On Tangible Sonic Temporal Space:
Designing New Musical Expression and Performing in a Mixed-Reality Space

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Abstract

Laboratory investigations into mixed reality (MR) technology predominantly concentrate on time-critical and location-specific image augmentation. In contrast, creative practices perceive the MR environment as a fostering space that expands our temporal and spatial experiences. Embedding digital elements into physical objects prompts tactile engagement and provokes us to reflect on the world we inhabit. In sound and music computing, MR presents a novel performance space for the design of new musical expressions. Musicians and their instruments can be networked, co-creating alongside acoustic instruments and mutually influencing one another. The "musicking" emerges as a product of the ecological resonance between musicians, their tools, and the surrounding environment.

In this talk, I aim to broaden our understanding of MR in creative applications. Specifically, I emphasise how mixed reality, as a meditative platform, can stimulate considerations of mindful musical interaction. Situated within an interdisciplinary field, I encourage a holistic perspective on human-technology relationships and an ecological approach to creating MR tools and works. In retrospect on existing MR musical expressions, I will present three projects that encompassing experiences as a performer and creator in collaboration with others. I conclude with insights into how this knowledge can contribute to the fields of sound and VR/AR art.

Introduction

The access into augmented space is a technology advancement that provides digital overlays to assist human tasks in physical space [13]. Mediated by computing devices, additional information is presented in the forms of visuals, sound or a hybrid mixed reality experience, serving as a point of reference and guidance. These benefits our daily activities including productivity [9], entertainment [11] and healthcare [14]. Whereas art or interdisciplinary researchers perceive mixed reality as a multi-dimensional platform that enriches our experiences within the physical world we inhabit [3]. By engaging our bodies in a trajectory experience through time and space, one can immerse themselves in personalised, cultural or social narratives.

In the field of sound and music computing, the utilisation of mixed reality (MR) technology adopts a transformative approach, drawing upon a joint socio-technological perspective in time and space.

Computer music performance is by essence a mixed reality experience. In this creative process, musicians deeply engage with their digital musical instruments and respond to other musicians in the surrounding sonic space [4]. This real-time collaborative musical situation is complex, encompassing a tension between their roles, actions and musical tools they use [1]. One crucial part of this creative endeavour is the relationship between musicians and their instruments, where musicians are primarily responsible for their sound and making contributions to the shared sonic task [1]. The expressiveness of a digital musical instrument significantly influences how musicians produce and communicate their musical ideas in practice [6]. This includes how a musical gesture can be spatially performed [7] and how a musical system processes input actions to provide a timely sonic response [15]. The digital instrument also acts as an epistemic tool, revealing the philosophical thought behind the creation of music [10].

Previous research has specifically explored the novelty of mixed reality musical instruments to assist musicians in their sonic expression. Virtual reality musical instruments provide musicians fully virtual experiences where musical gestures are performed in free space [12]. In contrast, augmented reality musical instruments consider the integration of the sound-making into the real world [16].

In addition to the materialistic view, MR can act as a "digital agent", mediating the interaction between musicians. A noteworthy example is the actuated mixed reality musical interface introduced by Arlsan et al. [2]. In an actuated augmented reality space, musicians are invited to improvise using physical instruments while interacting with virtual shapes surrounding them. This multimodal experience, involving the response to the creative output of collaborating musicians and the comprehensions of visual shapes for sound generation, results in a complex cognitive synthesis of perception, interpretation and expression [4]. Inherently, the product of this musical process is an ecological resonance between musicians, their tools, and the surrounding environment [1]. Certainly as Jones remarks, "the creativity is fundamentally a product of an integrated, open system of agencies and influences, exerted not just by our internal drives but by the network of

instruments, methods and stimuli that we adopt" [8]. The exploration of musical tools and practices undoubtedly necessitates continuous practice, reflection and discourse.

In this talk, I aim to expand our potential understanding of mixed reality by examining its creative applications in technology. Specifically, I emphasise how mixed reality, as a meditative platform, can stimulate considerations of mindful musical interaction without the reliance on the physical tactility. Situated within an interdisciplinary field, I encourage an entangled perspective on human-technology relationships and an ecological approach to creating digital tools and works in the *mixed-reality* world.

I will commence by discussing how the design and performance of mixed reality musical expression have been addressed in prior works. Subsequently, I will present my perspective on MR technology and how this concept is executed in my interdisciplinary research projects. In particular, I will outline three of my works, illustrating a progressive artistic exploration within this mixed space. These works encompass experiences as a first-person performer, collaborations with other musicians, and discussions with other musicians in following sections.

With a deep reflection on the evolving roles in musical performances, I will conclude by discussing how these insights can benefit electronic art and computer music practitioners in sound art and VR/AR practices.

iso-metricsen

iso-mentricsen is a mixed reality musical instrument designed for a head-mounted augmented reality environment. It enables users to activate tonal drone synthesis through freehand gestures interacting with individual coloured cubes. The user can play a combination of cubes for chords or focus on a tonal experience with poly-synthesised texture by enlarging the instrument, as shown in Figure 1. The instrument is in a 3D spiral shape with a flexibility of placement in space, allowing the user to be immersed inside the super-sized structure. While playing with the instrument, one can feel the tension of experience in the mapping of a subtle and embodiment sonic interaction and synthesis.

The instrument was created using the autobiographical approach by the author, aiming to explore a genuine musical expression in a mixed reality environment [16]. It reflects thoughtful consideration of recent-enabled freehand interaction, a self-contained synthesis mechanism and the aesthetics of musical expression in a mixed reality headset.

Performing with *iso-metricsen*

In addition to the authors' extensive performing experiences within their artistic practice, twenty musicians were invited to test this instrument in a laboratory study setup and provide constructive feedback regarding their musical experiences.

Of this novel mixed reality musical experience, musicians were particularly impressed with the **spatial** dimension of the musical expression and the **mobility** involved in the process of sound making. They highlighted the overall experience, stating that it brought them *"a new view of how music can work in a different way"* and revealed *"new possibilities and combos within the same zone and the same instrument"*.
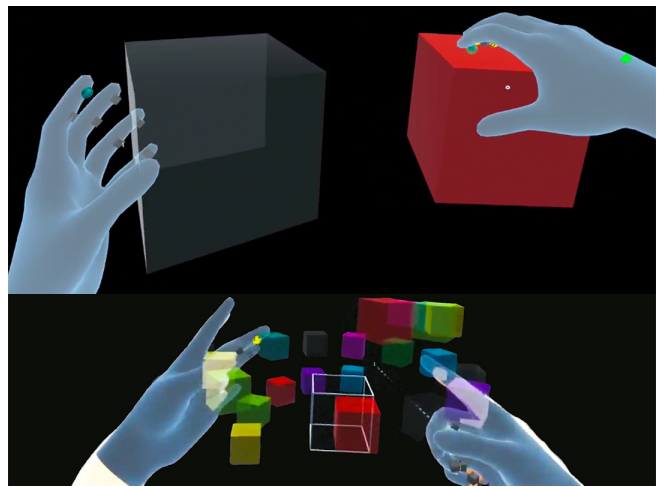

Figure 1: iso-mentricsen in-app view. Play poly synthesis texture of a tonal note (Top). Play through chords (Bottom).©Yichen Wang 2022

Figure 2: Performing using iso-metricsen with Charles Martin at OzCHI2022 ©Jiachen Liu 2022

破境[pò jìng] // beyond realms.

破 [pò] – to break, to burst, to fracture
境 [jìng] – boundary, border

beyond realms. is an ongoing artistic collaboration between Sandy Ma and the author. Drawing upon opposite sides of cultural experiences, the artists explore the literal meaning of mixed reality in Chinese language and actively challenge the sonic dialogue of mixed reality interactions. In this context, mixed reality blurs the boundary between the physical and digital realms. 破境 reflects on the spaces on either side of the boundary, investigating the symbiosis formed through the shared language.

The first work from this project was an improvised performance featuring the *iso-metricsen* and a traditional Volca synthesiser, performed by Sandy and author at Australasian Computer Musical Conference 2023 shown in Figrue 3. Mediated by computer-controlled lighting changes, players on both instruments respond to the colour change to find harmony and foster sonic communication. These instruments represented different eras in interfacing with frequency mod-

ulation (FM) synthesis, with the MR instrument transcending physical boundaries. This performance aimed to explore the consequences of these broken boundaries and discover the commonality between the two realms. Full performance video can be found at https://youtu.be/5QUpw_7yZqU.

Figure 3: 破境 Performance Excerpt. ©Yichen Wang 2023

On Ecological Dynamics in Digital Musical Ensemble

This is an ongoing work that continues the exploration of mixed reality musical performance, with a particular focus on collaboration. Inspired by the lighting communication protocol in *beyond realms.*, this work adopts a scientific approach to examine how mixed reality can enhance musicians' awareness and engagement in musical collaboration.

A MR collaborative system was created that mirrors the collaborating performer's instrument, assisting musicians in understanding the current musical process in a free improvisation setting. From the viewpoint of the performer's MR headset, they can see their collaborators' hands and eye gaze locations on their instrument, as well as musical information about the instrument, while simultaneously playing their own instrument, as shown in Figure 4). An excerpt of this work can be found at https://youtu.be/X6kQouxTiWM. Currently the study uses the same instruments for simplicity to eliminate other external factors.

This MR system aims to prompt social interactions and enhance the visibility among musicians by incorporating three key mechanisms in multi-user collaborative interface: awareness of others, control of action and information availability [18, 17, 5]. Ecologically, the system encapsulates an autonomy that mediates the musical interaction between human musicians. The cognitive process of musicking by humans is amplified and extended by the tool and the embodied dynamics in the surrounding environment [1].

Acknowledgements

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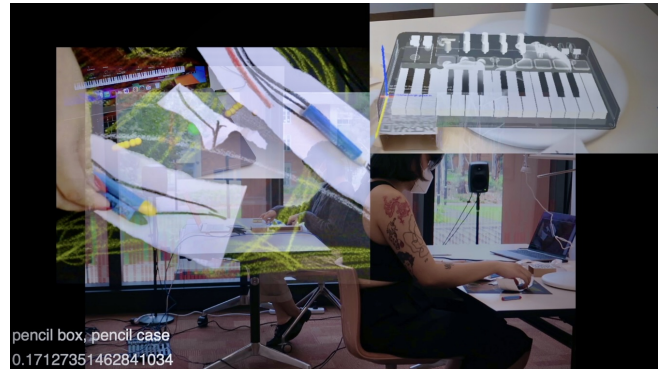
Figure 4: A demonstration of the collaborative MR system in an artistic performance. Both performers have access to their collaborator's hands, eye gaze location and musical information of their instrument. ©Yichen Wang 2024.

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Author Biography

Yichen Wang (she/her/hers) is a Doctoral Researcher in the School of Computing, The Australian National University. Her interdisciplinary research works encompass new interfaces for musical expression, augmented reality and the entangled nature of digital music ensembles in Human-Computer Interaction.

As a computer musician, Yichen has performed with her mixed reality musical instrument at *Electronique* (Canberra), NIME'23, OzCHI'23, ACMC'23. The system has also been demonstrated internationally including in Australia, the United Kingdom, Europe and Mexico.