Transmission of Information through Haptic Interaction

Koichi Hirota and Yuichiro Sekiguchi

Department of Human and Engineered Environmental Studies
Graduate School of Frontier Sciences, University of Tokyo
5-1-5 Kashiwa-no-ha, Kashiwa, Chiba 277-8563, Japan
k-hirota@k.u-tokyo.ac.jp, sekiguchi@media.k.u-tokyo.ac.jp

Abstract. This paper describes a novel approach to haptic interface that transmits information through dynamic interaction. The approach is based on the idea of emulating an object that causes dynamic reaction, such as a box with content inside, using a mechanical device. Hence, the device should be designed as an object-oriented and self-contained form that can be handled similarly to the real object. Implementation of a prototype device that materializes this idea is introduced, and a possibility of expanding the idea into various scales of interaction and different modality is also discussed.

Keywords: Haptic device, haptic interaction, inertial force, virtual reality.

1 Introduction

It is interesting that we can estimate the content of a box or a bottle by shaking it. It is a common practice that we shake a bottle to know the remaining amount of drinks; also we often give a box a shake to know if the box is empty or not (Figure 1). If the bottle or the box is held just statically, it informs us of only gross weight of the container and the content; through dynamic interaction such as shaking, it provides more information which is helpful to know, for example, about the amount of liquid or approximate number of candies. This observation leads us to the idea of a novel haptic interface that transmits information through haptic interaction. This paper focuses mainly on the concept of such device.

Fig. 1. Box and bottle with content as passive haptic device

2 Background and Related Research

Although shaking a box or a bottle is frequently experienced, the mechanism of recognition about content is considered to be still not clear. According to knowledge

R. Shumaker (Ed.): Virtual and Mixed Reality, LNCS 5622, pp. 313–317, 2009.

from psychology, it is experimentally proven that human can tell the difference of the shape of solid objects by swinging them [9]. In the research of robotics, identifying inertial parameter of robot arm through experimental actuation of the mechanism is one of common technique. Estimating content of box or bottle is considered as an advanced task for human in that it involves dynamics of content and that the model of the content is not necessarily known.

From the viewpoint of haptic feedback, there are researches on presentation of dynamics model. Most of them are focusing on modeling and computation algorism of physics-based model, and carried out using general-purpose haptic device that is grounded to the environment. This implementation does not conform to our idea.

Box or bottle is considered as a kind of haptic device that respond to user's interaction and feedback force to the user. Hence, a device that emulates the box or the bottle must be implemented in a form that is compatible to the box or the bottle. In other words, the device must be an object that is handled and behaves similarly to the box or the bottle.

The idea of encounter type device has been proposed [3,5,8], however, it was mainly focused on presentation of surface. Also, there are many researches on portable and wearable haptic devices [1,2,6,10]; most of them are intended to transmit information such as intensity of force or direction of rotation through haptic sensation, and little of them were focusing on information that is transmitted by dynamic interaction. There are some researches that deals with dynamic interaction in shaking operation [7,11], however, the reaction of these devices were strictly limited to fit to the application of these researches.

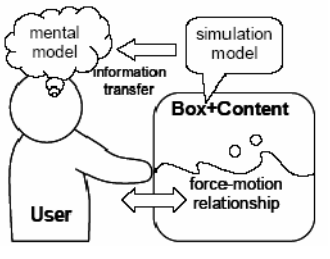

Fig. 2. Transmission of information through haptic interaction

3 Concept

The device that is based on our idea is considered to have two important aspects. One aspect is that, as stated above, it transmits information through haptic interaction, rather than through force or tactile sensation as independent sensory channel (Figure 2). There are various types of physical material and parameters that characterize each type of material. According to our experience, we can distinguish liquid, solid bodies, and powder as different type of content; also we will be able to approximately recognize parameters such as viscosity of liquid and size or weight of solid bodies. By

mapping these types of material and parameters into information that is specific to application area, the device is expected to serve as a display that provides information through haptic interaction.

Another aspect of our idea is that it seeks for object-oriented device. Similarly to box or bottle, the device serves as a portable and self-contained object. Haptic interface of this approach is considered to be advantageous in case when it is integrated with a hand-held information device, such as cellular-phone and personal digital assistant.

4 Prototype

A prototype device that materializes the concept has been developed [4]. The device consists of a mechanism that moves mass, hence gravity center of the device, by one degree of freedom. Figure 3 shows the picture of the device, where 'frame' represents a part of box or bottle while the link that is parallel to the frame is the mass that is actuated to emulate the motion of content. Also, the device is equipped with an accelerometer that measures the acceleration of the frame.

Since the device virtually represents an object, the weight of the device is identical with gross weight of the object. Also, in the design of the prototype, a special attention was paid on the ratio of weigh of the frame and the moving mass; because, by allocating more weight as moving mass, the device becomes capable of providing interaction with larger content mass. In the prototype, the mechanism was implemented as a parallel-link mechanism where actuators were integrated into a part of the moving mass.

The control system consists of a servo system that actuates the device so that the motion of the gravity center of the device becomes identical with that of the object model. Also, external force, which is usually applied by the user, was estimated based on the acceleration of the frame of the device. The goal position of the gravity center is computed by using an object model based on the estimated external force.

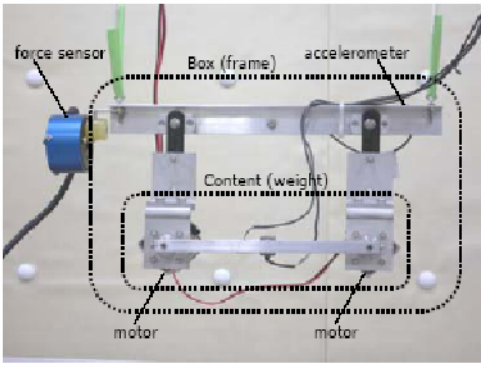

Fig. 3. Prototype device

5 Discussion and Conclusion

The prototype device has been designed following initial idea of emulating a box or a bottle, hence, design parameters such as movable mass and range of movement were determined assuming interaction using two hands. These design parameters must be determined based on modality of interaction that is required from its application. Device of various scales is conceivable, and also interaction style must differ from each other; a small device may be manipulated using fingers, on the other hand, larger device will require interaction using entire body (Figure 4). Implementation of these devices will be investigated in our future work.

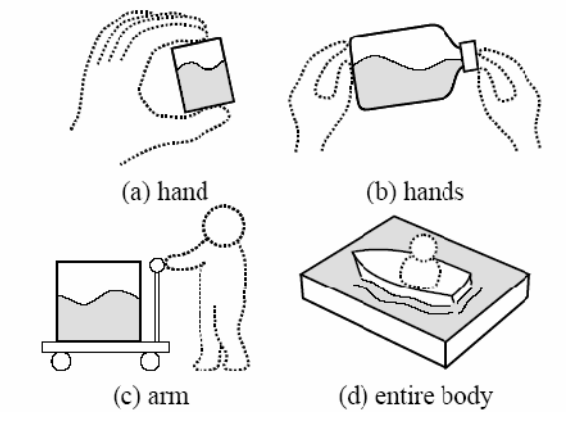

Fig. 4. Scale and modality in interaction design

References

1. Amemiya, T., Ando, H., Maeda, T.: Directed Force Perception When Holding a Non-grounding Force Display in the Air. In: Proc. EuroHaptics 2006, pp. 317–324 (2006)
2. Ando, H., Obana, K., Sugimoto, M., Maeda, T.: A wearable force display based on brake change in angular momentum. In: Proc. ICAT 2002, pp. 16–21 (2002)
3. Hirota, K., Hirose, M.: Providing Force Feedback in Virtual Environments. IEEE Computer Graphics and Applications 15(5), 22–30 (1995)
4. Hirota, K., Sasaki, S., Sekiguchi, Y.: Presentation of force-motion relationship by inertial force display. In: Ferre, M. (ed.) EuroHaptics 2008. LNCS, vol. 5024, pp. 567–572. Springer, Heidelberg (2008)
5. McNeely, W.A.: Robotic graphics: a new approach to force feedback for virtual reality. In: Proc. VRAIS 1993, pp. 336–341 (1993)
6. Minamizawa, K., Kajimoto, H., Kawakami, N., Tachi, S.: AWearable Haptic Display to Present the Gravity Sensation - Preliminary Observations and Device Design. In: Proc. World Haptics 2007, pp. 133–138 (2007)
7. Sekiguchi, Y., Hirota, K., Hirose, M.: The Design and Implementation of Ubiquitous Haptic Device. In: Proc. IEEE World Haptics 2005, pp. 257–258 (2005)

8. Tachi, S., Maeda, T., Hirata, R., Hoshino, H.: A Construction Method of Virtual Haptic Space. In: Proc. ICAT 1994, pp. 131–138 (1994)
9. Turvey, M.T.: Dynamic touch. American Psychologist 51, 1134–1152 (1996)
10. Yano, H., Yoshie, M., Iwata, H.: Development of a non-grounded haptic interface using the gyro effect. In: Proc. HAPTICS 2003, pp. 32–39 (2003)
11. Williamson, J., Murray-Smith, R., Hughes, S.: Shoogle: excitatory multimodal interaction on mobile devices. In: Proc. CHI 2007, pp. 121–124 (2007)