

How Much Haptic Rendering Is Enough?

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Abstract

Virtual Reality (VR) systems create immersive alternate realities by synchronizing visual, auditory, and haptic feedback into a unified perceptual experience. Among these sensory modalities, providing a realistic sense of touch remains a significant challenge. Consequently, extensive research has focused on developing novel haptic interfaces that deliver realistic tactile experiences during VR interactions. Most existing approaches aim to accurately reproduce the haptic characteristics of real-world interactions. As a result, these interfaces function independently of visual input and remain effective even when users close their eyes or operate outside a VR environment. However, achieving such standalone functionality often comes at the expense of scalability, affordability, or hardware complexity. Given that visual feedback is continuously available during VR experiences, we question whether complete standalone haptic functionality is necessary for effective VR interaction. Instead, we explore the opportunity to trade standalone capability for greater scalability, lower cost, and reduced hardware complexity by leveraging visuo-haptic perceptual integration. Although this approach relies heavily on visual information, it has the potential to enable the development of a general-purpose haptic interface that delivers perceptually realistic touch across a broad range of VR interaction scenarios. I'll describe some of our studies of users' visuo-haptic perception through psychophysical experiments and VR interaction studies, and the insights gained allow us to exploit visuo-haptic illusions to simplify haptic hardware.