Enriching Touch in Mixed Reality using Personal Fabrication

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Abstract
On a daily basis, we physically interact with a large amount of objects in our environment while receiving valuable information about their properties. One essential channel communicated through touch is the textural information an item conveys. In mixed reality environments, experiencing textures is greatly improved through multisensory perception. State-of-the-art approaches in passive haptics use a large set of physical materials to represent different virtual materials. Nowadays, fabrication techniques such as 3D printing, allow the user to create objects with customized surface structures. The resolution of these printers is already high enough to produce rich and fine-grained tactile structures. By employing personal fabrication techniques, we investigate enhancing texture perception in mixed reality environments. Our approach aims to enable a more customizable design of passive haptic texture experiences.

Author Keywords
Human Factors; Tangible Interaction; Personal Fabrication; Immersive Virtual Environments.

ACM Classification Keywords
H.5.3 [Information interfaces and presentation (e.g., HCI)]: Group and Organization Interfaces.

Passive Haptic Feedback

Providing realistic experiences in mixed reality environments demands a multisensory approach. While typical head-mounted displays combine visual information with spatial sound and simple force feedback to explore virtual worlds, other senses are typically omitted. The addition of haptic sensory input allows users to *feel* objects, enhancing their sense of presence [1].

One such technique, called Passive Haptics, allows users to touch and feel their virtual surrounding through passive haptic proxy objects. These passive props are physical twins of virtual objects which are typically registered in a 1-to-1 fashion. A naive approach requires virtual objects with varying materials to be represented by the same amount of physical objects with corresponding materials. This is inherently inflexible and technically challenging as it requires a continuous synchronization of physical objects for every change in the virtual environment. To address scaling issues when using a large amount of objects each with their own different surface material, we look towards fabrication as a means of extending passive hapic feedback to provide more flexible tangibility.

Personal Fabrication for Tactile Experiences

Personal fabrication aims to bring modern fabrication techniques into the hands of the consumer. Similar to the evolution of the paper printer, 3D printers will take their place into the everyday lives of consumers. The resolution of these printers is already high enough to produce rich and fine-grained tactile structures. For example *Haptic Print* [8], a specialized design tool, allows the user to apply a surface texture to an object's surface in order to define the haptic characteristics of the final print. Another approach to influence the *feeling* of an object is to augment its surface with 3D printed hair structures [3, 5].

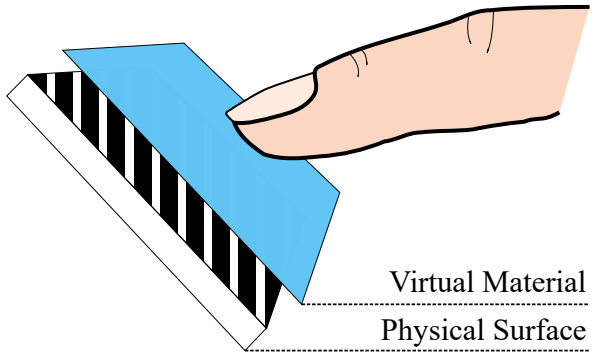

Figure 1: The concept of augmenting texture perception by overlaying a physical structure with a virtual texture, where the physical structure is created by a 3D printer.

Discussion

Motivated by the enhanced capabilities to produce 3D structures with precisely controlled features at a micro-scale, we investigate how these fabricated structures can serve as reusable and versatile physical surfaces, allowing users to experience many different virtual materials (see Figure 1). In our current approach, we present participants with visually augmented physical hair structures as passive haptic proxy surfaces in a virtual reality environment. As we modify the length of the printed hair structures, we aim to influence the perception of roughness and hardness of different visual textures.

Lessons learned from this approach will serve as a basis to extend the perception of touch by using personal fabrication. For example, a user browsing through the catalog of an online furniture store could download and print a 3D structure which, when combined with the correct visual augmentation, will provide a much more accurate

impression of the fabric of a couch. Additionally, by combining this approach with existing haptic photography techniques to *scan* the surface properties of an object [2], we envision a future workflow where users can record and share textural experiences.

Biography

If accepted, Donald Degraen will attend the workshop *Reshaping Touch Communication: An Interdisciplinary Research Agenda* at CHI '18. Donald received his Master's in Computer Science with a specialization in Human-Computer Interaction (HCI) at Hasselt University, Belgium. After having gained experience as a developer in the private sector and a teacher in the academic sector, he returned to Hasselt University as a full-time researcher in HCI. His past research focused on intelligible interaction [6], alternative route generation [7] and visual peripheral information [4]. In September 2016, he started his Ph.D. studies at Saarland University with his supervisor Prof. Dr. Antonio Krüger. Donald is part of the DISTRO Innovative Training Network through the Intel Visual Computing Institute. The DISTRO project is funded from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 642841. His main focus is on Personal Fabrication for Passive Haptic Feedback.

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