3D Contents Arrangement in Handheld Augmented Reality Application Based on Gravity Vector

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ABSTRACT

In this study, we propose a method for controlling a posture of 3D contents for handheld augmented reality (AR) applications. In in-situ AR applications, a 3D content creation phase is needed. In this case, users need to determine 3D position, rotation, and scale of 3D contents. However, general handheld devices have 2D input only. It is very hard to control 7 Degree of Freedom (DoF) of 3D contents using 2 DoF input. To solve this difficulty, we propose a gravity-aware 3D contents arrangement method. By using the proposed method, users can easily control 7 DoF of 3D contents.

Author Keywords

Handheld Augmented Reality, Gravity Sensor, 3D Manipulation

ACM Classification Keywords

H5.2. User Interface: Graphic user interface (GUI), Screen design, User-centered design.

INTRODUCTION

Handheld AR applications have widely been developed for entertainment, education, and task support. In some application, instant 3D content creation is need. In this process, users need to determine 3D position, rotation, and scale of 3D contents. Concretely, users need to adjust 7 parameters (3 for position, 3 for rotation, 1 for scale). Generally, handheld devices have 2D screen input. It is very hard to determine 7 DoF by using 2D screen input. To achieve 7 DoF control, Henrysson et al. have utilized smartphone's physical buttons for positioning where different buttons are mapped for different DoF (Henrysson et al., 2005). Castle et al. uses touch-screen button-based user interface for controlling 3D position, rotation, and scale of 3D contents (Castle, et al., 2008). However, these kinds of interface is not easy to put the 3D contents at the appropriate position, orientation, and scale. For 3D positioning of annotations, Polvi et al. propose a 3D position adjustment method using epipolar constraint (Polvi et al., 2016). In this method, 3D position is adjusted by changing single parameter by sliding the position of the annotation on the display. They reported that users can put annotations at accurate position with their interface. Their interface does not have rotation and scale control functions because they assume to put 2D text annotations. However, in the remote collaboration scenario, 3D annotations as shown in Fig. 1 is important to show actions to the remote user. In this case, 3D annotations need to be put at correct position with correct rotation and scale.

In our study, we use recent tablet devices embedded a camera, gyroscope sensor, accelerate sensor, and magnetometer sensor. In an actual remote collaboration, we can use remote user's view and voice communication. Therefore, we believe simple indicators such as basic arrows are enough for supporting most of tasks. In addition, we assume that most of objects are standing parallel/perpendicular to the gravity direction. From these assumptions, we developed intuitive 3D annotation arrangement interface for handheld augmented reality systems. Our system can control 7 DoF by three parameters. In the following section, we describe details of our proposed user interface.

7 DOF CONTROL METHOD

First, users need to select the 3D contents from a content list. In this list, there are basic indicators as shown in Fig. 1. These indicators are classified into two groups: perpendicular to the gravity and parallel to the gravity. After selecting the contents, users need to determine these positions, orientations, and scales. Our proposed interface is composed of position control phase, rotation control phase, and scale control phase. In each phase, users need to adjust single parameter. Therefore, our method can control 7 DoF of the 3D contents using three parameters.

Position Control Method

We employ the SlidAR user interface for determining a 3D position of 3D contents (Polvi et al., 2016). In SlidAR, users need to specify the target position in a 2D camera image displayed on the tablet device. After specifying the target 2D position, a depth value is set using a camera tracking

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Figure 1. Basic indicators

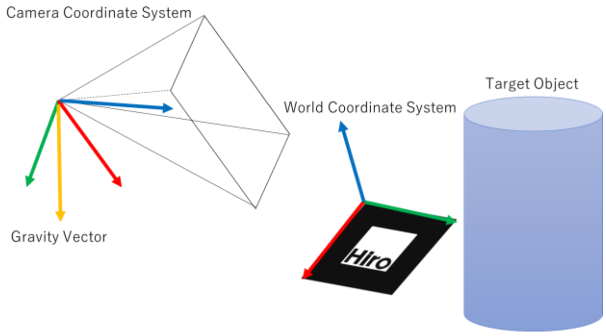

Figure 2. Relationship between coordinate systems and the gravity vector.

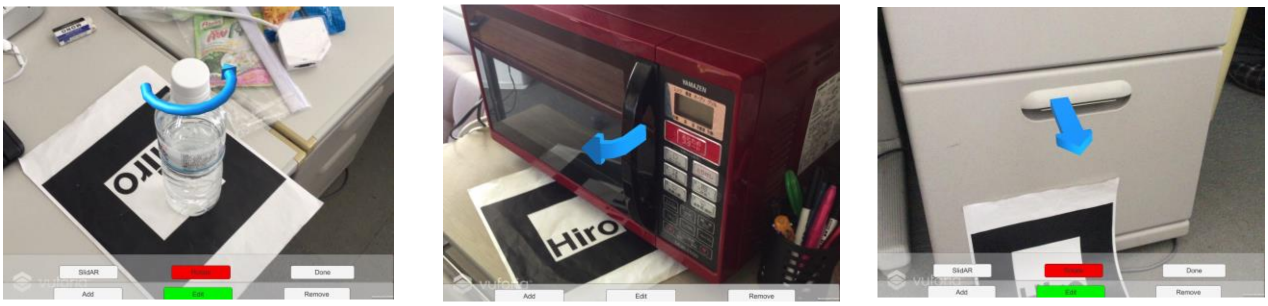

Figure 3. Results

result. If there is an error for the 3D position of the 3D contents, users can correct the 3D position using the SlidAR user interface. In this process, users can correct the 3D position of the annotation by changing the depth value by sliding along to an overlaid 1D line.

Rotation Control method

After determining the 3D position of annotation using SlidAR, users need to change the rotation of the 3D contents to fit target objects. In our system, initial orientation of the annotation is determined based on the gravity direction. In many augmented reality applications, a geometric relationship between the world coordinate system and the camera coordinate system is estimated using camera tracking methods such as marker-based, model-based, and SLAM (simultaneous localization and mapping) methods. In addition, recent handheld devices can measure a gravity direction using an embedded sensor. By using these information, the gravity direction in the world coordinate system can be calculated as shown in Fig. 2. Finally, the initial rotation of annotations is aligned to the gravity direction in the world coordinate system.

After setting the initial rotation, users need to rotate the annotation at the horizontal/vertical plane to the gravity vector. This 1D rotation is enough in our system because we prepare the basic 3D contents based on the horizontal and vertical planes.

Scale Control Method

Finally, users scale the annotation to fit the actual object size. In order to control a scaling factor of the 3D contents, we employ a pinching action on the handheld devices. A size of 3D contents changes by pinching-in and pinching-out actions.

PRELIMINARY EXPERIMENT

We developed the prototype system using iPad Air 2. We used Vuforia SDK[i] to get camera positions and rotations. The results of the 3D contents arrangements are shown in Fig. 3. By using our prototype system, 3D contents were put at the correct position, orientation, and scale.

CONCLUSION

We proposed 7 DoF control method for putting 3D contents into the real world using handheld augmented reality applications. By considering the gravity direction, users can control 3D orientation of the annotation easily. In the future, we are planning to conduct user study for evaluating an efficiency of our proposed user interface.

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[i] https://www.vuforia.com/