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Distant Hand Interaction Framework in Augmented Reality

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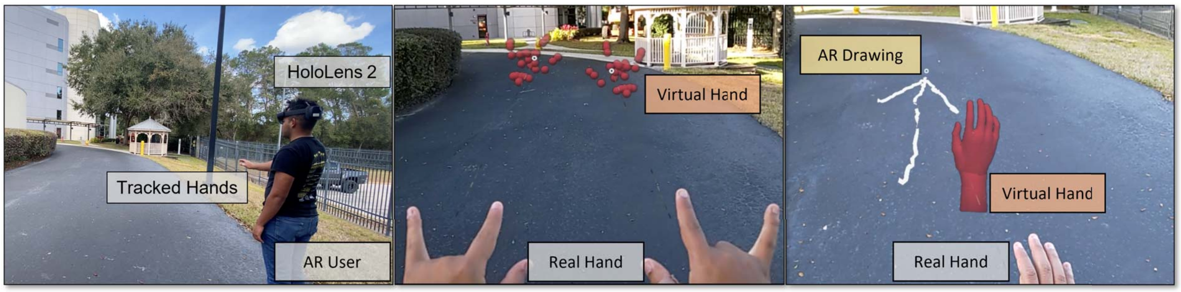

Figure 1: Illustration of exemplars of distant hand interaction techniques in augmented reality (AR) supported by our framework. From left to right: AR user utilizing the distant hand interaction framework, hand communication using deictic and/or symbolic hand gestures, and hand-based drawing at a distance in AR.

Abstract

Recent augmented reality (AR) head-mounted displays support shared experiences among multiple users in real physical spaces. While previous research looked at different embodied methods to enhance interpersonal communication cues, so far, less research looked at distant interaction in AR and, in particular, distant hand communication, which can open up new possibilities for scenarios, such as large-group collaboration. In this demonstration, we present a research framework for distant hand interaction in AR, including mapping techniques and visualizations. Our techniques are inspired by virtual reality (VR) distant hand interactions, but had to be adjusted due to the different context in AR and limited knowledge about the physical environment. We discuss different techniques for hand communication, including deictic pointing at a distance, distant drawing in AR, and distant communication through symbolic hand gestures.

Index Terms: Human-centered computing—Human computer interaction (HCI)—Interaction paradigms—Augmented reality

1 Introduction

Recent mixed reality (MR), augmented reality (AR), and virtual reality (VR) systems move towards free hand tracking for user interaction. While hand tracking systems are still facing various limitations, such as tracking accuracy, line of sight, etc., they are anticipated to provide a more natural experience [4]. This is particularly interesting when thinking about hands as a means for non-verbal communication and interaction in shared experiences.

However, while a user's hands are effective as a natural and intuitive non-verbal communication channel when seeing a user's real body or virtual avatar (e.g., deictic or symbolic gestures), leveraging them for communication and interaction at distances beyond one's arm reach or even beyond visibility of one's body/avatar still imposes major research challenges.

For instance, the Go-Go technique introduced a position control mapping for distant hand placement and movement in VR [3]. The Go-Go technique enables users to extend their hands beyond arm's reach in VR by applying a non-linear mapping, which allows users to freely move their hands within an increased volume around the user. Such techniques are interesting as such a distant hand could still be used for deictic or symbolic hand communication, while extending beyond the user's arm reach. There have been multiple similar techniques proposed over the last two decades. Another technique called Stretch Go-Go [1] leverages rate control, which allows users to shift their virtual hand linearly back or forward progressively depending on the shift region distance.

In the scope of this work, we present a basic framework for hand extension techniques adapted for AR environments, allowing users to reach with their hands to distant locations using two alternative mapping techniques, while supporting three hand visualizations, and two magnification modes, for different forms of communication.

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2 AR Distant Hand Interaction Framework

We utilize a Microsoft HoloLens 2 with the Mixed Reality Toolkit 2.7 for hand detection, and Unity 2020 to facilitate the deployment of different visualization techniques.

2.1 Calibration

To calibrate the hand extension techniques based on the reachable volume around the user's body, we first measure the distance between their hand and the HoloLens 2 by using air tap gestures to approximate three spatial points: The first point (P_{max}) indicating their *maximal* arm reach when stretching their hand out in front of them, the second point (P_{far}) indicating their preferred *comfortable far* arm reach, and the third point (P_{near}) indicating their preferred *comfortable near* arm reach. With these three points we approximate a basic volume for the total hand movement range of the user for use by our rate and position control techniques described below.

2.2 Mapping Techniques

For our AR framework, we implemented two common mapping techniques for distant hand interaction that were originally proposed for VR environments.

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Position Control To allow for distant hand interaction, we adopted a similar approach to the one from the original Go-Go technique [3]. Similar to the Go-Go technique, we used a threshold (see P_{near} above) within one's arm reach that defines the extent of a 1:1 mapping used for hand movements when they are close to one's body, and we used a parameterized exponential mapping for hand movements beyond this threshold up to maximal arm reach (see P_{max} above). Position control as supported by this technique allows users to move their hands with higher precision the closer they are to the user, while the precision is reduced for longer distances.

Rate Control We adopted a similar approach to that used in the Stretch Go-Go technique [1] to control the user's hand. Therefore, we define three regions around the user, which are used to shift the virtual hands back or forward linearly. When the user extends their hand into the outermost region, the hand shifts forward, and when the user brings their hand closer into the innermost region, the hand shifts back (for the thresholds see P_{near} and P_{far} above). While this rate control mapping avoids the reduced precision for longer-distance hand movements of the original Go-Go technique, it comes at the cost of a less natural and intuitive hand control mechanism.

2.3 Hand Visualization

Our framework currently supports three hand representations and two magnification modes.

Hand Representations Effective non-verbal communication over large distances in AR using just one's hands depends on the appearance of the hands. We integrated three basic visualization methods. The Virtual Hand (see Fig. 1) leverages the tracked hand representation of the HoloLens 2's Mixed Reality Toolkit to allow users to perform dyadic and symbolic communication by following the finger movement and pose of the real hands. The Virtual Arrow (see Fig. 2) is a simplified (abstracted) form that we integrated for users to be able to point at objects more effectively. The pose and end of the virtual arrow match the pose and tip of the user's index finger, respectively. The Point Cloud (see Fig. 1) is a further hand representation natively supported by the Mixed Reality Toolkit. We included this abstracted hand representation as it still conveys important hand pose and gestural information while also being mostly transparent, i.e., avoiding the occlusion of the background behind the hands.

(a) (b)

Figure 2: Illustration of two hand magnification modes: (a) regular mode and (b) magnified mode.

Hand Magnification When visualizing one's hands at a long distance away from one's body, their retinal size naturally becomes smaller, characterized also by them being represented by a smaller screen space and fewer pixels on the AR display. As a result, it becomes more difficult to perceive the hands at such distances, e.g., to visually verify that they are moving in the intended way or pointing in the intended direction. Similarly, as hands are a tool for communication, this also applies to other AR users seeing one's hands at the same or a range of different distances. As a potential countermeasure to losing sight of small hands at long distances, we implemented a basic *magnification* mode, in which the hands are scaled up depending on their distance from the observer, matching their optical field of view to that of their hands at their maximal arm reach distance. While this mode ensures that the hands are represented with the same retinal size independent of their actual distance, we are aware that this introduces some challenges in perceiving their distance accurately [2], hence this mode can be activated/deactivated (see Fig. 2).

2.4 Distant Hand Communication

Our framework supports, among others, three types of distant hand communication, presented here as exemplars.

Distant Hand Gesturing A high fidelity full hand mesh supporting deictic and symbolic gestures to be used in shared AR experiences, such as hovering with the hand over a distant building, pointing down, and holding up four fingers to indicate how many people are located inside.

Distant Hand Pointing Switching the hand representation to an abstract arrow to improve deictic communication such as moving the arrow along a distant path, or pointing at an object or in a direction.

Distant Hand Drawing While AR environments, in contrast to VR environments, usually have only limited or no knowledge about the scene geometry, it is possible to implement drawing with one's hands without such knowledge. We implemented a basic form of hand drawing in AR where a colored trail is left behind the 3D path taken by the user's hand in the physical environment. Users can enable drawing by holding the index and thumb fingers together.

3 Conclusion

In this work, we presented a framework for hand communication and interaction at a distance in shared AR experiences. We presented two alternative AR distant hand mapping techniques, three hand visualizations, two magnification modes, and three exemplar forms of communication. In future work, we are planning a comparative evaluation of these approaches.

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