Haptic Canvas: Dilatant fluid based haptic interaction

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1 Introduction

Some kinds of substances naturally attract people to touch them. The slurry made from water and starch is one of the haptically fascinating substances, and presents the amusing but mysterious sensation like playing in the mud when you were in childhood. The mysterious haptic sensation comes from the property of the fluid, "dilatancy", which is the change in the state from liquid-like to solid-like according to the external force. The purpose of this study is to establish the new haptic interaction by presenting both direct touch and mechanically variable haptic sensations with the slurry made from water and starch-i.e., "dilatant fluid".

"Haptic Canvas" is a haptic entertainment system presented by dilatant fluid with the controlling grove. Like painting a picture, users can blend haptic paints to create a new haptic sensation by touching virtual haptic paints represented in the shallow pool filled with dilatant fluid, thus coloring and drawing a haptic picture. The haptic paints called "Haptic Primary Colors" are "stickiness", "hardness" and "roughness" sensations represented by the proposed haptic glove. Users can have the experience of distinct multimodal haptic sensations created by the controlling grove with the dilatant fluid.

2 Innovation

The requirements of the system are both direct interaction with the viscoelastic liquid and the control of the dramatic change in the state to present variable sensations. Previous haptic devices using other functional fluid (e.g. Electrorheological fluid or Magnetorheological fluid) [Han et al. 2007; Blake and Gurocak 2009] are not sufficient for the former, while the tactile display using dilatant fluid by using vibrations [Saga and Deguchi 2009] is not sufficient for the latter. This study proposes a new mechanism for the haptic interaction by using jamming of the fluid caused by suction of the water. Jamming is the mechanism by which particulate material can make transition between a liquid-like and a solid-like state with external energy. We intentionally cause the jamming by using the sucking structure with filtration of the particle of the starch. Furthermore, we develop the haptic glove which enables users to make direct interaction with the viscoelastic liquid and to feel the dramatic change of the substance state in their hand by attaching the structure to the fingertip of the glove.

The mechanism of the presenting haptic sensation is as follows. First, users attach the sucking tube with the filter of the particle to their fingertip, and put the finger into the dilatant fluid. Next, during suction, the particles are gathering around the filter, making the concentration of the slurry higher thus leading the jamming. Because the density determines the viscosity of the liquid, we can mechanically control the viscosity of the dilatant fluid by controlling the amount of the accumulated particles. Finally, the friction between the accumulated particle around the fingertip and the precipitated particle at the bottom of the pool works as a break when the finger moves.

The proposed haptic device has four advantages. 1) The device enables users to touch directly with the dilatant fluid and to present distinct sensation of the viscoelastic fluid, like "sliminess" sensation so that exhibits the haptic entertainment. 2) The glove is small and light because of the simple structure consists of the tube and the filter. 3) The device can present large force because the force is presented according to user-intended hand movement. 4) Some other sensory modalities can be presented by considering the structure. We can set both sucking/ejecting pressure and duration to control the amount of the accumulated particles. We found that the sensations that the device can present are "stickiness", "hardness" and "roughness" sensations based on the preliminary qualitative analysis of the device.

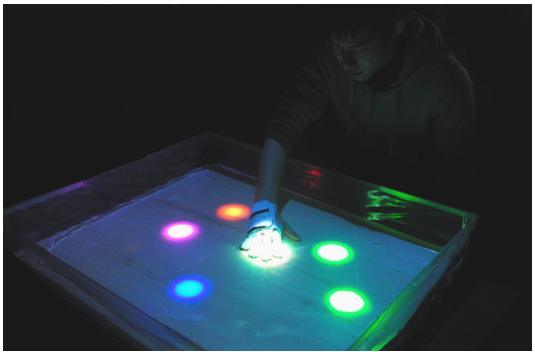

Figure 1: *Haptic Canvas: Red, green and blue correspond to stickiness, hardness and roughness respectively. When users touch the color, they can feel the haptic sensation varying with brightness value.*

3 Interaction

Fig.1 is the scene of the demonstration of "Haptic Canvas" system. Users enjoy the visual and haptic interaction of haptic color projected on the canvas with the haptic glove. The haptic primary colors are generated by touching the sources of haptic sensation (haptic paints) arranged on the canvas and utilized to blend the sensations. Users can move the produced haptic primary colors and blend them by visually contacting each other. The intensity of the light is directly presenting the intensity of the haptic sensation. The intensity of the primary haptic sensations varies with intensity of the colors. User paint a haptic picture by drawing haptic color with feeling the haptic sensation. "Haptic Canvas" system will show that the dilatant fluid based haptic device expands the possibility of haptic entertainment.

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