PhotoelasticTouch: Transparent Rubbery Interface using a LCD and Photoelasticity

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Figure 1: *Tangible objects made from transparent elastic body*

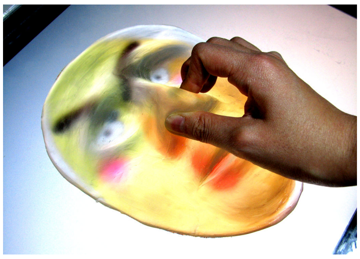

Figure 2: *Tangible interface using rubbery face model*

Figure 3: *Paint application using squeezing interaction*

1 Introduction

PhotoelasticTouch is a tabletop system designed to intuitively facilitate touch-based interaction via real objects made from transparent elastic material. The transparent elastic material (transparent rubber) provides a realistic haptic interface, which when combined with the visual content displayed on the LCD tabletop, enables a balanced coupling of the physical world and digital content. The system utilizes the photo-elastic properties of the transparent rubber to recognize when a user pushes, pulls or pinches the object, while the LCD provides the appropriate visual feedback in accordance to the stress applied to the elastic material.

The technical contribution of the PhotoelasticTouch system is the use of the transparent photo-elastic material to detect the stress applied to tangible objects on the LCD table. Previous vision-based force-sensitive elastic body interfaces [Kamiyama et al. 2004][Kakehi et al. 2008] require special markers to be embedded inside the elastic material which imposed restrictions on the shape of the elastic material. In contrast, our system does not require any markers and does not place any restrictions on the shape of the elastic material.

2 Technology

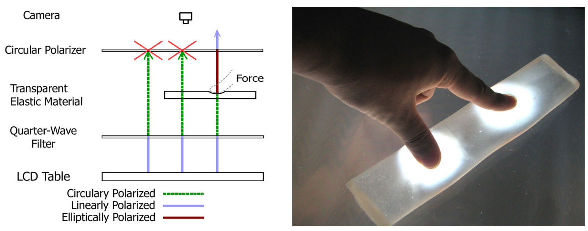

Figure 4: *The filter on the camera blocks the incoming light from the LCD. However, elliptically polarized light induced by deformed regions of the elastic body is visible to the camera.*

PhotoelasticTouch is composed of a horizontal LCD and an overhead camera. A quarter-wavelength filter is attached to entire surface of the LCD to convert the LCD's polarized light to circularly polarized light. In addition, a separate circularly polarizing filter is attached to the camera's lens to cut off the light from the LCD. However, when an user applies pressure to the elastic body on the LCD by pinching or pushing, the circularly polarized light that passes through the deformed area is transformed into elliptically-polarized light due to the properties of the photo-elastic material (Figure.4). This elliptically polarized light passes through the filter of the camera and is captured as a high-intensity region. PhotoelasticTouch detects these regions using low cost image processing to provide low-latency interaction (200fps). Moreover, the orientation and the power of the force can be calculated by monitoring the position and size of the high-intensity region. Note that the image on the LCD is still visible to the user because the wavelength filter and elastic material are both transparent to the naked eye.

3 Application

PhotoelasticTouch enables the user to interact with contents through elastic tangible objects. We have developed an entertainment application using a transparent elastic face, where the user can interact with the 3D face model, with such actions as poking the forehead, pinching the cheek or squeezing the nose. In response to these inputs, the system displays changes in facial expression. As seen in this example (Figure 2), the proposed system allows for an intuitive haptic interface for interactive applications like video games and digital signage.

We have also developed a paint application using small pieces of the elastic material. When the user picks up a piece of the material with his fingers and squeezes it above the LCD, virtual paint drips onto the canvas. The size and shape of the applied paint can be changed by using different pieces or by simply squeezing the piece harder.

References

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