AR Pottery Wheel-Throwing by Attaching Omnidirectional Cameras to the Center of a User's Palms

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ABSTRACT

This research describes our system for AR pottery wheel-throwing employing an HMD and omnidirectional cameras each of which is attached to the center of a user's palm. The omnidirectional cameras enable the user's finger postures and the three-dimensional relative position and orientation between the user's hands and virtual clay model on the wheel to be estimated. Our system detects a marker on the desk and the wheel is set on its coordinate system along with the finger posture estimation in real time. The system then simulates the collision between the virtual clay model and the left/right hand model based on the above information. Pottery wheel-throwing is reproduced in Unity software environment by deforming the clay model by contact with hand models in this simulation.

CCS CONCEPTS

•**Human-centered computing** → **Human computer interaction** → **Interaction paradigms** → **Virtual reality;**

KEYWORDS

Marker-based AR, Omnidirectional Camera, Finger Posture

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1 INTRODUCTION

Studies on three-dimensional reconstruction of finger postures have been actively conducted for user interfaces such as AR and VR. For instance, Leap Motion [1], which estimates the position and orientation of a user's hand with an active infrared camera and Digits [2], which is a wrist-worn sensor that recovers the full 3D pose of the user's hand. Previously, Maruyama et al. proposed a method for estimating the natural finger postures of a user's fingers by detecting the fingertips on each fish-eye image captured using an omnidirectional camera attached to the center of a user's palm [3]. The following preset information was referred to in the aforementioned study: The positional relationship between the camera and the user's fingers/fingertips, the length between the finger joints, and the interdependencies between the finger joints in real time. This paper describes our system for AR pottery wheel-throwing employing an HMD and the omnidirectional cameras, each of which are attached to the center of the user's palm. Our system mainly applies functions for estimating the user's finger postures, detecting the marker on the desk as the wheel, and deforming the virtual clay model on the wheel by simulating the collision between the clay model and the user's left/right hand in a virtual space of Unity. The proposed system in this paper is based on the method proposed by Maruyama et al. [3]. This method can estimate it independent of the user's hand position and wrist rotation since the camera is attached on the user's palm. CycropsRing is a ring-style fish-eye wearable imaging devise that identifies the gestures of the user's fingers using the environmental contexts [4]. This system identifies the user's gestures by tracking the user's fingers that are touched by the ring devise. It is difficult to stably track the user's fingers using CycropsRing because the relative orientation between the device and the user's palm changes with the posture change of the user's fingers where the ring is touched. Kashiwagi et al. proposed a measurement system for grasping postures using a fish-eye camera attached to the cap of a cylindrical object, such as a jar or a bottle [5]. The system requires that the fish-eye camera is attached to the object that the user is grasping. The method proposed by Maruyama et al. can estimate the user's finger postures just by detecting the fingertips because

Figure 1. Attaching the omnidirectional camera

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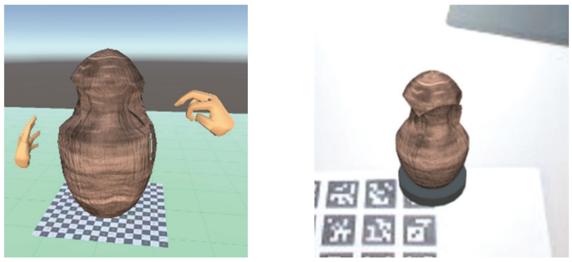
the relative orientation between the omnidirectional camera and the user's palm is fixed [3]. Our system reproduces pottery wheel-throwing with models of the clay and hands based on the three-dimensional relative position and orientation between the marker and each camera estimated by referring to the marker coordinate system. The clay model on the marker is deformed based on the information obtained from the collision simulation between the clay model and the left/right hand model. The user attaches RICOH THETA S to the center of each palm as depicted in Figure 1 to prevent restrictions to the movement of the user's fingers as far as possible.

2 SYSTEM IMPLEMENTATIONS

Our proposed system is composed of the following functions:

- Finger postures tracking using the method proposed by Maruyama et al. [3].
- Tracking of three-dimensional relative position and orientation between the user's hands and the clay model on the wheel.
- Deforming a part of the clay model on the wheel based on the information obtained from the collision simulation between the clay model and the left/right hand model in the virtual space of Unity software environment.

We have developed an AR pottery wheel-throwing application (Figure 2). The HMD shows the user images captured from their viewpoint using the attached camera. The system then detects the marker from the images and overlays the virtual rotating wheel and the clay model on the marker. The system estimates the user's finger postures along with the three-dimensional relative position and orientation between the user's hands and the marker on the desk using the omnidirectional camera attached to the center of the user's palm. The user's finger postures are estimated with the method proposed by Maruyama et al. [3]. The system then detects a marker on the desk from the images captured by the omnidirectional camera and the wheel is set on its coordinate system. The clay model on the wheel and the hand models are generated in the virtual space of Unity for simulating the collision between the clay model on the wheel and the left/right hand model which is adjusted based on the marker coordinate system (Figure 2(a)). These models are constituted by mesh. The system deforms a part of the mesh that constitutes the clay surface where the left/right hand model collided with the clay model if Unity detects the collision between these models. Pottery wheel-throwing is reproduced by reflecting the deformation of the clay model on the wheel and the user can see the change on the HMD (Figure 2(b)). We employ the Aruco marker [6], which consists of multiple AR markers because the user's fingers would often occlude a single marker in an image captured by the palm worn camera. Aruco only requires a single part of the unified marker to be detected. We also correct the distortion of the fish-eye image captured by the omnidirectional camera for improving the marker detection accuracy. Our system detects the Aruco marker from the image as depicted in Figure 3.



(a) Collision detection in Unity (b) Overlaying the clay model
Figure 2. AR pottery wheel-throwing

Figure 3. Marker detection in consideration of the fish-eye image's distortion and occlusion

3 CONCLUDING REMARKS

We have developed a system for playing AR pottery wheel-throwing by estimating the natural finger postures of a user's fingers and the three-dimensional relative position and orientation of a marker detected from the images captured by omnidirectional cameras, which each of which are attached to the center of the user's palm in real time. This system cannot detect the marker if the marker is not in the view range of the camera or if the area of the image is too small not including the user's finger. We intend to apply multiple plural Aruco markers on the desk. This method can be used to correct the three-dimensional position of hand models in the virtual space just by detecting one of the markers. We also consider a method to improve the correction of the three-dimensional position of hand models using additional sensors. These sensors would enable the estimation of the direction and the distance of the hand motion without using markers. Although this method cannot estimate unnatural finger posture, e.g., the user bends MP joints for lifting a desk, this method is useful except for systems in which the user is grabbing something because the finger postures are likely to be natural. Our system can be applied to the user's natural finger postures. We employ THETA S developed by RICOH in this system; however, the installation results in it protruding from the user's palm, which is dangerous. We expect the method is useful, and a device for using our system will be developed.

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