Immersive Design Reviews through Situated Qualitative Feedback

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As commercial AR and VR headsets become increasingly available to consumers, developing useful applications will be critical in unlocking the unique affordances of immersive headsets, such as an embodied perspective, natural input and large display space. Building these applications requires iterative design, where professional designers and domain experts can make changes based on user feedback. While quantitative measures such as time to completion and accuracy can provide insight into user performance, they do not capture feedback such as preference and recommendations for future iterations, which can be critical in refining the application design. With this position paper, we discuss how embedded qualitative feedback mechanisms can support the iterative design process for immersive applications. By supporting collection of qualitative feedback *in situ*, prototyping tools can capture a better snapshot of user experience than using quantitative metrics alone.

CCS Concepts: • **Human-centered computing → Mixed / augmented reality**; **Virtual reality**; **HCI design and evaluation methods**.

Additional Key Words and Phrases: augmented reality, virtual reality, design reviews

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1 INTRODUCTION

To build for desktop and mobile phone platforms, application designers and developers rely on iterative design processes to continually improve their proposed applications through user feedback. Iterative design refers to the repeating practice of prototyping, testing with users and making adjustments to the prototype based on user feedback. Designers determine next steps for the application based on feedback collected through mechanisms such as usability studies [1] and semi-structured interviews [5], which allow designers to collect feedback from end-users. With continued immersive application development in early stages of AR/VR technologies, the ability to prototype and iterate on proposed applications is particularly important for these nascent technologies.

With commercial virtual and augmented reality headsets becoming more ubiquitous, application design and development is a key to unlocking the potential for immersive displays. Prior work has explored enabling professional designers and domain experts to participate in development process by prototyping AR and VR applications [6, 7]. Evaluating the user experience requires that designers collect qualitative feedback on the effectiveness of prototypes to support quantitative measures such as performance metrics (e.g., time to completion and accuracy) and user behavior (e.g., eye-tracking and head movement). Unfortunately, collecting qualitative feedback requires users to either break their engagement with the immersive experience or wait until the end of the session to attempt to remember the salient points. To avoid this immersion break, prototypes should embed

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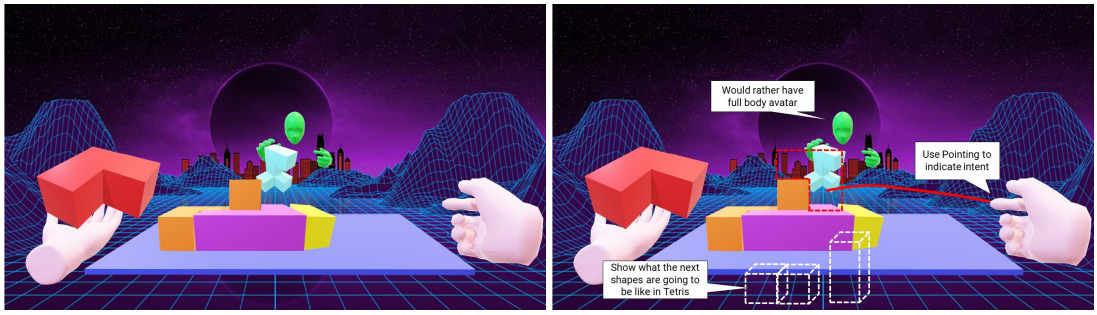

Fig. 1. Before and after providing feedback about a collaborative 3D puzzle game in VR. In this game, two players work to put together a 3D puzzle. Users propose changes through situated annotations and draw their recommendations, including use of gestures to indicate intent (dotted red lines) and seeing the next pieces they will need to place (dotted white lines).[1]

feedback mechanisms directly into the experience, such that users can provide situated feedback while it is relevant and immediately capture the context of the limitations. In this paper, we will discuss this vision for embedding qualitative feedback directly immersive applications to improve iterative design.

To support this vision, we propose two example use cases for immersive design reviews where users provide feedback on the environment: one in a virtual reality environment, and one in an augmented reality environment. We discuss how users would provide embedded qualitative feedback in the form of notes, sketches virtual models and dialogues with developers, and discuss possible extensions of the use case.

2 VISION FOR IMMERSIVE DESIGN REVIEWS

In this section we describe a vision for embedding qualitative feedback into immersive prototypes. We lay out two example use cases that depict different ways situated feedback could positively the impact iterative design of immersive environments: one VR application and one AR application. For both use cases, we explain and illustrate how users would leave feedback and propose changes to the prototyped environment.

2.1 Use Case 1: Immersive VR Application Review

A first use case for immersive design reviews is to critique immersive VR applications. We use a VR game as a platform for immersive design feedback, where users switch between playing the game and annotating the environment with suggestions to the game and to the UI. Here a user would pause the game at key points and add feedback such as updates to animations or awkward gameplay mechanics directly into the game environment. Figure 1 depicts the user recommending use of gestures to indicate intent to their partner and that the next puzzle pieces to appear in front of them be displayed in order to plan ahead. By allowing users to switch between engaging with and reviewing the immersive VR environment, users can provide feedback *in situ*, as it is relevant.

VR applications such as the one depicted in Figure 1 are particularly well-suited to collaborative usage. Recent work has extended this concept to include researchers, where VR researchers conducting a usability study can be virtually co-located with study participants [8]. This presents a way forward for VR user studies that is appealing with current guidelines brought on by COVID-19 and would also enable more diverse participant pools through inclusion of remote participants. Additionally, real-time collaboration would enable back-and-forth discussions while in the VR environment to supplement the situated notes from participant to tester. Continued research in virtually co-located VR should continue to explore how researchers can make sense of prototype feedback.

[1]Background imagery from wallpapercave.com

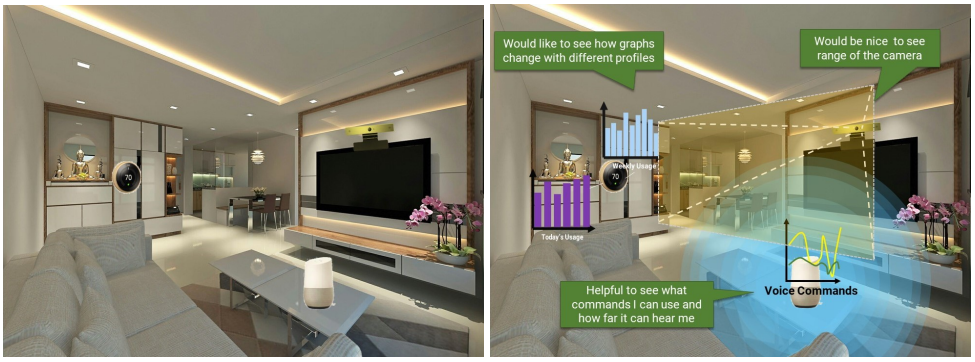

Fig. 2. Before and after proposing AR interfaces for IoT devices. Users can explore and visualize the data collected by IoT devices. Users can also build data visualizations and visualizations of effect ranges, as with the camera and smart speaker.[2]

2.2 Use Case 2: AR IoT Interfaces

With this use case, we propose building upon work using AR to propose static physical arrangements [7, 9] to include smart devices with situated AR interfaces. Though interaction with IoT devices is typically mediated through the devices themselves or through mobile devices, previous work has discussed how AR can provide situated interfaces to IoT devices [3]. Given that both IoT and AR technologies are relatively nascent, designing AR interfaces for IoT devices would likely require multiple iterations of prototyping and feedback. Figure 2 depicts a room with three IoT devices, where users explore and build data visualizations based on the data collected by each IoT device. The UI can also display the effect ranges of the devices, represented by the blue sphere around the smart speaker and the yellow frame extended from the camera. As with the previous use case, users can leave open-ended feedback about the environment through situated annotations.

As commercial AR headsets improve and become more ubiquitous, engaging users in design of AR visualizations and interfaces in smart home environments could increase efficiency in interacting with devices, understanding of IoT device capabilities and trust in the smart home environment. This participatory design foregrounds the importance of embedding feedback mechanisms into AR interface prototypes.

3 CHALLENGES & EXTENSIONS

Integrating qualitative feedback mechanisms within immersive prototypes will enable enhanced iterative design by streamlining users' abilities to provide rich, situated, qualitative feedback. In this section we discuss three key challenges to consider for long-term success of such an integration.

Expressivity vs Rigidity: One design consideration for qualitative feedback interfaces is how much flexibility to give users in proposing changes. The amount of functionality to implement in a feedback tool likely depends on the level of fidelity in the prototype and the user's level of comfort with AR/VR interfaces. Low fidelity prototypes would only require high-level feedback, easily supported by simple pick-and-place and annotation interfaces. With increased prototype fidelity, prototyping tools should support more expressive prototype feedback (e.g., building visualizations and interface components in Figure 2). Tailoring the tools available to users to the type of feedback needed will be an important when embedding qualitative feedback mechanisms into prototypes.

Co-Location: As discussed in §2, iterative design reviews should allow for both physical and virtual co-location when giving feedback about a prototype. Collaborating on a proposed physical environment or AR environment would require capturing the physical environment and rendering it into a remote user's VR headset, which

[2]Background and device imagery from newglobe.com, radiotimes.com, bgemarketplace.com

could cause a loss of fidelity to the target environment. Streaming a first person view of someone navigating the physical environment while allowing a remote user to annotate the view could mitigate this loss of fidelity [4]. Notable limitations of this approach are privacy issues associated with streaming a first person video stream and sacrificing the participant's embodied perspective to navigate the immersive environment.

Annotation Interface Design: The scenarios described primarily focus on leaving text-based notes for researchers to extract asynchronously, rather than live discussions or audio recordings. Users' abilities to provide situated qualitative feedback in AR and VR therefore depends on the effectiveness of the annotation interface to enter text, which is cumbersome when using AR and VR headsets. Research in text entry without a physical keyboard has identified a trade-off between speech-based text input and keyboard adaptations, where employing speech-to-text is faster but less accurate than a virtual keyboard adaptation [2]. Since design review during application use generally occurs as a preface to a larger conversation after the use session has concluded, quickly entering inaccurate notes would be preferable. With HMD-based text entry remaining an open problem in AR/VR research [10], open-ended qualitative feedback will rely on fast, accurate and non-obtrusive text entry.

4 CONCLUSION

Designers rely on both quantitative and qualitative feedback to understand how to iterate on prototype designs. As researchers try to understand the quantitative metrics that properly capture user experience in AR and VR, research should also provide users with the tools to leave qualitative feedback and propose changes directly in the immersive application. This position paper provides a vision for how qualitative feedback and proposal mechanisms can be integrated into iterative design workflows for immersive applications. With this discussion, we hope to contribute to improving AR/VR user experience and the iterative design of immersive applications.

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