VisuoTouch: Enabling Haptic Feedback in Augmented Reality through Visual Cues

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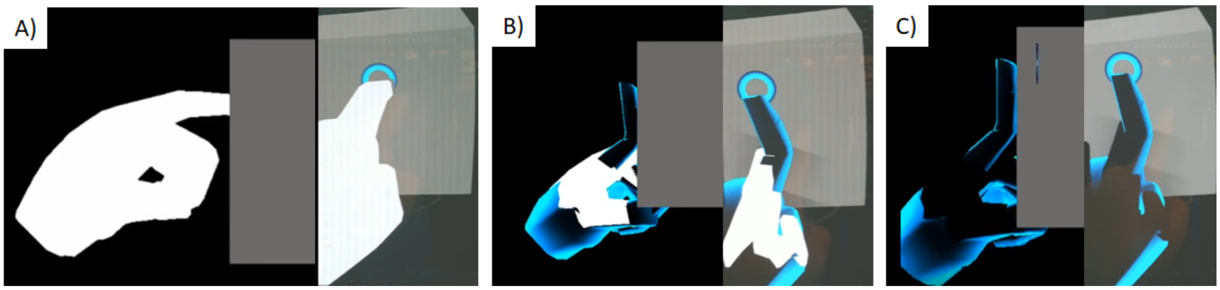

Figure 1: We present a visual-haptic feedback system to provide psycho-physical responses to touching virtual objects without the need of physical peripherals. A) Our tracked hand pushing into a virtual cube has no feedback other than the smaller surface cue. B) By instead capturing the point and rendering a new finger placed using IK along the surface, C) we provide a visual haptic feedback event, as if the real hand was pushed against a physical surface.

Abstract

The rapid advancements in Augmented Reality (AR) have recently included hand tracking frameworks that allow a system to understand the placement of a user's hand in virtual space, allowing for hand interactions with AR content. However, the lack of haptic feedback leaves the user confounded on whether or not their hand has successfully collided with the virtual content. Furthermore, in poke-to-select interactions, the user is unaware that they have triggered the selection process. In this demo, we showcase VisuoTouch, a system that enables the semblance of haptic feedback by providing visual cues. The cue illuminates the spot where the finger collides with the object. If the user continues to push through, a virtual finger is visualised as bending against the object, following real-world physics. We hope that by demonstrating this interesting approach, we can facilitate further exploration in the effectiveness and usefulness of these visual-haptic cues.

Index Terms: Human-centered computing—Human computer interaction (HCI)—Interaction paradigms—Mixed / augmented reality; Human-centered computing—Human computer interaction (HCI)—Interaction techniques—Pointing

1 Introduction

With respect to AR, there are several ways we can track the user's hand and provide tactile feedback. And all methods that provide physical, tactile feedback usually require bulky and heavy glove peripherals. On the other hand, haptic perception or pseudo-haptics studies have remarked that in spatial interactions, the visual-haptic coupling is indeed characterized by strong visual dominance [3]. Lécuyer et al. [4] define pseudo-haptic feedback as the feedback that corresponds to the perception of a haptic property that differs from the physical environment, by combining visual and haptic information and proposing a new coherent representation of the environment.

Nevertheless, there have been several explorations in providing visual cues in place of tactile feedback [1]. Alternatives aim to hybrid the combination of bulkier equipment with visual cues to provide completed experiences [5], but still require the cumbersome peripherals to afford physical feedback. We introduce VisuoTouch, a technique that approaches the problem by providing more lifelike tactile visual responses, with the aim of inducing psycho-physical tactile responses or pseudo haptics.

We implement haptic perception in VisuoTouch by providing the following visual cues:

1. A visual effect that is instantiated at the contact point between the hand and the virtual content.

2. A hidden virtual hand that becomes more prominent as the user pushes their real hand further into the virtual content, as seen in Figure 1.

Our contribution lies in a unique approach to a more recent challenge, and its real-time implementation; and we hope to inspire those interested in virtual interactions with AR content to explore this concept further.

2 Implementation

We utilise a variation of Project Esky [2] for our demo, which runs on a Project Northstar[1] Head-Mounted Display (HMD). The HMD has a diagonal field-of-view of ~100 degrees and comes with the Leap Motion hand tracking[2]. Furthermore, to provide six-degrees-of-freedom to the HMD, we employed the Intel RealSense T265[3] module. For development, we use the Unity game engine, running on a HP VR G2 Backpack PC with the following specifications: Intel Core i7-8850H, 32 GB RAM, and an NVIDIA GeForce RTX 2080.

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[1]https://developer.leapmotion.com/northstar
[2]https://www.ultraleap.com/tracking/
[3]https://www.intelrealsense.com/tracking-camera-t265/

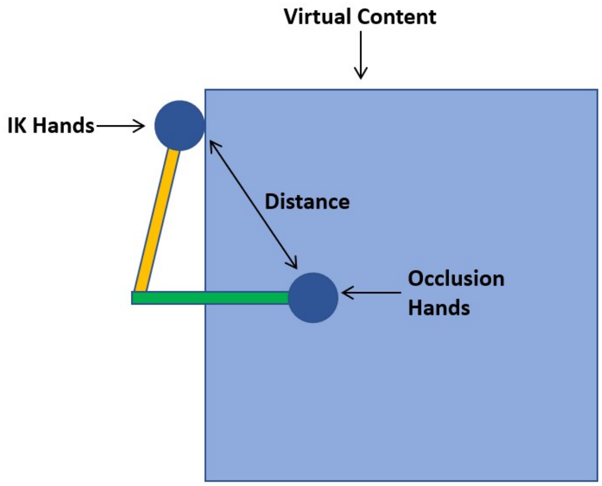

Figure 2: As the user pushes their finger through the virtual content, the distance between the IK and Occlusion Hands increases. If the distance increases, the custom shader renders the IK hands more prominently and vice versa.

3 VisuoTouch

The system utilizes the Leap Motion to continuously tracks the user's hands. The tracked data, i.e. the position and orientation coordinates, are extracted and applied to two hidden hand meshes. Both the hand meshes are rendered using custom shaders. One of the hand mesh includes an Inverse Kinematics (IK)[4] skeleton and is hence referred to as the 'IK hands' hereafter. The IK assists in providing real-world physics to the hands when it interacts with virtual objects, i.e. the hand does not pass through the object but instead bends against it.

Our approach applies a means of Inverse Kinematics to orient and position the tip of the finger towards the target destination, whilst keeping the ideal structure between the finger and the knuckle nodes. When there are no collisions, the target is set to be the fingertip tracked by the Leap Motion, and when a collision is registered, the target is switched to the contact point between the fingertip and collided object.

The other hand mesh has an occlusion shader and is referred to as the 'occlusion hands' hereafter. The role of the occlusion hands is always to follow the real hands of the user. Therefore, when a collision is registered, the occlusion hands follow the user's real hands and goes through the object, whereas the IK hands bend against it. During the collision, the euclidean distance between the fingertips of the occlusion hands and the IK hands is computed and fed to the shader rendering the IK hands (see Figure 2). Therefore, when the distance increases, the IK hands start to glow and become more prominent - indicating that the user is pushing through the virtual content. Moreover, a visual effect is also instantiated at the contact point, providing additional feedback. The effect is made using Unity's VFX graph.

4 Demonstration

We demonstrate VisuoTouch by showing a basic AR scene with several interactable objects. As the live actor interacts with the virtual objects, they will cycle the visual feedback shown between the basic hand tracking mask, VisuoTouch, and the combination.

Since the conference will be held virtually, we intend to present the system as a live online streamed demonstration. While we have a live actor demonstrating the system, viewers can preview the demo with through-the-lens and video see-through previews of the action occurring. The live actor will be pushing and interacting with objects found in the MRTK Toolkit[5], toggling between the various visual-haptic feedback styles.

5 Conclusion and Future Work

It is challenging to perceive hand interactions in AR without stimulating the physical senses. Despite the existence of haptic interfaces such as gloves, they are not suitable as their very presence hinders the otherwise intuitive and inherent experience that AR bestows. We present an innovative approach to provide a more realistic visual-haptic feedback event, with the aim of inducing physical haptic feedback through our realistic visual cues. We hope to explore this further by investigating the psychological responses and improved efficiency when interacting with virtual content.

References

[1] O. Bau and I. Poupyrev. REVEL: Tactile Feedback Technology for Augmented Reality. *ACM Trans. Graph.*, 31(4), July 2012. doi: 10.1145/2185520.2185585

[2] Constantine, Rompapas Damien and Quiros, Daniel Flores and Rodda, Charlton and Brown, Bryan Christopher and Zerkin, Noah Benjamin and Cassinelli, Alvaro. Project esky: Enabling high fidelity augmented reality on an open source platform. In *Companion Proceedings of the 2020 Conference on Interactive Surfaces and Spaces*, ISS '20, p. 61–63. Association for Computing Machinery, New York, NY, USA, 2020. doi: 10.1145/3380867.3426220

[3] Y. Hatwell, A. Streri, and E. Gentaz. *Touching for knowing: cognitive psychology of haptic manual perception*, vol. 53. John Benjamins Publishing, 2003.

[4] A. Lécuyer. Simulating haptic feedback using vision: A survey of research and applications of pseudo-haptic feedback. *Presence: Teleoperators and Virtual Environments*, 18(1):39–53, 2009.

[5] G. Ye, J. J. Corso, G. D. Hager, and A. M. Okamura. VisHap: augmented reality combining haptics and vision. In *SMC'03 Conference Proceedings. 2003 IEEE International Conference on Systems, Man and Cybernetics. Conference Theme - System Security and Assurance (Cat. No.03CH37483)*, vol. 4, 2003.

[4]https://en.wikipedia.org/wiki/Inverse_kinematics

[5]https://microsoft.github.io/MixedRealityToolkit-Unity