Air Haptics: Displaying feeling of contact with AR object using visuo-haptic interaction

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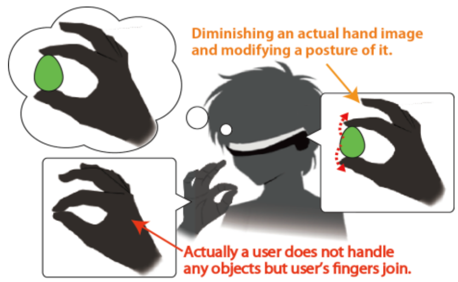

Fig. 1 Visuo-haptic AR system

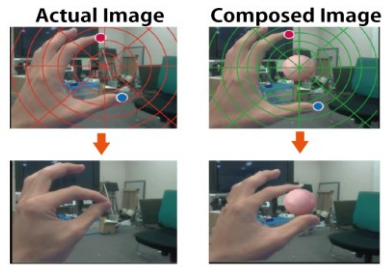

Fig. 2 Modifying hand image's posture

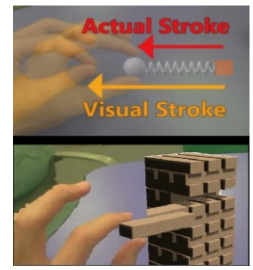

Fig. 3 Interaction with AR objects

1 Introduction

"Air Haptics" is a visuo-haptic Augmented Reality (AR) system which gives us a sense of interacting with AR objects and characters like pinching and pulling, without any haptic devices, only using an effect of visuo-haptic interaction.

AR technologies have been developed, and used to various contents, such as trainings, games, navigation, and so on. However, most of these systems superimpose only visual stimuli, but did not superimpose haptic stimuli to show the interaction with virtual objects. Some researches aimed to realize a system that can display haptic sensation of AR objects, but these systems need haptic devices which reproduce physical force feedback of touching with exoskeleton mechanism or display vibrational or electric stimuli to give a senses of touching AR objects artificially. These devices need to be equipped to user's hands, so these systems tended to be too complex and costly to be used briefly.

On the other hand, there are increasing numbers of works which focus on alternative approaches such as passive haptics, which include visuo-haptic interaction. This phenomenon is a kind of cross modal effect between our visual and haptic sense [Lecuyer et al. 2000], which indicates an illusional perception in our haptic sensation evoked by vision. Using this effect, we can display haptic sensation without physical force feedback. This effect usually uses counterforce from handled objects so it can only display weak haptic sense like wind when a user does not handle objects which generate counterforces. We focus on the point that fingers feel equivalent contacting sensation when pinching an object with fingers (Fig.1 top) and when joining fingers (Fig.1 bottom). Therefore we thought that it can be possible to make users regard joining fingers as contacting to AR objects by controlling bathyesthesia using visuo-haptic interaction effects.

We compose a rendering algorithm of visual feedback to evoke haptic sensation of touching AR objects without any haptic devices. This algorithm composes the visual feedback in which we can observe as if we were pinching AR objects, although actually, we only join our fingers. The system diminishes actual hand's image and superimposes composed hand's image which posture and movement are modified in real time.

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2 Rendering algorithm for Visual Feedback

The video see-through system is composed with a Head Mounted Display (HMD) that mounts a RGB-D camera (Senz3D, Creative) posture and movement are modified in real time. This haptic sensation can enhance an operational feeling of AR objects. Our rendering algorithm is composed of four processes. First, we detect a hand area and fingertips from camera image. Second, the system composes a background image by diminishing actual hand from a captured RGB image. The system interpolates a detected hand area with a background image of pre-frame. When interpolating, the system revise a pre-frame's background image by projective transformation using correspondence of SURF feature points between now and pre frame's image.

Third process is a generation of a distortion map based on an AR object's shape. We translate and deform the shape of the user's hand and fit it to an AR object's shape, using this distortion map. The system synchronizes a time at which a user's actual fingers join and a time at which a deformed hand image contacts with an AR object. To deform user's hand, we use the algorithm based on moving least squares [Schaefer et al. 2006], 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). The system superimposes the deformed hand's image on the back-ground image. Through these processes, the system can display the haptic feedback as if a user pinched AR objects without any haptic devices. We conducted some studies using this system, and revealed 80 percent of people felt pinching AR objects which maximum size is 35mm, although they only contact their fingers.

With the rendering algorithm previously described, we implemented a system which enable us to interact with AR objects with haptic sensation (Fig. 3).The system display a sensation of pinching and moving various size of AR objects.

Acknowledgment

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References

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