Navigating Realities: Assessing Cross-Reality Transitions Through a Spatial Memory Game in VR and AR Environments

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ABSTRACT

This tech demo offers an immersive exploration of the most prominent scene transitions within the Reality-Virtuality Continuum (RVC). It delves into the seamless integration of real and virtual worlds, showcasing a spectrum of environments ranging from entirely real to fully virtual and various transitions to switch between them. Our innovative approach centers around an engaging cross-environmental spatial memory game. This game is not just a playful experience but a carefully crafted task designed to challenge users. As players navigate through different environments via transitions, they encounter different object categories and a dynamic scoring system. Previous studies have explored transitioning between stages like augmented reality (AR) and virtual reality (VR), but our work integrates these technologies into a demanding, interactive task. This integration allows for a nuanced examination of six types of transitions, ranging from diegetic to disruptive. Our demo is not just a showcase; it is a step forward in understanding and optimizing cross-reality applications. It offers a fresh perspective on RVC transitions and paves the way for future research into enhancing user experience in mixed-reality environments. A video of this tech demo can be found here: `https://www.youtube.com/watch?v=o46r4QdUNgg`

Index Terms: Human-centered computing—HCI—Interaction paradigms—Mixed / augmented reality; Human-centered computing—HCI—Interaction paradigms—Virtual reality;

1 INTRODUCTION

The reality-virtuality continuum (RVC) depicts the range from fully real environments to fully virtual ones. This continuum includes stages like the real environment, augmented reality (AR), augmented virtuality (AV), and virtual reality (VR) [3]. Each stage has its advantages and drawbacks. For example, while VR allows for a higher place illusion than a Desktop-PC in the real environment stage, common tasks, like text entry, can be challenging in this stage. Therefore, combining multiple stages could enhance the versatility of a single application, then referred to as Cross-Reality (CR). To switch between these stages, a system could provide various transitions to help the user mentally adapt to the new stage. These transitions can vary from seamlessly integrated to disruptive. The importance of transitions within and between stages of the RVC and how they influence user experience is not a new field of research. Prior evaluations, such as the one by Husung & Langbehn [2], have shown that the transition used can greatly influence user presence and usability in VR. In the realm of CR, research by, e.g., Pointecker et al. [4] demonstrates that transitions in CR can affect aspects like continuity and user experience. Most studies, however, investigate transitions in isolation and when the user is actively paying attention to the transition. Therefore, we developed a system that allows switching between VR and AR environments and vice versa. Further, it contains a cross-environmental spatial memory game to simulate a cognitively demanding task. The task design requires users to frequently transition between both environments using multiple transition designs extracted from related work. With this demo, we showcase different transition designs embedded in a cognitively demanding task when switching between a real and virtual environment.

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2 TRANSITIONS

Our demo currently supports six different transitions that range from diegetic, like an interactive portal, to disruptive, like an instant teleport. The selection is based on the investigation of Husung & Langbehn [2], as they already provide a sound collection of transitions common in related work. The transitions can be seen in Figure 1.

Cut is an instant teleport with no visuals. According to related work, this transition breaks the continuity and receives low preference ratings by users [2]. It is mainly inspired by film-making.

Dissolve linearly blends the other environment over the current environment via changing transparency. This is also a common transition in film-making and tends to achieve a higher continuity than Cut.

Fade is similar to Dissolve, but rather than using transparency, it linearly fades to black, teleports the user to the target environment, and then fades back to normal visual. While this transition is also used in film-making, it tends to be more perceived as a "*slideshow*" rather than providing continuity.

Rift creates the visual of a breaking rift, revealing the target environment. This is inspired by the VR game "NVIDIA VR Funhouse" and is included as it utilizes VR-specific features.

Orb provides an orb hovering over the user's controller, providing a 3D preview of the target environment. To transition, the user must move the orb closer to their face. It is inspired by the games "Budget Cut" and "The Lab". This transition provides a high interactivity compared to the previous ones.

Portal creates a portal in the center of the environment, providing a 3D preview of the target environment. To transition, the user has to simply walk through the portal. This transition also provides high interactivity but requires more movement than Orb. The Portal transition is a common transition in experiences within the RVC.

3 APPARATUS

In this demo, these transitions are used to switch between a reconstructed real room (e.g., an office) as the real environment and a virtual farm as the virtual environment. Both environments are designed to fit into a play space of around $\sim 3m$ x $3m$. The size allows the user to solve the spatial memory task without major movement restrictions, and it provides enough space to support transitions that require physical walking, like the Portal transition. The transitions are triggered via a button press on either controller (HTC VIVE controllers). We use the Varjo-XR 3 to implement the transitions, as it can seamlessly switch between VR and AR. Further, we use Unity 2021.3 to implement the system and use assets from Synty Studios[1] for the virtual environment and the implementation of the memory task.

[1]https://www.syntystudios.com/

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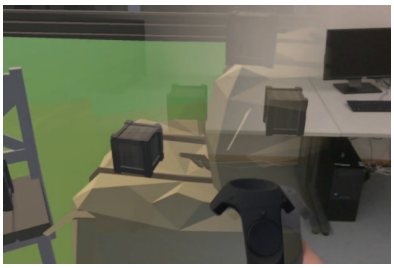
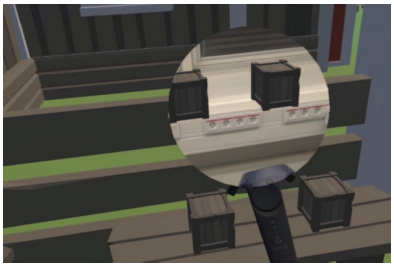
(a) The **Cut** transition, where the user can switch instantly to the other environment without animation.



(b) The **Dissolve** transition, where the user can gradually switch to the other environment through a transparency change.

(c) The **Fade** transition, where the user can switch to the other environment by a short fade to black.

(d) The **Rift** transition, where the user can switch to the other environment by an animated morphing effect around the user.



(e) With the **Orb** transition, the user can switch to the other environment by moving an orb to their head with their controllers.

(f) With the **Portal** transition, the user can create a portal and walk through it to transition to the other environment.

Figure 1: The six selected transitions that are supported in this demonstration.

4 Memory Task

To convey the possible impact of a task on the transitions, we design a demanding task requiring the user to transition between two environments. Drawing inspiration from previous work [5], a memory game is created where players must match identical objects hidden under boxes. Users can open two boxes in one turn, and boxes are spread across a virtual farm (VR) and a physical room (AR), like an office. To create the necessity to transition between both environments, two categories of objects are introduced: If an object is in the *Environment Category*, it fits in its environment's theme. For instance, an office might have a folder, lamp, or cup, and a farm might have apples, beehives, or pumpkins hidden under the boxes. Their matching pair is in the same environment, so no transition is needed. In the *Cross Category*, an object does not belong to either environment and, in the current design, has a pirate theme, like a bomb, skull, or compass. Their matching pair is in the other environment, forcing the user to transition. To ensure users can not simply match all *Environment Category* objects first, they must switch environments if they reveal a *Cross Category* object as the first object in a turn and can not reveal another object in the current environment. The game also introduces a scoring system where users earn points for correct matches and lose points for incorrect ones. This gamification discourages guesswork and promotes memory use. A spatial element is added to make the game more challenging and relevant by placing boxes within the environments rather than a simple grid, encouraging players to form spatial maps in their memory. To reduce the randomness of the user's choice of boxes, the objects hidden under each box are determined when the user first opens it. This approach ensures that every user encounters the objects in the same predetermined sequence, making comparisons between users more robust. This task design aims to showcase different transitions in the context of a demanding task where the user is not actively focusing on the current transition.

5 Application in Research

By integrating a challenging spatial memory game, this system offers a unique platform to investigate transitions between VR and AR in a task-driven context. The application of a predecessor of this system already revealed a significant impact of a challenging task when transitioning between two virtual environments [1]. As the current system also supports transitions from and to real environments, we are currently using this system to investigate the task's impact when transitioning between AR and VR. As the task design is independent of the transition used, it allows for an easy integration of additional transitions for future investigations. In summary, our work presents a promising foundation for future studies to deepen our understanding of incorporating multiple CR environments.

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