
“Mergereality”: Leveraging Physical Affordances for Multi-device Gestural Interaction in Augmented Reality

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Abstract

We present a novel gestural interaction strategy for multi-device interactions in augmented reality (AR), in which we leverage existing physical affordances of everyday products and spaces for intuitive interactions in AR. To explore this concept, we designed and prototyped three demo scenarios: pulling virtual sticky notes from a tablet, pulling a 3D model from a computer display, and ‘slurping’ color from the real-world environment to smart lights with a virtual eyedropper. By merging the boundary of digital and physical, utilizing metaphors in AR and embodying the abstract process, we demonstrate an interaction strategy that harnesses the physical affordances to assist digital interaction in AR with hand gestures.

CSS Concepts

- **Human-centered computing-Human computer interaction (HCI)**; Interaction techniques; gestural input

Introduction

Gestural interaction in augmented reality is an increasingly popular field of research. Most of this research focuses on interacting with digital content (e.g. virtual objects or UI elements) but little work touches upon interacting with multiple devices or the physical environment around us. Interacting with physical devices using gestures is especially challenging for several reasons. First, existing hand-based gestural interactions allow people to interact with virtual content (e.g. a virtual button, or 3D models), but it rarely supports richer interactions and

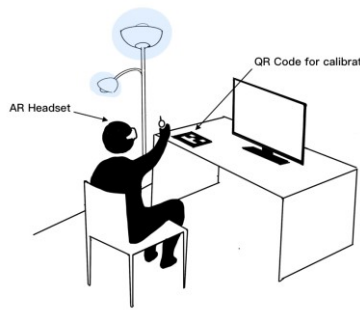


Figure 1: Room setup with a computer display and smart lights

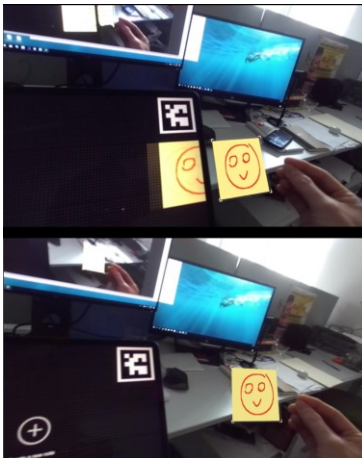


Figure 2: Demo 1: dragging a sticky note from a tablet to AR environment

intersections between the physical environment or the devices and objects it contains. Second, users' mental models of interacting with multiple devices are different, so it is challenging to make the interaction feel consistent and intuitive. Third, gestural interaction within these contexts has the added complexity of needing to support interaction with devices that are not only in arms-reach, but also far away and widely distributed in the space [1,7]. Last, hand-based gestural interactions seldom address the complexities of manipulating abstract information, such as colors or features embedded in the environment.

To address these above-mentioned issues, we present a novel AR gestural interaction strategy that leverages physical affordances for intuitive controls over multiple devices (e.g. smart lights, a tablet, and a computer display). We designed and prototyped 3 demo scenarios: pulling virtual sticky notes from a tablet, pulling a 3D model from a computer display, and slurp in/out color from the real-world environment to smart lights. With preliminary user research, we found this approach can increase the discoverability of the interactive device, allow visual capture from users' physical environment, and may help to ease the cognitive load by embodying the abstract process. We believe our research may unlock some new opportunities for AR gestural interface design, especially for multi-device interactions.

Related works

The concept of affordances [8] are not new to the HCI community, and has been widely used for screen-based gestural interaction [10] as well as the emerging field of AR. Some examine how to leverage physical affordances to assist tangible interactions in AR [2], while others have focused on interacting with virtual content, such as menu and buttons. We, however, consider affordances applied to interactions with multiple devices in AR. Most relevant is project "reality editor" [3]

allows users to use smartphone AR to connect and control multiple devices together, and Zhanpeng Huang and his team's project "Ubii" [4] explored gestural affordances to manipulate documents and files between devices. While these projects demonstrate possibilities, we believe there are many opportunities to better leverage physical affordance and make the interaction feel increasingly seamless.

Our also research builds on existing work on leveraging physical affordances for tangible interactions. Among those, Hiroshi Ishii and his research group are known for a range of experiments in "Tangible Bits" [5]. These experiments use metaphors to embody abstract digital interactions or tasks into physical interactions that people are familiar with. Metaphors hold important values for us to build a bridge of our mental models from physical world into digital interactions. For instance, Zigelbaum and his team [6] designed the project "Slurp" used a tangible eyedropper to metaphor data transfer between different locative media, and our third demo is inspired by their research and revived that concept into an AR gestural eyedropper for controlling smart lights.

Technical realization

To prototype the gestural interactions in AR, we used an Oculus Rift VR headset, combined with Leap Motion for gesture sensing. This is coupled with a Zed Mini camera to turn the VR headset into a passthrough AR headset. For the prototype of the smart light (see demo 3 below), we used Philips Hue light bulbs, and for the tablet and computer display prototype, we used the Open Sound Control (OSC) protocol to sync data between devices.

To interact with physical devices, we need to localize the interactive devices. For this project, we created a virtual room in Unity to map out the IoT devices, and it matches the layout of the real physical environment. Then we utilized an AR marker (using OpenCV) to calibrate the virtual and real environment.

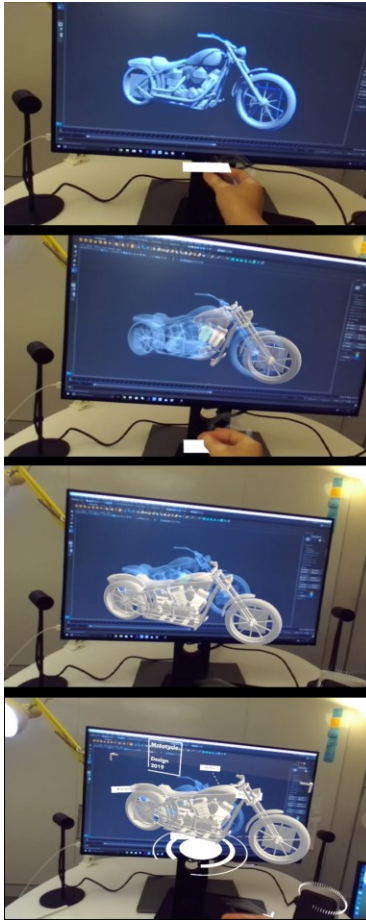


Figure 3: Deme 2: pulling a 3D model from a computer display

Therefore, when the user points the eyedropper to a smart light, or looks at a computer display, it can recognize the device, and display augmented information on top. In the future, this approach could be improved by using either a visual perception approach by recognizing the device with the camera, or indoor localization techniques such as Ultra-Wideband (UWB) chips [10] to achieve a similar outcome.

Design concepts and prototypes

In the first two demos, we translate basic physical affordances from everyday objects, such as pulling a handle, into gestural-based digital interactions for AR. In the third demo, inspired by “Slurp” project [6], we expand affordances into metaphorical interactions and implement a virtual color-picking eyedropper to control the color of smart lights.

Demo1: Pulling virtual sticky notes from a tablet

Sticky notes are useful in design practice and in brainstorming/thought exercises, but drawing or writing a high-fidelity sticky note in AR with gestures is difficult. Additionally, placing and arranging sticky notes for sense-making activities, like affinity diagramming, on a 2D screen is quite limiting. In this design, we attempt to address the problems by allowing seamless transitions between sketching on a tablet 2D screen and manipulating sticky notes in AR space.

We use a QR code on the tablet to identify the exact coordination of the tablet relative to the AR headset. We place a small virtual handlebar on the side of a tablet. This can be grabbed by a user to pull it out of the tablet and into an augmented world. This makes the two vastly different systems - a tablet and the AR space – connect seamlessly through a simple gesture.

Demo 2: Pulling a 3D model from a computer display

Pulling things out indicates a conceptual change of state. For instance, pulling a drawer out means items previously hidden

inside are now visible and available. So, the interaction of pulling aligns with existing mental models of switching status between two modes - inside/outside or open/close. Therefore, this concept utilizes this metaphor to afford switching modes between screen space (inside a display) and our physical environment (outside a display).

In this prototype, a user can pull out a 3D model from a computer display and place it in the environment.

To indicate the transition, we modify the shading and color of the 3D model inside the screen while a user is pulling it. By making the model inside transparent, this helps build a mental connection of his action and the result. By harnessing a physical affordance of pulling and its metaphoric meaning, we intend to help a user to understand this unfamiliar way of switching content from a digital real-world display into AR space.

Demo 3: Slurp in/out color from the physical environment to smart lights

Inspired by the original “Slurp” project, this demo creates a virtual eyedropper placed in a user’s hand. It functions as a magical color-picker like those found in design tools such as Photoshop, however here a user selects colors from the real-world environment and apply it to connected products, in this case smart lights.

We use a pinch gesture to activate the slurp in/out action with the virtual eyedropper because of several affordances. First, it matches the gesture used with a physical eyedropper, a user’s expectations for interaction and it aligns well with an eyedropper’s original physical affordances. Second, as the user performs a pinch gesture, their fingers will naturally come into physical contact, thereby creating explicit haptic feedback to reinforce the virtual action. To help users identify selection targets, a Bezier curve is added. This mimic the physics of attraction, bend towards a possible target, like a fishing pole.

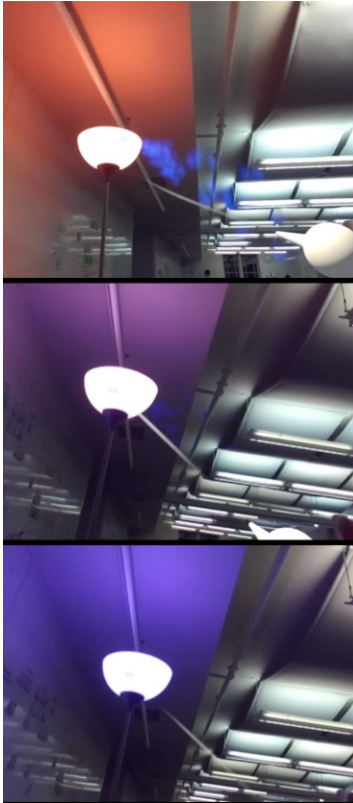


Figure 4: Deme 3: slurping color to a smart light with a pinch gesture



Figure 5: Deluminator from Harry Potter movie

The curve helps to signal the interactive devices and also create a sense of targeting and selection.

Inspired by the “deluminator” in the Harry Potter movies. We employ an animated particle effect of color being slurped in and out. During usability studies, participants noted that this helped them to embody the intangible process into a visualized substance, that is both intuitive and magical. The embodiment bridges the gap between the physical and digital by mediating the interactions. Also, most users think that the metaphor enables an easier learning curve and that it supports them in leveraging existing knowledge or and experience with familiar real-world interactions.

Discussion and conclusion

In this paper, we present a novel interaction strategy for AR gestural interfaces that directly leverages people’s familiarity with physical affordances into digital interaction. Moreover, it helps users to merge the boundaries of digital and physical of allowing them to interact with multiple IoT devices seamlessly. We harness people’s existing mental models of physical interactions and physical metaphors into the emerging field of AR and gestural interface design.

We believe this approach holds many exciting potential opportunities. As a next step, we plan to extend the interactive system to support a wider variety of interactions with IoT devices and physical environments, and to develop a series of demonstrator use cases for the smart home. We also intend to conduct an in-depth user study to collect quantitative data and formally evaluate the metaphorical approach used for AR interactions.

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