D. Gross, and Ellen Yi-Luen Do. "DualStream: Spatially Sharing Selves and Surroundings using Mobile Devices and Augmented Reality." In: *2023 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*. ISSN: 2473-0726. Oct. 2023, pp. 138–147. DOI: 10.1109/ISMAR59233.2023.00028.

[3] Tyler Blackman and Daniel Harley. "Interpreting Apple's visions: Examining the spatiality of the Apple Vision Pro." en. In: *Platforms & Society* 1 (Nov. 2024). Publisher: SAGE Publications. DOI: 10.1177/29768624241283913.

[4] Paul Dourish. *Where the Action is: The Foundations of Embodied Interaction*. MIT press, 2001.

[5] **Rishi Vanukuru**, Krithik Ranjan, Ada Zhao, David Lindero, Gunilla Berndtsson, Gregoire Phillips, Amy Banic, Mark D. Gross, and Ellen Yi-Luen Do. *Studying Mobile Spatial Collaboration across Video Calls and Augmented Reality*. 2025, Under Review.

[6] **Rishi Vanukuru**, Payod Panda, Xinyue Chen, Ava Elizabeth Scott, Lev Tankelevitch, and Sean Rintel. "Designing Interfaces that Support Temporal Work Across Meetings with Generative AI." In: *Proceedings of the 2025 ACM Designing Interactive Systems Conference*. DIS '25. Association for Computing Machinery, 2025, pp. 3600–3620. DOI: 10.1145/3715336.3735833.

[7] Sarah Kaplan and Wanda J. Orlikowski. "Temporal Work in Strategy Making." In: *Organization Science* 24.4 (2013), pp. 965–995.

[8] Ava Elizabeth Scott, Lev Tankelevitch, Payod Panda, **Rishi Vanukuru**, Xinyue Chen, and Sean Rintel. "What Does Success Look Like? Catalyzing Meeting Intentionality with AI-Assisted Prospective Reflection." In: *Proceedings of the 4th Annual Symposium on Human-Computer Interaction for Work*. CHIWORK '25. New York, NY, USA: Association for Computing Machinery, 2025. DOI: 10.1145/3729176.3729204.

[9] Xinyue Chen, Lev Tankelevitch, **Rishi Vanukuru**, Ava Elizabeth Scott, Payod Panda, and Sean Rintel. "Are We On Track? AI-Assisted Active and Passive Goal Reflection During Meetings." In: *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems*. CHI '25. New York, NY, USA: Association for Computing Machinery, 2025. DOI: 10.1145/3706598.3714052.

[10] Ivan Illich. *Tools for Conviviality*. Harper & Row, New York, 1973.

[11] **Rishi Vanukuru**, Jens Emil Grønbæk, and Ellen Yi-Luen Do. *SpaceConnector: Cross-Reality Transitions for Mobile Hybrid Collaboration*. 2025, In Preparation.

[12] Philip E Agre. "Toward a critical technical practice: Lessons learned in trying to reform AI." In: *Social Science, Technical Systems, and Cooperative Work*. Psychology Press, 2014, pp. 131–157.

[13] S. Sandra Bae, **Rishi Vanukuru**, Ruhan Yang, Peter Gyory, Ran Zhou, Ellen Yi-Luen Do, and Danielle Albers Szafir. "Cultivating Visualization Literacy for Children Through Curiosity and Play." In: *IEEE Transactions on Visualization and Computer Graphics* 29.1 (2023), pp. 257–267. DOI: 10.1109/TVCG.2022.3209442.

[14] **Rishi Vanukuru**. "Accessible Spatial Audio Interfaces: A Pilot Study into Screen Readers with Concurrent Speech." In: *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems*. CHI EA '20. Honolulu, HI, USA: Association for Computing Machinery, 2020, pp. 1–6. DOI: 10.1145/3334480.3381440.

[15] Krithik Ranjan, Anika Mahajan, **Rishi Vanukuru**, and Ellen Yi-Luen Do. "The Design Space of Tangible Interfaces for Computational Tinkerability." In: *Constructionism Conference Proceedings*. Vol. 8. 2025, pp. 325–340.

[16] Torin Hopkins, Suibi Che Chuan Weng, **Rishi Vanukuru**, Emma A Wenzel, Amy Banic, Mark D Gross, and Ellen Yi-Luen Do. "AR Drum Circle: Real-Time Collaborative Drumming in AR." In: *Frontiers in Virtual Reality* 3 (2022), p. 847284.