Mixed Reality Collaboration for Contextualizing Immersive Spaces

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Abstract
Head mounted displays (HMDs) can provide users with an immersive virtual reality (VR) experience, but often are limited to viewing a single environment / data set at a time. In this position paper, we argue that co-located users in the real world can help provide additional context and steer virtual experiences. With the use of a separate canvas, such as a large-scale display wall, non-immersed users can view a multitude of contextual information. This information can be used to drive the VR user's interactions and lead to deeper understanding. We will highlight two digital humanities use cases that capture real locations using a 360° camera: 1) urban art and 2) urban community gardens. In both cases, HMDs allow users to view a space and its surroundings, while non-immersed users can help with tasks such as placing overlays with auxiliary information, navigating between related spaces, and directing the VR user's actions.

Author Keywords
Head mounted display; large-scale display wall; collaboration; mixed reality; digital humanities.

CCS Concepts
•**Human-centered computing** → **Collaborative interaction;** *Computer supported cooperative work;*

Figure 1: Mixed reality collaboration set up. The user wearing a HMD is able view 360° images in VR, while the other two users can view other related 360° images and contextual information on the large-scale display wall.

Introduction

Head mounted displays are designed to provide immersive experiences to users. This immersion has been shown to enhance engagement and understanding in many situations [9, 10]. However, as Gunkel et al. [2, 3] point out in their research, HMDs typically isolate users in a virtual world, which can be detrimental in collaborative situations. While the use of avatars can be helpful when all collaborators are immersed in the same virtual experience, issues persist when only some collaborators are wearing HMDs and other collaborators are not.

Large-scale display walls, on the other hand, have been shown to be excellent tools for collaborative work [1, 11], but can suffer from a lack of immersion. Creating a collaborative environment that combines these two technologies, where some users wear HMDs, and others are interacting with a large-scale display wall, enables the group to benefit from the major affordances of each system [5].

In this position paper, we will highlight how such a mixed reality collaboration environment can be used to effectively enable collaborators to provide additional contextual information to immersed users wearing HMDs. This would allow for more effective conversations between collaborators and reduce isolation for immersed users. For example, a non-immersed collaborator could select relevant data shown on the large-scale display wall and push it to the immersed user, thereby helping walk them through a virtual space. This process can create a feeling of shared experience between co-located participants.

Figure 2: Team capturing urban art using a 360° camera.

Using HMDs with Collaborative Display Walls

Traditional multi-display VR setups simply involve projecting the immersed user's view on a public monitor. This relegates non-immersed users to a passive role where they simply watch the immersed user's experience. Instead of this traditional model, we propose to link applications designed for large-scale display walls with VR applications running in HMDs to create a mixed reality, multi-user collaborative experience.

SAGE2 [4, 7] is a server-client collaboration software that allows multiple users to share and interact with digital content on large-scale display walls. The SAGE2 server supports multiple client types – e.g. display clients to render content, and interaction clients that allow users to upload and modify content from their own personal devices. By creating a SAGE2 client for VR applications built with the Unity game engine, we can allow non-immersed users to push information from the large-scale display to HMDs.

One type of data that is well suited for both VR and large-scale display walls is full surround images captured by 360° cameras. Immersed users can modify their view by simply turning their head as if they were truly in the space, standing where the camera took the image. SAGE2 allows non-immersed collaborators to juxtapose multiple related 360° images along with other contextual data (e.g. images, PDF documents, websites). The non-immersed users can then aid immersed users by sharing content with the HMDs – for example placing overlays with auxiliary information or navigating to a related 360° image. Figure 1 shows a setup with one user immersed in a HMD and two non-immersed collaborators using the SAGE2 software on a large-scale display wall.

Use Cases

Urban Art

As people navigate urban spaces in the real world, they are frequently surrounded by a wide variety of art forms, including unsanctioned graffiti, tags, and stickers as well as commissioned murals, monuments, and memorials. In many cases, these art forms enter into communication with one another in ways that reveal the complexities of urban social dynamics. A mural depicting a significant but unheralded community member, for example, may “speak back" to a nearby sculpture, calling attention to the hierarchies that shape the dominant discourse whereby some individuals are monumentalized while others are ignored. In another example, a simple word or name written in spray paint may be used to express support or dissent when applied near to or opposite from a commissioned mural.

When navigating the visually stimulating urban landscape, we often fail to process the many forms of art that appear in the streets, whether on walls, on sidewalks, or in traffic circles. Additionally, many forms of urban art, particularly graffiti and uncommissioned murals, have a fleeting presence in the city and are ephemeral by their very nature. For these reasons, documenting urban art by way of 360° images is important because it allows us to consider how various forms of art intersect and communicate with each other while also helping to preserve art. Figure 2 shows a 360° camera being set up to capture an urban mural and its surroundings.

Outside of viewing a work of art in person, people are typically exposed via single or paired images in a text book or website. VR offers important opportunities for urban art since, as Riggle argues when looking at art in an urban environment, a work's specific relationship to the street is integral to its meaning [8]. Therefore, an immersive VR en-

Figure 3: Immersive view of a community garden showing the images rendered to the left and right eyes in a HMD.

vironment is highly beneficial because it allows us to capture the space more fully, including the relationship between nearby art forms. However, users are only aware of what is visible from a single vantage point, and have a tendency to notice the larger works of art (sculptures / commissioned murals) while the smaller works (tags / stickers) go unseen. Mediation from non-immersed collaborators can enrich the virtual experience by drawing attention to the various art forms or by pushing additional content such as comparative examples, artist interviews, and other contextual content.

Urban Community Gardens

Urban community gardens are centers of enterprise, creativity and industry in marginalized communities. They carry a social justice mission to supply their community with fresh food and sustainable agriculture. Even when shopping local, most people are not aware of exactly who or where their food comes from. Viewing a 360° image of a community garden in VR, as depicted in Figure 3, shows a user exactly where food is produced along with its relation to the city, and it offers glimpse into the work community members put in to tend to the plants. The benefits of such an immersive experience becomes twofold – it allows consumers to learn about the place where their food is produced, and it also provides an opportunity for non-community members to break potential stereotypes about the societal contributions of a marginalized community.

While already beneficial, we believe that a virtual experience can be enhanced with contextual information – for example locating the garden on a city map, overlaying data about the plants, or listening interviews from those who operate and tend the gardens. As John V. Palvik states, “Experiential media can help engage audiences in empathetic narratives that facilitate an understanding of the truth in controversial and complex stories" [6]. The layering of stories offers a wider lens that can spark conversation and understanding of social justice issues. The mission of urban community gardens is lost to the everyday produce buyer or someone who happens to pass by the garden. Mixed reality collaboration offers the opportunity for immersed users to engage with the community and their food source, while non-immersed users can help direct interactions by queuing up contextual information.

Conclusion

This position paper investigated pairing HMDs with large-scale display walls to enhance collaboration and create shared experiences for co-located users when some are immersed in a virtual experience and others are not. The combined use of technologies would enable the group to leverage major benefits from each. We outlined two use cases that capture real spaces using 360° cameras. Both cases, urban art and community gardens, necessitate multiple layers of information in order to allow users to fully understand the complexities of urban experience. Non-immersed collaborators could view such layers simultaneously on the large-scale display and push relevant content to the immersed users on demand to help guide their virtual experience.

Future work will seek to assess how viewers gain an understanding of the complex contexts of urban spaces. We intend to conduct a user study that involves a qualitative comparison of the viewing experience when these urban spaces are presented as a flat image on a screen, an immersive 360°image in VR, and an immersive 360° image in VR with non-immersed collaborators who guide the experience by pushing content from a large-scale display wall.

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