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Invited

ModularHMD for Seamless Interactions between VR and Real worlds

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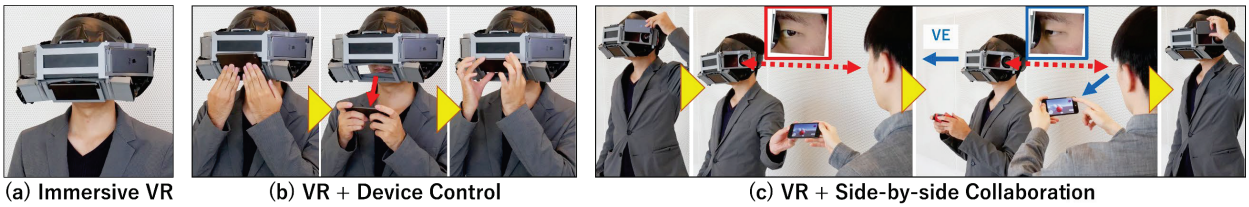

(a) Immersive VR (b) VR + Device Control (c) VR + Side-by-side Collaboration

Fig. 1. ModularHMD's main use cases: (a) user is immersed in VR content using ModularHMD with three modules displaying extended VR views; (b) user can remove bottom module and employ it as an input device to interact with VR content; (c) user can remove side module for peripheral awareness and lend removed module to a non-HMD user as an instant interaction device, allowing ad-hoc cross-device collaboration of VR content

ABSTRACT

We propose ModularHMD [1], a new mobile head-mounted display, which allows a user to seamlessly switch interactions between VR and real-worlds. ModularHMD is comprised of a central HMD and three removable modules. Each module has four main states: occluding, extended VR view, video see-through, and removed/reused. The user can quickly setup the necessary HMD functions for ad-hoc VR and real-world interactions.

1 INTRODUCTION

Head-mounted displays (HMDs) have become more affordable, portable, and no longer require external equipment. Such mobile HMD setups offer huge potential beyond entertainment uses, including enabling mobile working environments in which users can enter a virtual workspace while they are physically in an office, in shared spaces, or on transportation like trains and airplanes, etc. In such scenarios, HMD users require a certain level of situational awareness of the real world to respond to sudden physical interactions or nearby actions from non-HMD users. However, most current HMDs use occlusive cowls to induce an immersive VR experience that completely isolates the HMD user from the real world. We call such isolation the "HMD boundary," which causes the following two issues. First, HMD users cannot view and control around-hand real objects (e.g., cups, pens, keyboards, etc.) without removing the headset. Second, HMD users have limited situational awareness and interactivity with nearby people while wearing the headset.

Individual solutions have been proposed for each issue. For the first issue of hindered ad-hoc object interaction, the most common approach uses a video see-through (VST) display that visualizes surrounding objects in the VR view. Another approach is to redesign the HMD. Closely related to our work, in Multi-channel Dynamic Immersion (MDI) [2] transparency-controllable LCD panels are installed in the side cowls of an HMD to dynamically provide peripheral vision of the real world to HMD users. The second issue of limited ad-hoc asymmetric collaboration is more complicated because bidirectional situational awareness between HMD and non-HMD users should be ensured. A viable solution is FaceDisplay[3] which adopts a unique HMD form. It is comprised of three outward-facing touchscreens that visualize the HMD user's face, allowing co-located collaboration between HMD and non-HMD users through touch interactions around the HMD user's head. Nonetheless, even though the two issues have been addressed separately, no coherent solution has addressed them altogether.

2 MODULARHMD

We propose ModularHMD [1], a reconfigurable mobile HMD concept that enables HMD users to perform two types of ad-hoc peripheral interactions with real-world devices and non-HMD users while maintaining an immersive VR experience. ModularHMD's basic idea is using detachable modular devices in the HMD's peripheral cowls. Each module has four main states: occluding, extended VR view, video see-through (VST), and removed/reused. Among different combinations of module states, a user can quickly setup the necessary HMD forms, functions, and real-world visions for ad-hoc peripheral interactions without removing the headset. Although the concept of modular devices offers huge customizing opportunities, we focus on the above two main issues arising from the HMD boundary. Fig.1 illustrates our proof-of-concept prototype of ModularHMD, which is comprised of a conventional HMD with three removable module devices for its side

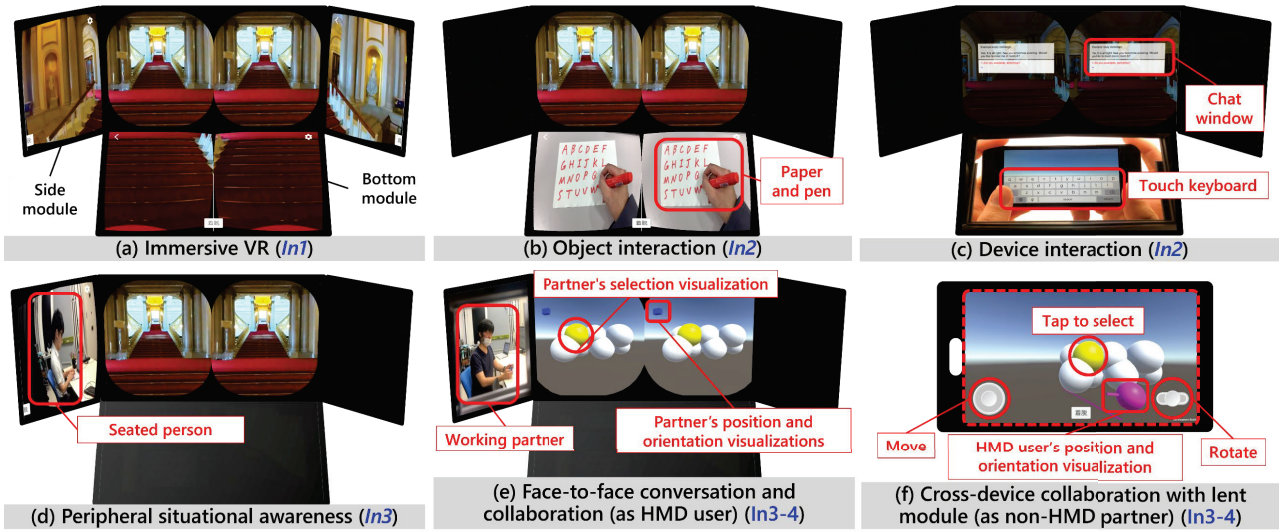

Fig. 1 ModularHMD Interaction senarios

and lower cowls. In the initial configuration of ModularHMD, all the modules are attached, and their inward-facing screens can display an extended VR view of the central VR content (Fig.1(a)). Figs.1(b) and (c) illustrate the two types of peripheral interactions with peripheral devices (e.g., a hand-held keyboard) and a real-world non-HMD partner. Both interactions, which are initiated by removing a module from the HMD, can be conducted by reusing it as an interaction device and terminated by returning it to the HMD. Fig. 1 (b) shows an example of text typing during a VR experience where the HMD user is reusing the removed bottom module as a touch keyboard that is visible through the opened-bottom slot. Fig.1(c) is an example of an ad-hoc cross-device collaboration with a real-world partner where the HMD user gives the removed-side module to a partner as an interaction device. They exchange facial expressions and eye contact through the opened-side slot. The cyclic action of removing, reusing, and remounting a module explicitly manages the workflow of ad-hoc peripheral interactions as well as makes the HMD setup fully mobile and self-contained (without requiring extra devices).

3 INTERACTION SENARIOS

ModularHMD basically supports the four interactions, and the following illustrate some derivative interactions for more realistic contexts (Fig.1).

Immersive VR (all modules: VR): When all the modules are attached and display the extended views of the VR content, the user has an immersive VR experience augmented by the peripheral VR views provided by the screens of the inner-facing modules. Fig.2 (a) shows an example of this interaction where the user is watching a 360-degree walkthrough VR video.

Ad-hoc around-hand object interaction (bottom: VST): When a module is put into the VST mode, the user has desktop awareness to grab peripheral objects on the desk, e.g., a cup, a pen, and notes, while remaining focused on the central VR content (Fig.2 (b). Due to the current VST limitations (e.g., delay, depth field mismatches, it might not be suitable for such subtle delicate interactions as text typing. But we believe it will be more powerful in near-future high-quality VST systems (e.g., Varjo XR-3).

A-hoc device interaction (bottom: removed) is a more mobile-oriented interaction. Instead of VST, if the bottom module is removed, the HMD user can directly see the desktop devices as well as her own hands through the opening, allowing subtle around-hand device manipulations. In addition, the removed bottom module immediately becomes available as a hand-held input device (e.g., a keyboard, touchscreen etc.) that can be manipulated with her visible fingers. She can place the module back in the HMD to return to the full VR experience (Fig.2c)).} This interaction will be useful in full mobile work scenarios (e.g., train or air-plain sheet) specifically where desktop devices, voice inputs or VR-gesture controllers are unavailable or unacceptable.

A-hoc peripheral situational awareness (side: VST or removed): his interaction increases the HMD user's peripheral situational awareness and supports the first stage for face-to-face conversations with real-world partner. The HMD user can use the side-module VST mode to recognize a person who is approaching or sitting nearby while she continues to focus on the central VR view (Fig.2). We focused on side-by-side formation to adapt our module arrangement. Head rotation might be needed to capture persons in other formations (e.g., front or back). This VST mode only provides unidirectional awareness to the HMD user. If bidirectional facial awareness between HMD and non-HMD users is required in the second stage after identifying a nearby non-HMD user, removing a side module can be a valid

choice. The empty space by removing the side module allows both users to understand their facial expressions (e.g., attention or gaze direction) for conversations. Fig.2e) shows a ModularHMD whose side opening captures a nearby person. }

Ad hoc side-by-side cross-device collaboration (side: removed/reused)}: o achieve cross-device collaboration, HMD users can establish a face-to-face communication channel with a real-world partner (Fig.2e)) by removing the side module. They can also immediately start asymmetric cross-device interaction by lending the removed module to a partner as an interaction device. Since the module is still working as part of the ModuarHMD system, bidirectional interactions can be ensured between modules by partner and VR view by HMD users.} If all the modules are lent, a one HMD user and a three-partner collaboration is enabled. Yet for simplicity, we focus on the simplest HMD user: one non-HMD user collaboration.

4 CONCLUSION

We proposed ModularHMD, a new HMD concept using a modular mechanism to support seamless interactions between VR and real-world devices and partners while maintaining an immersive VR experience for HMD users.

References

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