Grasping a Virtual Object with a Bare Hand

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1 Introduction

We have developed an augmented reality (AR) system that can allow a user to interact with a virtual object with a bare hand. To realize a natural interaction between a user and a virtual object, it is important to obtain the user's movements accurately and to bring the user into the virtual space. In conventional studies, the user's position is measured by using markers and/or gloves. A problem with this approach is the discomfort experienced when devices are mounted on the user's hand. To solve this problem, we use a depth camera that can measure the depth of a real space. With our AR system, the user does not wear markers or gloves. Instead, a depth camera continuously measures the user's position.

MirageTable [Benko et al. 2012], which also uses a depth camera, was proposed for holding a virtual object; however, with this device, the user cannot grasp the object. We focus on grasping a virtual object, because it is one of the basic movements involved in manipulating an object and more difficult than just holding the object. To achieve grasping, we devise precise detection of the user's fingertips and compute the positional relationship between the virtual object and the fingertips. While grasping the virtual object, the user easily experiences incongruity as regards his interaction with the virtual object, because grasping needs more complex contact conditions than holding. We reduce this incongruity by providing the user with visual information that is close to that of actually grasping an object.

2 Our AR System

To enable a user to grasp a virtual object with a sense of reality, our AR system satisfies the following conditions:

- Grasping a virtual object with a bare hand
- Reducing the visual incongruity between the virtual object and the bare hand

Our AR system uses a depth camera (SoftKinetic DepthSense 325) attached to a head-mounted display (HMD) (SONY HMZ-T3) and an AR maker placed on a desk. The processing procedures for fulfilling the above conditions are described below:

1. By using a depth camera, we can detect a user's fingertips and obtain their three-dimensional coordinates.
2. We transform these three-dimensional coordinates into those in a virtual space.
3. From the positional relationship between the virtual object and the fingertips, we determine whether or not the user can grasp the virtual object.

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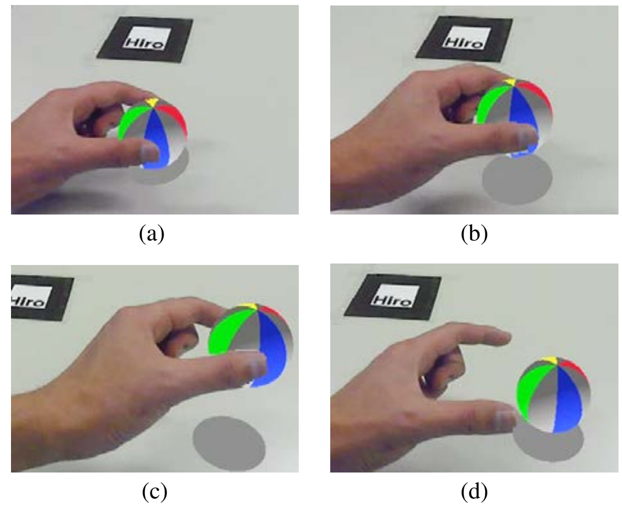

Figure 1: *Results for our AR system. The user (a) grasps, (b) lifts, (c) moves, and (d) releases the virtual object.*

4. With hidden-surface processing, when the user grasps the virtual object, we generate composite images containing the virtual object and the user's hand so that the user can perceive his grasping action as occurring in the real world.
5. We present the composite images on the user's HMD.

3 Results

The user could grasp the virtual object with his bare hand if the distance between his fingertips almost equaled the diameter of the virtual object. Note that we are now implementing more realistic grasping using a physics engine. Figure 1 shows results obtained with our AR system. The hidden-surface processing meant that the index finger behind the virtual object was invisible to the user. On the other hand, the thumb in front of the virtual object was visible to the user. Under the virtual object, we drew its shadow. As the grasping continued, the virtual object moved with the position of the hand and the shadow also moved with the position of the virtual object. Lastly, the virtual object fell from the fingertips to the desk because the distance between the fingertips exceeded the diameter of the object. An assessment of the results reveals that the barehanded interaction and the less-incongruity visual information improved the user's perception of grasping.

In our next stage, we investigate pseudo-haptics with our AR system. With the development of HMDs, our AR system is expected to be useful for realizing natural interactions with virtual objects.

References

BENKO, H., JOTA, R., AND WILSON, A. 2012. Miragetable: Freehand interaction on a projected augmented reality tabletop. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '12)*, 199–208.