Haptic Editor

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Abstract

In this project, we propose an interactive content creation and editing system for haptic-enabled 3D content by drawing shapes in the air and copying and pasting surface textures. To achieve realistic haptic interaction, we create a data structure for haptic content using three kinesthetic layers and a tactile layer. The user creates haptic 3D models by drawing geometries through aerial sketching; painting compliance and friction values on the layers; and copying and pasting the vibrotactile surface textures of real objects onto the virtual model. We present a user-friendly haptic interface to enable these functions.

CR Categories: H.1.2 [Information Systems]: Models and Principles—User/Machine Systems, Human Factors H.5.2 [User Interface]: Haptic I/O—;

Keywords: haptic interaction, haptic interface, 3D modeling

1 Introduction

A number of haptic interfaces have been proposed thus far. For the popularity of haptic technologies to reach the next stage, a creation system for haptic-enabled content is required. At present, the market offers a number of commercially available visual editors for creating and editing images or 3D models, such as LightWave [NewTech, Inc.] and 3ds Max [Autodesk, Inc.]. Standard methods for the creation of visual content allow the user to copy and paste colors or visual textures from one place to another, as with the eyedropper tool in Photoshop [Adobe Systems, Inc.]. Based on image textures obtained from real objects using cameras, content with realistic surface features can be achieved. I/O brush [Ryokai et al. 2004] enables copying and pasting of various visual images from the real world to the virtual world.

Haptic sensation represents integration of considerable amount of sensory information, therefore, it is difficult to design haptic- enabled content. Although some research on 3D modeling systems using haptic interfaces has been conducted [Foskey et al. 2005][Fiorentino et al. 2006], these works do not focus on the creation of models designed for haptic interactions. To construct realistic haptic content, it is important to obtain detailed surface textures of real objects. There are a numbers of studies on surface shape reconstruction, including [Johnson and Adelson 2009], and some researchers have proposed devices for haptic scanning as WHaT [Lang and Andrews 2011]. WHaT enables the user to obtain textures by interactively scanning the surfaces of objects. However, although these methods reveal fine-grained surface details, they do not enable direct design or allow the user to test the sensations of touching the content. For realistic representation of the texture of virtual surfaces, vibrotactile feedback is more effective than force feedback because vibrations can be generated easily and rapidly with simple actuators. In addition, vibrotactile feedback can be easily integrated with force feedback as reported in [Nomura et al. 2010]; forces and vibrations are provided on the basis of the surface properties of virtual objects calculated from photometric images of real objects. In [Minamizawa et al. 2012], Minamizawa et al. proposed a simple method of vibrotacitile feedback using a voice coil to generate vibrations and a microphone to record the vibrations of haptic experiences.

In this project, we propose a data structure of haptic contents for realistic haptic interactions and an editing system for creating haptic-enabled 3D content. As shown in Figure 1, the user can create haptic 3D content by editing haptic properties on a layer editor and touch the created content to test sensations using a pen-shaped haptic interface. To allow the user to design haptic content by using various realistic haptic textures, we realize copying and pasting of haptic textures from tactile materials in the real world to the surface of 3D content in the virtual world.

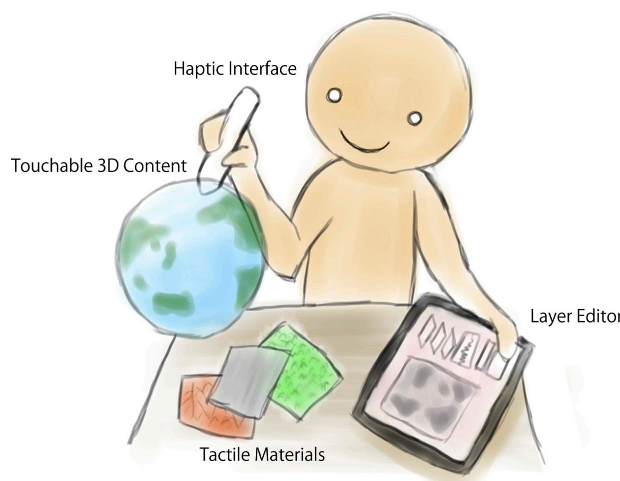

Figure 1: *Concept Sketch of Haptic Editor.*

2 Proposed Method

2.1 Structure of Haptic 3D Content

To generate realistic haptic experiences, we have focused on human haptic perception to create a structure for haptic-enabled content. Human haptic sensations include tactile sensations of the skin and kinesthetic sensations produced at the joints of fingers and arms. Although most conventional display and rendering methods for

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haptic interactions use a unitary physical stimulus, multiple stimuli, each targeting tactile or kinesthetic sensation provide more effective and realistic sensations of touching virtual objects with rich haptic features.

Based on this hypothesis, we propose a data structure for haptic content, which is composed of four layers (see Figure 2). The geometry layer represents geometries of haptic content. The compliance layer and friction layer represent distributions of the values of compliance and friction respectively. These three layers are used for rendering kinesthetic feedback. In addition, the tactile layer represents the distribution of vibrotactile textures, which is used for rendering of tactile feedback.

Since compliance and friction are one-dimensional values on each point of the surface, compliance layer and friction layer are treated as gray scale images to describe distributions of each parameter. On the other hand, to realize vibrotactile feedback based on tactile layer, multiple vibrotactile textures are prepared and tactile layer contains a distribution of IDs of the textures.

To provide sensations of touching 3D haptic content, at first, a physics simulator for 3D interactions detects a contact between a proxy and the geometry. Based on the detected contact point, values of compliance and friction are obtained by referring to layers. These values are used for calculation of contact forces. The ID of vibrotactile texture is also obtained by referring to tactile layer. The vibration of texture is provided based on the speed of stroking toward the surface of the geometry. By changing the playing speed of vibration, uniform sensations of tactile textures are realized.

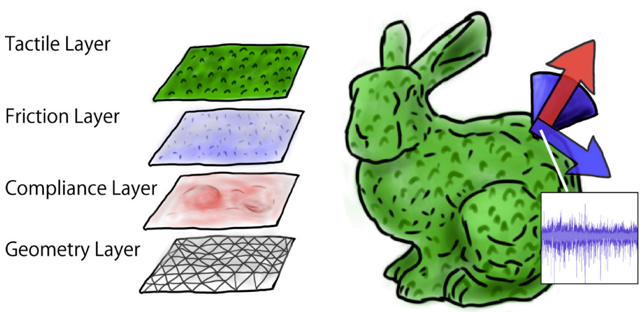

Figure 2: *Proposed Data Structure of Haptic 3D Content.*

2.2 Editor for Haptic 3D Content

The flow of haptic 3D content creation is shown in Figure 3. First, the user draws the geometry of the content through aerial sketching with a pen-shaped interface. 3D shapes are generated on the basis of our sketch-based shape creation method proposed in [Kamuro et al. 2011]. Then, the user paints haptic parameters on layers mapped to surface meshes of geometries. Vibrotactile textures for the tactile layer are obtained by scanning materials in the real world using the haptic interface as a scanner. An audio microphone is attached at the tip of the interface to record vibration sounds as vibrotactile textures [Minamizawa et al. 2012]. The user can design tactile textures for their content easily by using this interactive scanning method. During these processes, the user can check the content by touching its display on a 3D monitor.

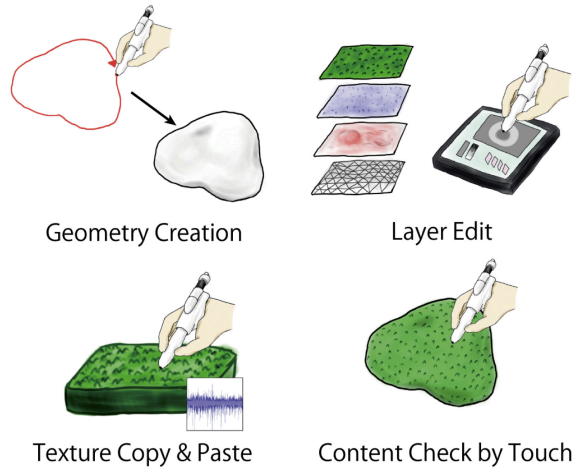

Figure 3: *Flow of Creation of Haptic 3D Content.*

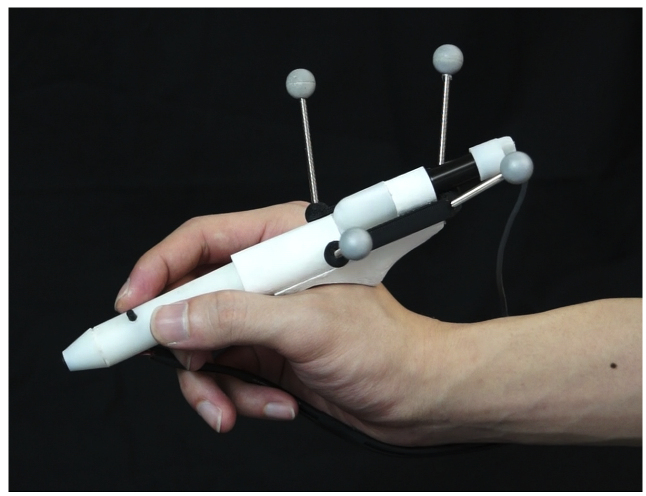

Figure 4: *Ungrounded Pen-shaped Haptic Interface.*

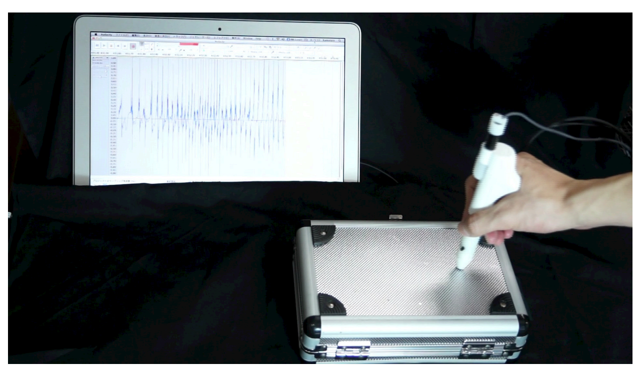

Figure 5: *Vibrotactile Texture Obtained Through Scanning.*

3 System Construction

3.1 Interface for Cration and Experience

We constructed a simple and easy-to-use haptic interface (shown in Figure 4) for the creation and experience of haptic content by integrating the force-display method proposed in [Kamuro et al. 2009] with vibrotactile feedback. The device is composed of two parts: a grip and a base. A DC motor built into the base generates the translation of the grip, which applies forces on the users fingers. Moreover, a voice coil motor built in the grip provides vibrations to the fingers. These components are used for kinesthetic and tactile feedback, respectively. In addition, this haptic interface works as a haptic scanner. In the tip of the grip, a microphone is attached for interactive scanning of real objects. The user can scan target objects with the tip of the interface and obtain vibrotactile textures, as shown in Figure 5.

3.2 System Overview

Figure 6 shows the appearance of the constructed system. The user wears 3D glasses for the 3D monitor and grasps the pen-shaped haptic interface. Positions and poses of the users head and the interface are tracked by an optical tracking system (OptiTrack V120: trio, NaturalPoint, Inc.). Sketching gestures are tracked and recorded, and 3D geometries are generated in a simulation environment constructed on the basis of a physical simulation engine (PhysX, nViria Corp.), as shown in Figure 7.

A layer editor (shown in Figure 8) is displayed on the tablet monitor. Gray scale paintings are used to edit compliance and friction layers that represent distributions of compliance and friction values. To edit the tactile layer, the user paints IDs of vibrotactile textures by palette painting. The user can scan tactile textures from real objects and the sccaned textures are integrated with images and used as tactile palettes. The result of the painting is also shown on the surfaces of the corresponding geometries displayed on the 3D monitor, as shown in Figure 9. Moreover, the user can check the created haptic content by touching the image and getting haptic feedback with the interface. When the user touches the 3D content, the position of the contact between the content and the proxy in the simulation environment is sent to the layer editor. The layer editor extracts the values of friction and compliance and the ID of the tactile texture at the corresponding point of each layer. Contact and frictional forces are calculated on the basis of these values as well as the simulation, and they are generated by driving the motor of the haptic interface. Textural vibrations are provided by the voice coil on the basis of the scanned vibrotactile texture and the stroking velocity toward the surfaces. These separated feedback methods result in the realistic sensations of touching textured objects, produced in an efficient manner.

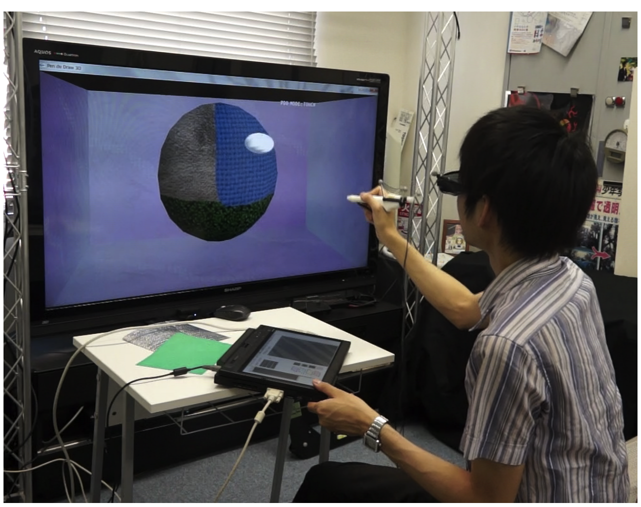

Figure 6: *Constructed Haptic Editor System.*

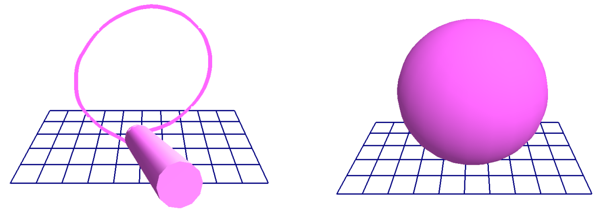

Figure 7: *Example of Sketch-based Geometry Creation.*

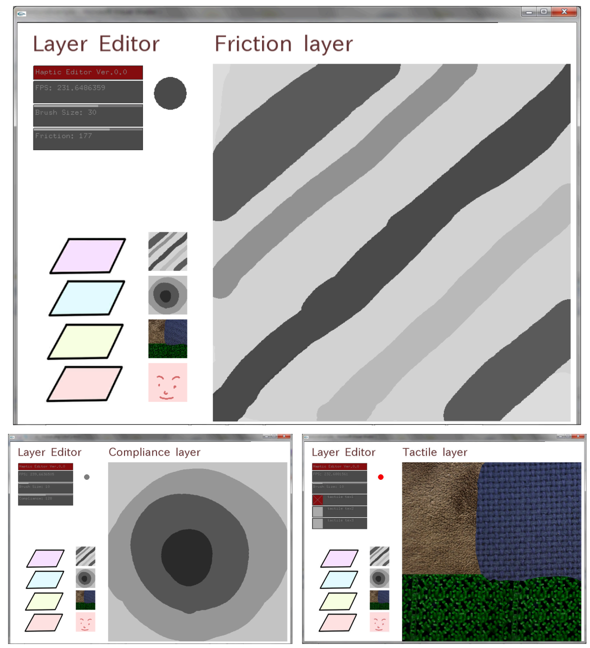

Figure 8: *Layer Editor for Haptic Content. (Top: friction layer, Bottom left: compliance layer, Bottom right: tactile layer)*

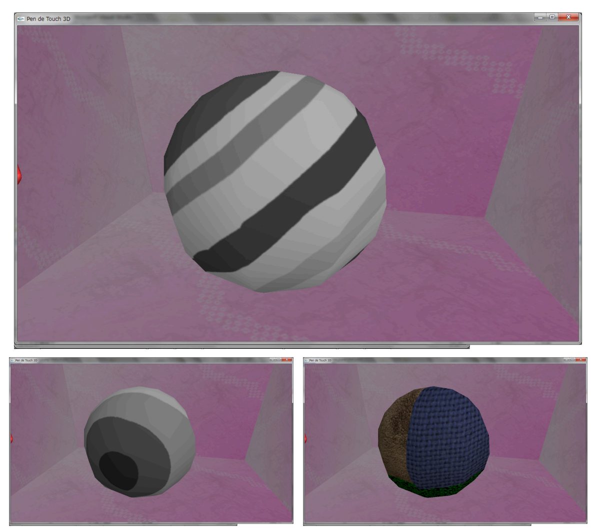

Figure 9: *Reflection of Editing on 3D Content. (Top: friction layer, Bottom left: compliance layer, Bottom right: tactile layer)*

4 Applications

Our simple editing system provides an efficient and intuitive development environment for designers of 3D haptic content. They can design the desired content while editing and experiencing the effects of such content using a simple haptic interface. Furthermore, the users can enjoy creating content with their own hands in the comfort of their homes. Such user-generated-content will serve as a foundation for the popularization of haptic technologies in the future.

One possible example of the practical uses of the proposed system is haptic-enabled online shopping. For this experience, designers would prepare various types of textures that can be used for customizable products. Users, sitting in their homes, would be able to select and test their favorite textures by touching the products virtually via the haptic interface, as shown in Figure 10.

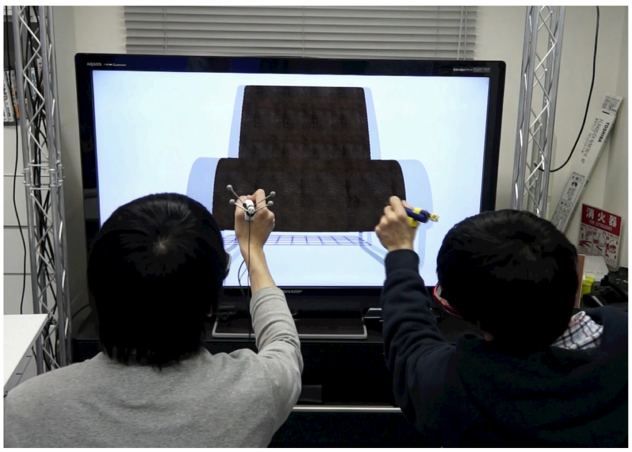

Figure 10: *Haptic-enabled Online Shopping.*

5 Conclusion

In this project, we propose a structure for haptic 3D content with multiple layers for realistic haptic feedback. We constructed an interactive editing system for creating and experiencing the proposed content by using an ungrounded pen-shaped haptic interface. The system enables a user to interactively create haptic content by drawing shapes in the air, painting haptic properties on surfaces, and copying and pasting textures from the real world to the virtual world. Moreover, using the system, the user can touch and enjoy their created 3D content as though it existed in the real world.

Acknowledgements

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