R-V Dynamics Illusion Experience System in Mixed Reality Space

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ABSTRACT

In Mixed Reality (MR) space, we can change appearances of a real object (R) and virtual object (V). In this research, we visually change movements of the real and virtual objects and observe the influences of the virtual object's dynamics on the sense of the weight of the real object. In this demo, participants can experience this illusion under some conditions that moving virtual liquid is superimposed on the real object.

Keywords: Mixed Reality, Sense of Weight, Visual Stimulation, Psychophysical Influence.

Index Terms: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, augmented, and virtual realities

1 INTRODUCTION

In our research group, we have studied interaction and complementary effects between the visual sense and tactile sense using MR technology. Through the use of MR technology, in which it is possible to combine the real world and virtual world in real time, phenomena that occur in the real world can be superimposed on CG (Computer Graphics) image, and a discrepancy between the visual sense and tactile sense can be intentionally produced. We have conducted tests and analysis in a systematic way in regard to the kind of influence visual stimulation (hereafter, "MR visual stimulation") has on the visual sense. Through this, we have discovered various illusions, such as the "Shape-COG Illusion" [1], in which an illusion of the center of gravity is provided by MR visual stimulation for a center of gravity that differs from the actual object and the "Dent-Softness Illusion" [2], which is an illusion of hardness gained by providing MR visual stimulation of hardness that differs from the actual object. We have gained a significant amount of objective knowledge about these illusory phenomena.

Here, we demonstrate "R-V Dynamics Illusion" where different movement states of the real object (R) and virtual object (V) could influences the perception of weight of the actual object through the visual sense [3].

2 R-V DYNAMICS ILLUSION EXPERIENCE SYSTEM

2.1 System Design

In the system, we firstly focus on a situation in which a virtual object that has movable portion in it is superimposed on a real object.

From previous study [3][4], we found that, when the liquid computer-generated image (CGI) was shown to be moving, the object was felt to be lighter than the case where the liquid was not moving. This tendency was regardless of the liquid level. We also found that the lower the liquid level became, the lighter real object was perceived. Moreover, when acceleration of liquid was higher, the lighter real object was perceived.

In the experience system, we designed for participants to be experience the combination of these conditions of the visual stimulation.

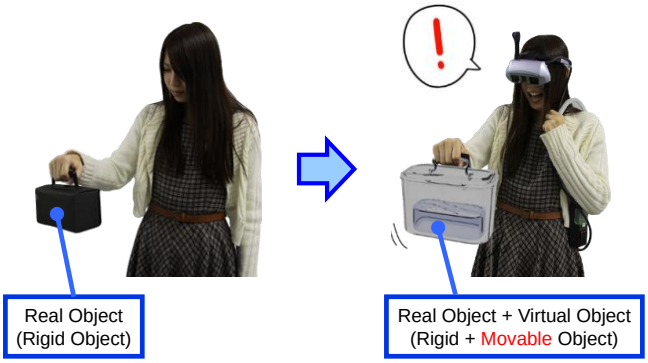

Figure 1: R-V Dynamics Illusion

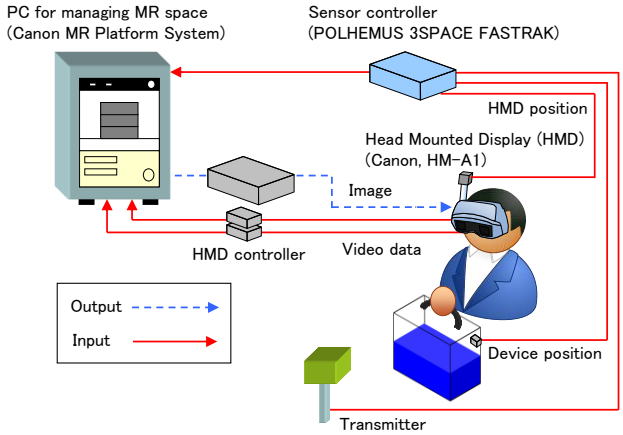

Figure 2: System configuration

2.2 System Configuration

Fig. 2 shows the system configuration of our Demo system. In this system, participants wear a head-mounted display (HMD) (HM-A1, Canon Inc.) with a pair of built-in video cameras. The participants view the stereoscopic images that are CGI in the scene in front of their eyes. Their head positions and position of real object were constantly tracked within six degrees of freedom (6-DOF) by a magnetic sensor (3SPACE FASTRAK, Polhemus Inc.), which allows the participants to move their head freely. The sampling rate of the magnetic sensor is 120Hz, and the HMD is operating at 30fps. The participants, when observing the MR space, depict the hand area for the HMD camera capture image, and by masking that area, ensures that the CG is not superimposed on the hand area.

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2.3 Actual object used

The real object used in the experiment was a plastic case (165 mm width × 90 mm height × 80 mm depth) with the handle (**Fig. 3, Fig. 4**). The weight of the plastic case was adjusted to 750 g, which was the weight of a case filled with water up to the level of 45 mm (50 % of the case height).

2.4 MR visual simulation

The size of virtual object used for MR visual stimulation was the same as the real object. The parameters of MR visual stimulation are following;

(i) Liquid is moving or not moving
(ii) Liquid level
(iii) Acceleration of liquid movement

We superimpose MR visual stimulation on real object, which is reminded of moving liquid in an object to confirm whether tactual perception is different between a case that liquid in the object moves according to the user's hand movement and a case that liquid dose not move. We prepared five liquid levels, 27mm (30% of the virtual object's height), 36mm (40%), 45mm (50%), 54mm (60%), and 63mm (70%) in this system. The liquid section was light blue while the section without any liquid was colored white (**Fig. 5**). Participants shook the container left and right, presenting an image of the liquid inside moving left and right. We employed a simplified model that mimics the swaying of the liquid, without a detailed representation such as waves or splash (**Fig. 6**).

In Fig. 6, C is a value affecting the acceleration of the liquid. The viscosity of liquid is perceived higher as the value C increases. In a preliminary experiment, the participants felt the movement of our liquid model like the water when the value C was approximately 0.98 (deg/s^2). Therefore, we prepared five stimulations based on this 0.98 (Pattern1: 0.98 × 0.50, Pattern2: 0.98 × 0.75, Pattern3: 0.98 × 1.00, Pattern4: 0.98 × 1.25, Pattern5: 0.98 × 1.50).

3 Conclusion

We developed the experience system of R-V Dynamics Illusion. This system superimposes several MR visual stimulations on the real object, which reminds of moving liquid in an object to confirm whether tactual perception is difference or not between various parameters. Parameters of the MR visual stimulation in the system are "liquid moving / not moving," "liquid level," and "liquid acceleration." By adjusting these parameters, it is possible to experience the R-V Dynamics Illusion.

4 Acknowledgement

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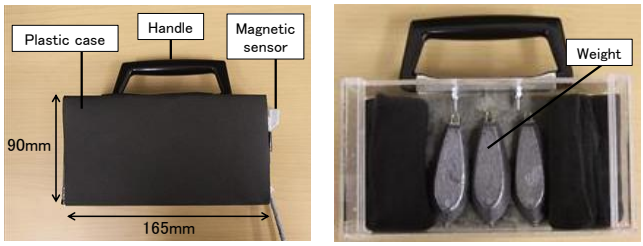


Figure 3: Real object used in the system

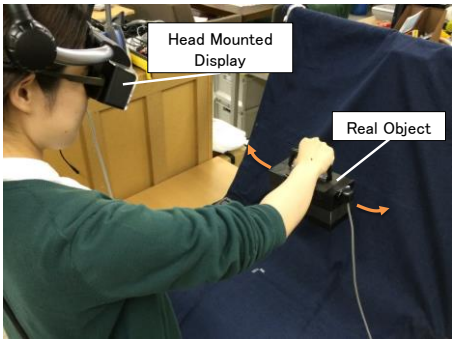


Figure 4: Experimental Scene

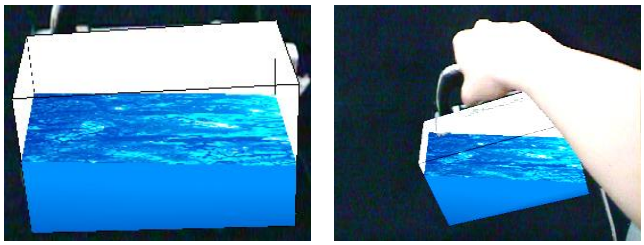
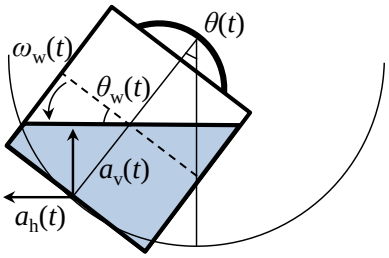


Figure 5: MR visual stimulation used in the system



$$a_w(t) = -(C - a_v(t))\cos\theta(t) + a_h(t)\sin\theta(t) \quad (1)$$

$$\omega_w(t) = \int a_w(t)dt \quad (2)$$

$$\theta_w(t) = \int \omega_w(t)dt \quad (3)$$

$a_w(t)$	Angular acceleration of a liquid
$\omega_w(t)$	Angular velocity of a liquid
$\theta_w(t)$	Angle of a liquid
$\theta(t)$	Angle of object
$a_v(t)$	Acceleration of object (vertical direction)
$a_h(t)$	Acceleration of object (horizontal direction)
C	Acceleration value

Figure 6: Simplified model of virtual liquid movement