Manipulation of a VR object using user's pre-motion

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1 Introduction

VR (Virtual Reality) is a technology to artificially generate a sense of reality by using computer graphics and acoustic techniques. Manipulation in VR has some problems: the necessity of pre-learning for manipulations, the difficulty of manipulation commands for some users, and limited parts of available human's motion. In this paper, we propose a new method to intuitively and easily manipulate objects in VR. The purpose of the method is to give common users an instinctually simple interface to a VR system with using their natural behaviors as their commands when they want to manipulate VR objects. To capture the natural behaviors as the interface to VR, we present the definitions to classify the kinds of objects in VR and the motions with which users may perform their behaviors to face the classified objects. We focus the initial motions of users to face an object in VR. The initial motions include "hand pre-shaping" [1]. Hand pre-shaping is known as human's unconscious behavior to face a small object to be grasped [2, 3]. We unconsciously prepare the motion in advance of the actual behavior to the facing object according to the purpose of the behavior and the property of the object. In this paper, we call "preparation of motion" pre-motion. The pre-motion differs according to the purpose of behaviors and the property of objects. Given the definition of pre-motion, users' will can be guessed by the pre-motion. In this paper, the characteristics of pre-motions to a facing object with various sizes, hardness and weights, are classified with the purpose and the property. To validate the pertinence of the classifications, preliminary experiments are performed.

2 Classification definitions

2.1 Definition of object classification by feature

Aiming at the classification of VR object attributions that trigger different pre-motions, we investigate the classification of VR object features. We focus on the following five features: shape, location, size, weight, and hardness.

2.2 Shape

We assume that human's pre-motions are similar for the target objects with a similar shape. Based on the assumption, we need to classify pre-motions by object shape. Shapes are classified into several primitives. Human's holding motions are similar when the target objects are classified in a shape with the same primitive.

2.2.1 Location

The direction of reaching out for an object varies according to the location where the object is placed. It turns out that the location of an object plays an important role in understanding user's will for the object in advance because different object locations cause the user to reach out for the objects in different directions.

2.2.2 Size

When we are going to hold an object, we unconsciously decide whether we reach out one hand or both hands for the object in advance. So we classify objects by size in two categories: hand size objects to be grasped by one hand and larger object to be held by both hands. It turns out that a single hand is used for grasping an object with at most hand-size while both hands are used for holding an object with larger size than his/her hand. So the object size dominates human's motions of holding and grasping, and the object size should be classified.

2.2.3 Weight

Lifting an object by hand, we judge whether we use one hand or both hands by the physical appearance weight of the object. It turns out that the weight of the target object affects the motion of the user. So the weight of objects should be classified in two categories: heavy (requires both hands to hold) and light (requires one hand to grasp).

2.2.4 Hardness

When the size of the target objects is too large to grasp by one hand, some objects are graspable by one hand. In this case, the hardness of the target objects is different: soft and hard. The motion is possible when the target is enough soft that a part of the object can be deformed to be grasped by one hand and the object is enough light for one-hand grasping. However, it turns out that some objects are soft and deformable so that they are grasped by one hand. So the hardness of objects should be classified in two categories: hard (requires both hands to hold) and soft (requires one hand to grasp).

2.3 Definition of motion classification

The motion of holding or grasping includes the pre-motion of reaching out one hand or both hands to the target object. When reaching out user's hand(s), there are two possible motions of touching and lifting. We believe

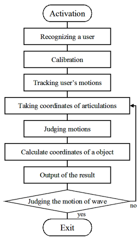

Fig. 1. The operation flow of the prototype system.

that the difference between the two motions is predictable by analyzing the shape of the fingers, the number of the hands, and the way of opening one's hands regarding to the object features.

2.3.1 The number of hands

When reaching out to an object, we judge whether we use one hand or both hands regarding to the size, the weight, and the hardness of the object. In the case of one hand, when the object size is small and the object weight is light, we predict that the object is to be grasped or touched. Even when the object is large, it could be grasped, provided that it is light and very soft. Otherwise we predict it is to be touched. In the case of both hands, we reach out to the object with opening the hands when the object size is large. Even when the object is small, we use both hands to hold the heavy object.

2.3.2 The shape of fingers

When the target object is enough small and light to be grasped by one hand, the motion of reaching out may be also a touching. To predict whether the motion is for grasping or touching, we classify the shape of fingers. The shapes of fingers, exactly saying the shapes formed by the thumb and the other fingers, are with sharp and right angles. Since the target object is hand-size, the distance between the thumb and the other fingers is larger than the height of the object. To grasp the object, since it is taken between the thumb and other fingers with conforming the palm, we understand this case represents a grasping motion. In short, the pre-motion for grasping includes a curve formed by the fingers and a longer distance between the fingertips than the object height (or width).

2.3.3 Distance between two hands

In this paper, the horizontal, the vertical, and the depth directions to the VR screen are defined as x-, y- and z-axis, respectively. The object width along the x-axis and y-axis are defined as sideways and longitudinal width, respectively. To hold an object by two hands, the distance between two hands is prepared to be longer than the sideways or the longitudinal width of the object in advance of actual holding. On the other hand, when the distance is shorter, the motion is predicted as touching. In this way, the distance between two hands should be classified so that the change of holding and touching motion is predictable.

3 Preliminary experiment

We perform preliminary experiments using a prototype system provided that we focus a limited target with corresponding motions. The target object we use in this experiment is a cuboid. The preliminary experiment requires motion capture ability. So we use Kinect as a sensor device to capture user's motions. The operation flow of the prototype is shown as Fig.1. As the results of the experiment, we conclude that the prototype system based on the definition works well as. Figure 2 shows the user reaches out her both hands. The distance between two hands is shorter than the sideway width of the cuboid, and the user reaches out her hands toward a side of the cuboid. It means that user's request to VR objects is predictable and understandable based on the definition shown in subsection 2.2. Therefore we show that it is possible to take in human's natural motion, as we here propose human's pre-motion, for manipulating VR objects.

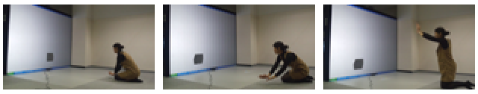

Fig. 2. Reaching out both hands for (a)Touching (b)Pushing and (c)Lifting.

4 Conclusion

VR is one of the most effective presentation methods for giving any people various information that is difficult to show such as world heritages or national treasures. The most critical problem to use such VR is that typical VR systems require pre-defined control commands for presented 3D objects. In short, it is difficult for common people, who are not familiar with VR operations, to manipulate 3D objects using such special commands in VR. In this paper, we proposed the definition to classify the relation between user's pre-motion and his/her target 3D object in VR. The purpose of the definition is to allow any user to intuitively and naturally manipulate 3D objects in VR. In such a VR system, user can manipulate 3D object without learning control methods in advance. To get user's natural behavior as commands, definitions of classifications in user's motions are constructed based on user's initial, here we say "pre-", motions. So we classify objects and user's motions to the objects. To validate the pertinence of the classification, a prototype system with Kinect has been developed, and we performed some experiments with the prototype. In this experiment, a cuboid is displayed in the prototype VR system to be manipulated by an examinee. As the results, the examinee's pre-motions, reaching out one/both hand(s), are recognized by the prototype based on the classification definitions. We conclude that it is possible for ordinal people to intuitively and naturally manipulate 3D objects in VR. Our future work includes smarter classifications for more complicated objects and various pre-motions.

References

[1] Bard C., Troccaz J., Vercelli G., Shape Analysis and Hand Preshaping for Grasping, IEEE, vol.15, pp.23-30, 1996.

[2] Jeannerod M., The timing of natural prehension movements, Journal of Motor Behavior, 16, pp235-254, 1984.

[3] Arbib M.A, Iberall T., and Lyons D. Coordinated control programs for movements of the hand, Experimental brain research, 10, pp.111-129, 1985.