Magic Pot: Interactive Metamorphosis of the Perceived Shape

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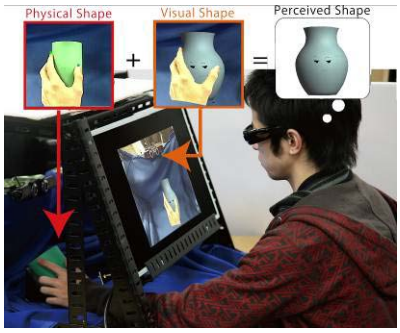

Fig.1 Video See-through System

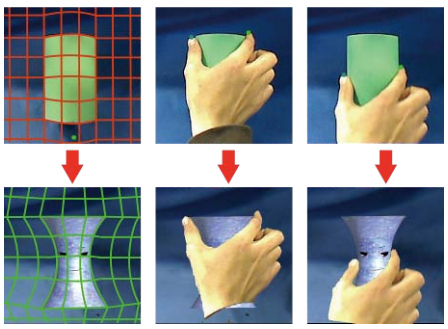

Fig.2 Fitting Hand based on Distortion

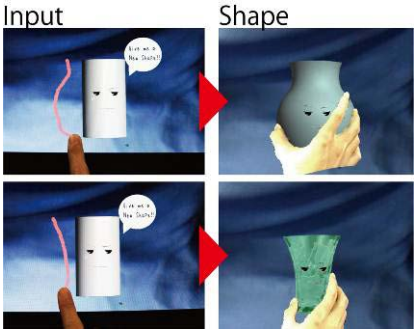

Fig.3 Interactive Metamorphosis of Shape

1. Introduction

"Magic Pot" is an interactive system which changes the perceived shape of a physical object by using haptic illusion.

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.

On the other hand, there are increasing numbers of works which focus on alternative approaches such as passive haptics, which include pseudo-haptics. Pseudo-haptics is a kind of cross modal effect between our visual and haptic sense [1], which indicates an illusional perception in our haptic sensation evoked by vision. This illusion is evoked when we work under an inconsistent situation between the physical behavior of our body and the one observed in our vision. For example, it is revealed that the mismatch between a speed of physical computer mouse and the one of corresponding cursor in display evokes illusional force feedback on our hands. Pseudo-haptic approach is a potential solution for exploiting boundaries and capabilities of the human sensory system to simulate haptic information without physical force feedback.

In our system, we compose a rendering algorithm of visual feedback to evoke pseudo-haptic effects, which affects our haptic perception about shape. This algorithm compose the visual feedback in which we can observe as if we were touching the virtual shape of the object, and evoke a pseudo-haptic illusion which make us to perceive as if the shape, especially the curvature and the size of the static object changed. By using this algorithm, we realize an interactive metamorphosis in the shape of "Magic Pot" using simple interface to shapen it.

2. Rendering algorithm for Visual Feedback

To make up an inconsistent situation between our vision and haptic sensation to evoke effective pseudo-haptic illusion, we composed a video see-through system (Fig. 1). Two cameras and a mirror are placed to capture the images around the physical object placed behind the display from the position corresponding to the user's eyes. These images are processed to change the shape of an object to the one of virtual objects based on the rendering algorithm. Using these composed images for each user's eye, we realize stereoscopic video see-through, in which the user can touch an object observed in display.

Our rendering algorithm is composed of three processes. First, we detect the point on which a user is touching on the physical object. The area of the user's hand is extracted from captured images based on color to find finger tips of the user's pointing finger and thumb as first and second height of the area. Second process is a generation of a distortion map based on difference between the shape of the physical object and the one of virtual object. The area of the physical object is extracted from captured images as green colored area to detect its outline. Then we compute the distortion which fits the outline of the physical object to the virtual one. Finally, we translate and deform the shape of the user's hand and fit it to the virtual shape. To deform user's hand, we use the algorithm based on moving least squares [2], which can generate the natural deformation considering the rigidity of the object, based on the displacement of control points. We displace the user's hand according to the distortion map computed in previous step. Then we deform its shape based on the displacement of two control points, pointing finger and thumb (Fig. 2).

These processes make up the inconsistency between the position and shape of user's hand and the one in the visual feedback, and make up pseudo-haptic effect, which makes the user to perceive virtual shape in visual feedback. We conducted some studies using this system, and revealed 85 percent of people felt the virtual curvature and the size of shape in visual feedback, although they were only touching on a statics cylinder.

3. Interactive System to "Change" Shape

With the rendering algorithm previously described, we implemented an interactive system which displays a variety of shapes of virtual magic pots (Fig. 3).

In this experience, a user draws an outline of the magic pot on touch panel. The shape of virtual magic pot is generated based on this drawing as the rotating shape. Then we compare the shape of a physical cylinder placed behind the display and the one of magic pot in the display, and render the visual feedback to evoke pseudo-haptic sensations, which make users feel as if the curvature of the cylinder changed according to user input.

In addition, the scale of magic pot also changes as user touches on it. The distortion map is regenerated according to the change in scale, and also makes up pseudo-haptic illusion on the perception about the scale of the object.

References

[1] A. Lecuyer: Simulating Haptic Feedback Using Vision: a Survey of Research and Applications of Pseudo-Haptic Feedback, Presence: Teleoperators and Virtual Environments, MIT Press , Volume 8, Issuel, pp. 39-Si53, 2009.

[2] S. Schaefer and T. McPhail and J. Warren: Image Deformation Using Moving Least Squares, ACM SIGGRAPH 2006 Papers (SIGGRAPH '06), ACM, New York, NY, USA, pp.533-540, 2006

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SIGGRAPH 2012, Los Angeles, California, August 5 – 9, 2012.
ISBN 978-1-4503-1435-0/12/0008