Pot the Magic Pot: Interactive Modification of the Perceived Angular Shape

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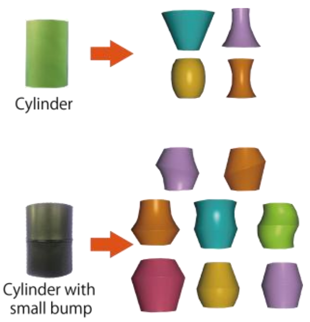

Fig1. Presentable shape

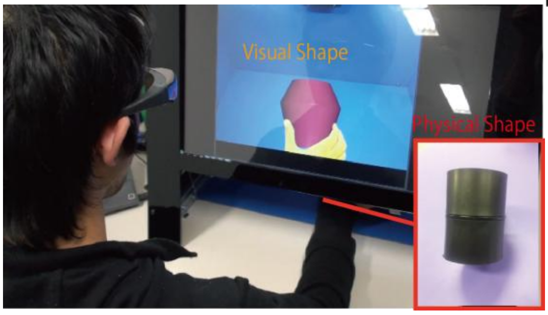

Fig.2 Video See-through System

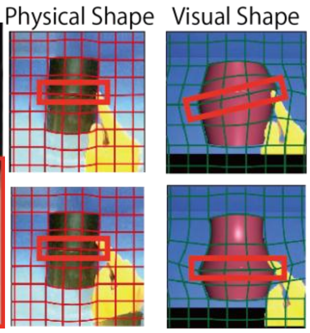

Fig.3 Distortion map based on an edge's posture

1. Introduction

"Pot the Magic Pot" is an interactive system which enables us to experience a haptic illusion as if we were handling various shapes of object of which form and stiffness are modified by users interactively.

Haptics is one of the most important sensations in our life, and many researches have been conducted to realize a device to present virtual haptic sensations. However, because these devices are mainly focus on active haptics which aim to reproduce physical force feedback, they become physically too complicated when we try to reproduce complex haptic sensations to use them easily.

We have aimed to construct the perception-based shape display system which can display various shapes with a brief mechanism, by modifying a perception of shape using visuo-haptic interaction. We already constructed video-see through system which can modify an identified curved surface shape by displacing and deforming user's hand image on the monitor [1]. With this system, we can compose visual feedback as if users were touching various curved surface shape although they are touching only a static cylinder in actual. To present more various and complex shape with this system, we also should adapt to modify the perception of angular shape, stiffness, texture and so on. However, it is very difficult to make users to perceive the angular shape with only touching a static cylinder.

Though, we revealed that we can display angular or scoop with a small particular shape such as small bump through the user experiments [2]. Meanwhile, we also revealed that modifying the movement of hand image to fit to the virtual object can control an identified angle and position of edges on an object [3]. In addition, Lecuyer et al. revealed the pseudo-haptic effect can alter the perception of stiffness with space ball [4].

From these knowledge, this time we constructed interactive visuo-haptic system which can alter more complicated shape include the angular shape and shapes of various stiffness (Fig.1).

2. Rendering algorithm for Visual Feedback

To evoke effective pseudo-haptic illusion, we composed a video see-through system (Fig.2) which can make up an inconsistent situation between our vision and haptic sensation. As the physical object users actually touch behind the monitor, we set a cylindrical object with small bump (Fig.2). The elastic rubber with pressure sensors cover a surface and a bump of this object. The system measures the surface pressure users push and determine the amount of deformation of a surface to modify the perceptual stiffness. The elastic rubber is the source of various perceptual stiffness the system composes.

The hand image is replaced and deformed to fit to the virtual object. This rendering algorithm is composed of three processes. First, from captured image, we detect the contact point and the area of hand and cylindrical object based on color. Then the system generate a distortion map based on difference between the shape of the physical object and the one of virtual object. In this phase, we compose the distortion map to synchronize the timing that a finger passes through an edge physically and virtually to modify the perception of position and angle of edge (Fig.3). Finally, we translate and deform the shape of the user's hands and fit it to the virtual shape. To deform user's hands, we use the algorithm based on moving least squares, which can generate the natural deformation considering the rigidity of the object, based on the displacement of control points. With this method, we already revealed that it can be possible to modify an identified size of object handled with two or more fingers . We displace the user's hand according to the distortion map computed in previous step. Also this system is able to modify its stiffness variously. The system measures the surface pressure and controls the deformation amount to modify an identified stiffness of the virtual object.

3. "Forming" Shape Interactively

With the rendering algorithm previously described, we implemented an interactive system which displays a variety of shapes of virtual objects.

In this experience, a user reform the virtual shape freely like pugging a clay by pinching and pushing the edges and surface of shape. The shape of virtual object is deformed based on these actions. Then we compare the shape of a physical cylinder placed behind the monitor and the one of virtual object in the display, and render the visual feedback to evoke pseudo-haptic sensations, which make users feel as if the curvature and the edge of the cylindrical object changed according to reforming.

References

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