Enjoyable Carving with ChiselDevice in Mixed Reality Space

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ABSTRACT

In this paper, we propose a system that can carve virtual objects in Mixed Reality (MR) space. The procedures of real-world carving include sculpting a rough outline, shaping sections, and carving patterns onto an object's surface. Of these, we focus on the procedure for carving patterns. Users of our system stroke a real object directly using ChiselDevice, and the surfaces of 3D virtual objects superimposed on the real object are "carved." This paper describes the design and development of the ChiselDevice and the MR carving system and the findings of users' experiences of our system.

CCS CONCEPTS

• **Human-centered computing → Mixed / augmented reality**;

KEYWORDS

Carving system, mixed reality, ToolDevice

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1 INTRODUCTION

With the rapid technological development of 3D printers, users can create 3D models and print them as real objects by themselves. However, it takes time for novice users to learn how to create the model data by using modeling software. In addition, understanding the 3D shapes of models on the 2D display is not intuitive. In contrast, Arisandi developed a modeling system using Mixed Reality (MR) technology and a ToolDevice, which utilizes the shape and operational feeling of existing tools [Arisandi et al. 2014]. In this system, by using a ToolDevice, which replicates the shape and operational feeling of existing tools familiar in everyday life, users can intuitively understand the tool's usage. However in this MR modelling system, it is hard to edit its surface in detail such as to create decorative carving patterns. In this paper, we propose and develop a novel ToolDevice, called a ChiselDevice, and an MR carving system that imitates actual carving tools and their operations. In our MR carving system (Fig. 1), the users can replicate wood carving on the surface of a 3D model using the ChiselDevice.

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2 RELATED WORK

[Mizuno et al. 2003] proposed a system in which users can intuitively input the depth and angle of carving using a graphics tablet with pen pressure. However, this system uses 2D displays and planar input/output devices, so there is a problem with this approach in that it is not intuitive to operate. Some studies have attempted to achieve direct/intuitive modeling operations by introducing real-world tools and work procedures into the system. For example, [Zoran and Paradiso 2013] developed "FreeD" as a system combining actual carving and modeling. In this study, the feeling of fingers and hands and the haptic feedback of touching objects in modeling work is realized by imitating the process of physical modeling in the real world. There are few studies to virtually carve a surface using a similar approach with physical carving in the real world. [Hisada et al. 2006] developed a system "HYPERREAL" that enables users to perceive as if real objects are deformed. However, this system was not designed for carving requirements such as changing the depth of the carving line from the angle and pressure of a device. Therefore, in our research, we develop a system that satisfies the following requirements:

(1) Direct/intuitive modeling in which users can directly touch the input device to the real object
(2) Replicating the operability of actual carving work, such as flexibility, operational ease, and tactile nature.
(3) Changing the nature of the carving line, such as depth and width, by user operations in real time.

Figure 1: A virtual carving using proposed system.

3 IMPLEMENTATION

In this study, we analyzed actual carving work with carving tools and created a model to generate carving lines for our MR carving system. There are various methods for generating carving lines in computer graphics, such as bump mapping. In this study, however, in order to achieve real time processing, we generated them as simple textures. Specifically, based on the image of the actual carving stroke, we created a basic shape with the texture of the v-chisel, gouge, straight chisel, and skew chisel trace. In the real world carving, the ratio of expansion of the length, the width and the depth of the carving stroke are determined from the basic shape depending on the "pressure" and "angle" between the carving tool and the carving surface. Therefore, we deform the basic shapes according to the pressure and angle between the carving tool and the carving surface. Then, the carving line is expressed by arranging the textures at the position where the tip of the carving tool and the carving object are in contact (Fig. 2). To implement the MR carving system, we use a binocular see-through HMD (Canon MREAL HM - A1), which enables the user to perceive depth. In addition, we monitor the position and orientation of the HMD and the ChiselDevice, which are tracked using Polhemus FASTRAK, a six-degree-of-freedom tracking system equipped with magnetic sensors. The ChiselDevice we developed is shown in Fig. 1. To detect the pressure of the carving tool on the real object, a pressure sensor (Interlink Electronics Inc., FSR400 SHORT) is attached to the tip of the device. The value acquired by the pressure sensor is transmitted to the MR space management PC through Arduino Uno (Arduino LLC). To obtain the position and orientation of the device and the real object, a magnetic sensor is attached to the back end of the device and the corner of the real object. The angle between the carving tool and the carving surface can be calculated from these values. In addition, sandpaper is attached to the tip of the device to provide tactile sensations. The middle figure of Fig. 1 shows an example of carving result.

4 USER EXPERIENCE AND DISCUSSION

We confirmed whether the proposed system can imitate real carving operations, and the effect of the proposed system on the behavior of users through this approach. To do this, we compared carving operations using our system vs. those using a liquid crystal pen tablet. We recruited 12 right-handed participants (nine males and three females, aged between 22 and 25 years), all of whom were beginners in both systems. As a result, we confirmed that the participants' behavior in our system was similar to actual carving work (such as when they carved while holding and rotating the carving object) compared to the behavior using a liquid crystal pen tablet. In our system, sandpaper is used to enable the user to feel a reaction force, so the tactile feedback is different from the liquid crystal tablet where there is little reaction force. In actual carving, because the tip of the carving tool catches on the carving surface, it does not shake, and the carving line does not blur. Since our system gives a reaction force, the carving line does not blur, as with actual carving. In terms of carving results, our system was able to carve a straight line with less blurring. From the comments from participants, we confirmed that they could change the depth and width of carving by using the feeling of the reaction force as a cue. These comments supported the assertion that our system can provide natural operational feeling and that the users could control the depth and width of the carving lines based on force feedback in a similar way to actual carving.

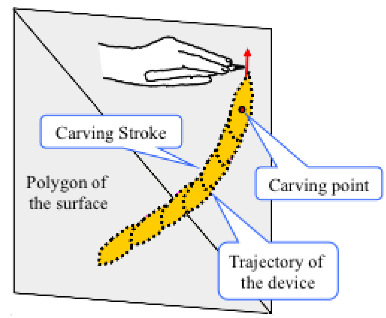

Figure 2: Expression of carving lines.

In addition, there were comments such as "I felt the MR carving system was similar to real carving because of the reaction force" and "Because I got a reaction force using the MR carving system, it was enjoyable as a carving process." These comments suggested that our system achieved "carving-like operation." We also confirmed the limitations of the proposed system. In actual carving, the reaction force increases as the user tries to carve deeper, and they can perceive the amount of the force. In contrast, since our system only presents a simple reaction force, participants commented that it was difficult to understand the difference in depth.

5 CONCLUSION AND FUTURE WORK

We proposed a system by which it is possible to carve (as in wood carving) on the surface of a virtual object in MR space in a similar way to performing an actual carving. By imitating actual carving and direct input, users can intuitively understand the usage of the device and work without losing creativity. We compared the proposed system to a system using a liquid crystal tablet and confirmed that the proposed system can imitate actual carving. For future work, we will extend the carving to complex 3D shapes and add some virtual carving functions that take advantage of digital modeling. Furthermore, we will develop a device with a mechanism that can provide a variable reaction force depending on the depth of the carving line.

REFERENCES

R. Arisandi, M. Otsuki, A. Kimura, F. Shibata, and H. Tamura. 2014. Virtual Handcrafting: Building Virtual Wood Models Using ToolDevice. *Proc. IEEE* 102, 2 (Feb 2014), 185–195. https://doi.org/10.1109/JPROC.2013.2294243

M. Hisada, K. Yamamoto, I. Kanaya, and K. Sato. 2006. Free-form Shape Design System using Stereoscopic Projector - HYPERREAL 2.0. In *2006 SICE-ICASE International Joint Conference*. 4832–4835. https://doi.org/10.1109/SICE.2006.314978

Shinji Mizuno, Daigo Kobayashi, Minoru Okada, Jun-ichiro Toriwaki, and Shinji Yamamoto. 2003. Virtual Sculpting with a Pressure Sensitive Pen. In *ACM SIGGRAPH 2003 Sketches &Amp; Applications (SIGGRAPH '03)*. ACM, New York, NY, USA, 1–1. https://doi.org/10.1145/965400.965551

Amit Zoran and Joseph A. Paradiso. 2013. FreeD: A Freehand Digital Sculpting Tool. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '13)*. ACM, New York, NY, USA, 2613–2616. https://doi.org/10.1145/2470654.2481361