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AR-HMD Multitask Viewing System Concept with a Supporting Handheld Viewport for Multiple Spatially-Anchored Workspaces

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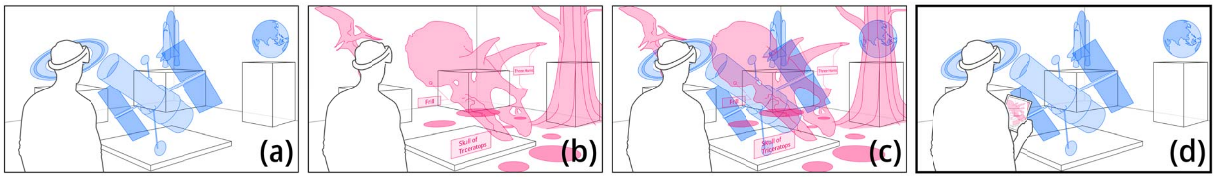

Figure 1: An example scenario where a user wants to design an Augmented Reality exhibition in a science museum: (a) the new exhibition the user is currently working on, (b) the previous exhibition that the user wants to refer to for object scales and visitor heat-map represented on the floor. The user's Head-Mounted Display view will be visually overwhelmed if the two workspaces are simply overlaid (c). **The proposing concept (d)** allows users to separate two different sets of reality-anchored information and inspect them side-by-side.

Abstract

We propose a system concept for Augmented Reality Head-Mounted Display users, which supports multitask viewing with multiple virtual workspaces anchored in the real-world space. Although people encounter multitasking necessities frequently, the native AR HMD and existing interfaces lack measures to visualize multiple sets of spatially-anchored information in parallel. The system separately visualizes two different sets of spatially-anchored information, one on each AR HMD and smartphone, enabling side-by-side multitasking on AR HMD without applying heavy load on users. We implemented a proof-of-concept prototype that allows side-by-side viewing of the two different virtual workspaces. The proposed concept shows promises of multitasking on AR HMD, and future research will develop the system to be fully functional and verified with user studies.

Index Terms: Human-centered computing [Mixed / augmented reality]: ;— [Human-centered computing]: User interface programming—

1 Introduction

This research proposes a supportive use of mobile devices for AR HMD(Augmented Reality Head-Mounted Display) to let users see and utilize multiple sets of spatially-anchored 3D information in parallel. The recent rise of interest in professional usage of AR HMDs highlights the importance of augmented information anchored on real-world space, including architecture and cultural heritage. Although we are closely facing the era of AR HMD as the main workstation, we still don't have a proper multitasking interface on AR HMD. While the split view is proven to have advantages over sequential information retrieving [5], it is hard and inefficient to deploy a split view on AR HMD since it deals with spatially-anchored information in real space. Currently, switching back and forth between applications on AR HMD is the only solution users can take, which is slow and cumbersome.

Despite recent approaches utilizing smartphones as supporting or complementary devices for AR HMDs [3, 4], the existing methods do not enable multitasking on AR HMDs. Zhu and Grossman [7] investigated a broad design space of cross-device interaction between smartphones and AR HMDs but did not focus on multitasking or multi-layer observing centered on AR HMDs. From the need to explore multiple layers of information, the concept of a hand-held AR viewing plane revealing hidden information has a long history [2]. However, the idea has been mainly applied on large-wall or tabletop displays [1, 6], not reaching the AR HMDs with reality-anchored information.

Our contribution proposes the system concept for multitasking on AR HMD and introduces a proof-of-concept implementation. This concept will allow users to view and manipulate multiple sets of virtual information without visual and mental overload. Users can benefit under various situations such as, but not limited to, the following: when there are multiple layers in the reality-anchored information, when there are multiple versions of work to be compared side-by-side, and when a user wants to do different tasks on the same information set.

2 System Concept

The proposing concept intends to aid users of AR HMD who want to multitask among multiple sets of virtual information that are spatially anchored to reality. When multiple virtual workspaces are anchored to the same space in the real world, AR HMD users view one with the HMD and another with the smartphone. By doing so, users can examine the two sets of information side-by-side and utilize them together. Users can select a specific workspace of interest to be shown on either an HMD or mobile device. Each HMD or mobile device estimates its own pose in the real world and retrieves corresponding spatially-anchored information. The mobile device serves as a separate viewport and also an interaction surface. Through the system, users can copy & paste an object, migrate an object, or link two objects from one workspace to another.

AR HMDs are bound to the user's head position, augmenting virtual contents directly on the user's naked-eye view. Meanwhile, spatially-anchored information common in AR has objects connected to a Context of Interest in the real-world space. These attributes of AR HMDs and spatially-anchored information make it hard to visualize multiple sets of information in parallel on AR HMDs since the displayed information cannot be scaled or disoriented from the real space. Considering this, we set design requirements for multitasking on AR HMDs below. In our system concept, the mobile device supports AR HMD so that the user can perform

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the primary task on AR HMD while sub-tasks that require cross-workspace manipulation can be done on the mobile device. We explain the design requirements and how the proposed system achieves them.

- *The system should allow users to* ***explore multiple workspaces simultaneously***: Mobile device adds another visual output channel that users can use, so multiple workspaces are visible without a cluttered view.
- *The system should* ***separate multiple workspaces visually***: Mobile device serves as an independent display, detached from the user's head position and AR HMD. Users can maintain the AR HMD view as it was while freely moving around the hand-held mobile device.
- *The system should* ***enable cross-workspace tasks*** *without burdening users*: Using our system, users can perform cross-workspace tasks on mobile devices, showing another workspace but still having a spatial connection with the main workspace. The mobile device also works as an interaction surface for the user. Users can always switch back to one's main task involving only one workspace by setting aside the mobile device and working on AR HMD alone.
- *The system should be* ***scalable to more than three workspaces***: The system can include multiple AR HMDs and mobile devices. Each device will visualize one workspace, making the system scalable with the number of devices involved. Additional devices also provide tracking and computing resources, making the system scalability more feasible.

3 Proof-of-concept Implementation

For the proof-of-concept implementation for the proposed system concept, we used a Microsoft HoloLens 2 and a Samsung SM-G960N(Android 8.0). For 6 Degree-of-Freedom pose estimation of HoloLens in the space was achieved with Microsoft Mixed Reality Toolkit[1]. To create, place, and share a 3D object in real-world space, we utilized Azure Spatial Anchor[2]. The HoloLens and the Samsung smartphone networked using Photon Unity Networking[3].

Figure 2 shows the result of implementation. Figure 2 (a, d) are the Holographic captures from the HoloLens, and (b, c) are screenshots from the smartphone. The two workspaces share the same coordinate origin so they are aligned in the real-world space, but only the objects that belong to the selected workspace are shown on each device. After the user specifies a target object and the action (Figure 2 (b, c)), the AR HMD retrieves the updated workspace information in real-time and visualizes it (Figure 2 (d)). Currently, only the copy & paste interaction by double tapping on the target is implemented in the system. As the information sets are aligned in the real-world space, the copy & paste action does not require an explicit positioning step.

4 Conclusion and Future work

In this work, we have proposed a system concept that enables intuitive and easy multitasking with AR HMD as the primary working device. With our system, users utilize a supporting hand-held mobile device to visualize and manipulate a multitasking workspace without visual and interaction burden. We have specified design requirements for multitasking with AR HMDs and spatially-anchored information and proposed a system concept to resolve them. Our proof-of-concept implementation remains simple, but we will introduce a prototype with cross-workspace interactions in the following research. We will also present user feedback through a structured interview with experienced AR HMD users. Exemplar information sets for user feedback will include multi-layered information and version control of information. We expect the proposed system will encourage the daily utilization of AR HMDs in professional tasks.

[1] docs.microsoft.com/windows/mixed-reality/mrtk-unity/
[2] azure.microsoft.com/ko-kr/services/spatial-anchors/
[3] photonengine.com/en-US/PUN

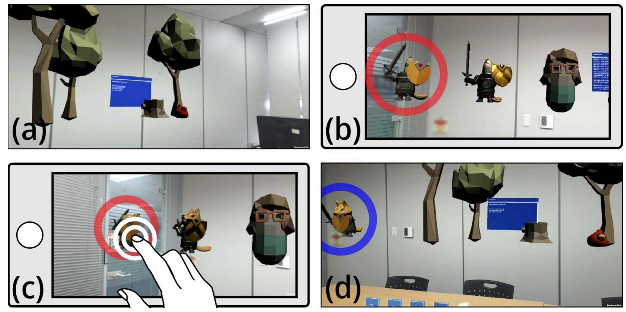

Figure 2: Implementation result of the proof-of-concept prototype. Here the user has two sets of information, one is scenic objects for an AR game, and one is character models for the game. (a) AR HMD view showing scenery objects such as trees. (b) Mobile device view showing character models, and the user wants to copy & paste a character (in the red circle) to the designed scene. (c) The user performs the copy & paste interaction, a simple double tap, on the desired target. (d) AR HMD view shows that the user successfully copies & pastes the character to the scene (in the blue circle) while maintaining the position relative to the real-world space.

Acknowledgments

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