Sharpen Your Carving Skills in Mixed Reality Space

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ABSTRACT
This paper proposes a virtual carving system using ToolDevice in a mixed reality (MR) space. By touching and moving the device over real objects, users can carve it virtually. Real-world wood carving with wood carving tools requires several steps such as carving a rough outline, shaping the wood, and carving patterns on its surface. In this paper, we focus on the step of carving patterns on a surface and implement it in our MR carving system.

Keywords
Carving system; Mixed Reality; ToolDevice

1. INTRODUCTION
We have developed ToolDevice, which is a set of interaction devices using the metaphor of existing tools familiar in everyday life and a mixed reality (MR) 3D modeling system that imitates real-life woodworking [1]. In this system, users can pick up and move virtual objects with the TweezersDevice, and cut and join virtual objects using the Knife/HammerDevice. By repeating these operations, users can build virtual wood models.

In the same way, we propose an MR carving system with an input device "CarvingToolDevice" which imitates actual carving tools for creating patterns on a 3D object in a manner similar to real-world carving (Figure 1). Using this system, users can understand the shape of the objects intuitively and change the carving strokes dynamically. In this paper, we focus on relief carving, a type of woodcarving in which patterns can be engraved on a flat wood panel.

2. CARVING MODEL
In real-world carving, the depth, width, and length of the carving footprint changes depending on the "pressure" and the "angle between the surface and carving tool." Similarly, in our carving model, users can change the virtual stroke based on the "pressure" and the "angle between the surface and device."

The carving depth is proportional to the pressure of the carving tool on the real object surface as well as the angle of the carving tool and the surface. As the angle of the tool becomes more vertical, the depth increases, because the tip of the carving tool cuts into the object surface more deeply. The width and length are proportional to the curve depth and angle of the device, respectively. The stroke becomes longer when the angle between the surface and the device is horizontal, because the pressure of the CarvingToolDevice disperses in the direction of the stroke (Figure 1).

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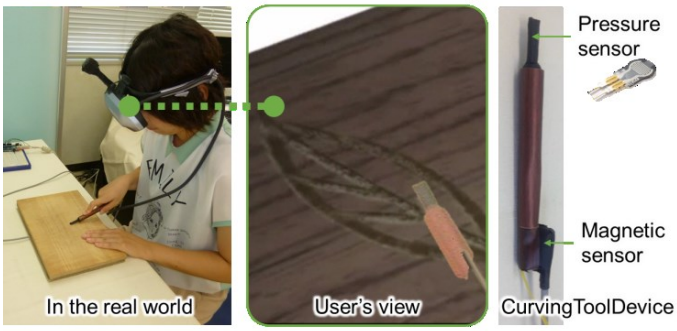

Figure 1: MR carving system

If users overlay a carving stroke, the system determines the overlapping part and increases the depth of that part.

3. MR CARVING SYSTEM
In the MR carving system, users wear a binocular see-through head-mounted display (HMD; Canon VH-2002), which enables them to perceive depth. The position and orientation of the HMD and the device are tracked using Polhemus LIBERTY, a six-degree-of-freedom tracking system equipped with magnetic sensors. We have developed the CarvingToolDevice. To detect the pressure of the carving tools on the real object, a pressure sensor (Interlink Electronics Inc., FSR400 SHORT) is attached to the tip of the device. To obtain the position and orientation of the device, a magnetic sensor is attached to the back end of the device. In addition, to provide tactile sensations, sandpaper is attached to the tip of the device.

4. CONCLUSION
In this paper, we proposed a virtual carving system that allows users to carve patterns virtually on the surface of a real object in an MR space, just as in real world carving. Using this system, users can change carving strokes with their actions (i.e., the pressure and angle of the device) in real time. For future work, we plan to extend the carving from a 2D plane to a 3D object and add more digital carving functions.

5. REFERENCES
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