Designing a Shape-Changing Table-Top Interface to Enhance Bodily Experience in a Therapeutic Context

Narae Lee
KAIST
335 Gwahangno,Yuseong-gu,
Daejeon 305-701, South Korea
narae40@kaist.ac.kr

ITS'12, November 11–14, 2012, Cambridge, Massachusetts, USA..

Abstract

This paper explores the physical kinetic interaction of a shape-changing interface (SCI) for the enrichment of bodily activity in a therapeutic context. In recent years, the use of human bodily movement as a major modality for a game interface has been explored in the field of interaction design, even in a therapeutic context. Previously, we developed MoleBot [2], a SCI based on an XY stage system, which uses the change in the shape of a table surface to embody only the user's movements via kinetic interaction. Here, we explore questions regarding how an SCI can enrich bodily experience, and what elements of an SCI need to be designed in order to motivate and amplify the user's bodily experience in a therapeutic context. Thus, we conducted a co-design process with therapists with the aim of promoting the user's bodily experience using an SCI. (figure1)

Author Keywords

Bodily activity, Therapy, Shape-changing interface, Rehabilitation

ACM Classification Keywords

H.5.m. Information interfaces and presentation

General Terms

Design

Figure 1. Shape changing table-top interface table and squeezable controller.

Figure 2. User observation.

Figure3. Essential movement for therapeutic context.

Introduction

In the field of human-computer interaction, bodily movement has been widely employed as a means of interaction ever since the development of Nintendo Wii and Microsoft Kinect. Motion-based applications have been explored on the basis of these cost effective interfaces, which could also be applied to the design of entertaining applications that could have a therapeutic purpose. It has been discovered that motion-based applications promote human physical and mental wellbeing. Thus, these approaches help to overcome the limitations of occupational therapy, which tends to reduce the patient's intrinsic motivation and interest because of repetitive tasks.

Such motion-based activities in the virtual world, however, lack the physical properties of virtual contents because users cannot directly touch or manipulate virtual objects on the screen. Because users must interact with video contents in virtual reality, they have no opportunity to make physical contact with the contents on the screen. Thus, users will not experience a rich bodily experience regarding the physicality of a real object (e.g., weight, texture), which can promote the bodily sense of patients in occupational therapy settings.

A few of tangible interfaces start to offer both the interactivity to improve bodily activity and actual physicality that can support a therapeutic process. [3][4] These tangible interfaces, however, still fundamentally serve as just an embodiment of digital information. They also do not provide a richer degree of physicality since the tangible provides only a static and passive kinetic response to the user's action. Therefore, there still remains unexplored design area such as utilizing kinetic and dynamic elements of interface for therapeutic purposes.

this paper explores physical kinetic movement as input or output in order to exploit the benefits of a *Shape-Changing Interface* in a therapeutic context. Our approach not only allows a series of physical activities to be enriched via skin sensation and kinesthesia in the physical world, by means of direct manipulation, but also allows for gestural interaction. To this end, we introduce an ongoing design process and possibilities for utilizing an SCI, called the MoleBot system (Figure 1). These allow us to examine the effects of kinetic interactions of an SCI in promoting bodily experience in therapeutic contexts.

DESIGN PROCESS

First, we defined shape-changing interfaces as interfaces that can perform self-actuation and allow for physical kinetic interaction by means of shape changing as input or output.

In a therapeutic context, patients and doctors would be the major users who participate in the therapy. Thus, we conducted observations with patients and therapists to obtain a general understanding of the therapeutic context. We then conducted in-depth interviews to discover users' needs and motivations (Figures 2, 3). In addition, three patients who have different level of functional impairment due to hemiplegia were recruited. Three therapists with clinical experience to facilitate motion-based applications (e.g., Kinect, Wii) for therapeutic purposes also participated. Finally, we were able to draw a number of important insights in order to determine the direction of future designs, as described below.

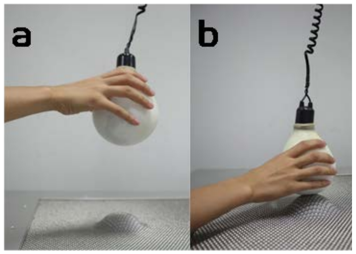

Figure 4. Examples of interaction types: (a) move for controlling MoleBot, (b) vertical pulling down to capture MoleBot,

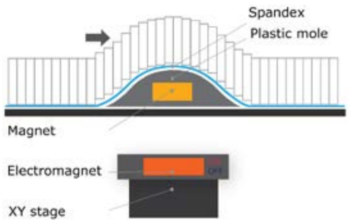

Figure 5. Mechanism of tabletop shape-changing interface.

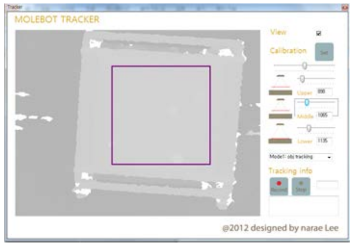

Figure 6. Kinect software to provide control the MoleBot.

For Patients: 1) Support to improve gross motor and fine motor skills using different grips. 2) Design individualized objects for the expression of self-achievement and identity. 3) Provide support for multiple feedbacks for self-progress of therapy such as a visual and haptic means of interaction. 4) Provide tangible objects/devices to help users interact in mid-air physically by placing their arms on a tangible object. 5) Provide familiar embodied metaphors in order to operate motion-based applications.

For Therapists: 1) Need for data logging of results and details of the intervention process in order to identify each patient's physical state. 2) The ability to easily adjust the level of difficulty and the movement area of applications. 3) Playful contents to evoke the patient's active engagement. On the basis of these design considerations, we conducted several ideation sessions using video prototyping

CONCEPT AND IMPLEMENTATION

We sought to build a shape-changing table-top system based on MoleBot, using a squeezable interactive controller that can support the evoking of bodily experience. These devices facilitate both kinetic and magnetic interactions by the integration of two interfaces. (Figure 4)

MoleBot: Table-top shape-changing interface

We designed table-top forms for the SCI so that it could be used in a wheelchair. First, we tested low-fidelity prototypes in order to learn the sizes and forms that would be ergonomically suitable for patients and therapists. We utilized an XY stage with two stepper motors to actuate the plastic mole on second version of prototype. Unlike the previous MoleBot, the XY stage involved a moving head with an electromagnet, which was paired up with the plastic mole on magnet in order to provide control of the different levels of magnetism. (Figure 5) The two motors of the table were connected to a PC via a Phidgets bipolar stepper motor controller, and were controlled by a processing program using Microsoft Kinect. (Figure 6) The Kinect is placed above the table so as to detect both objects on a table top and human body movement.

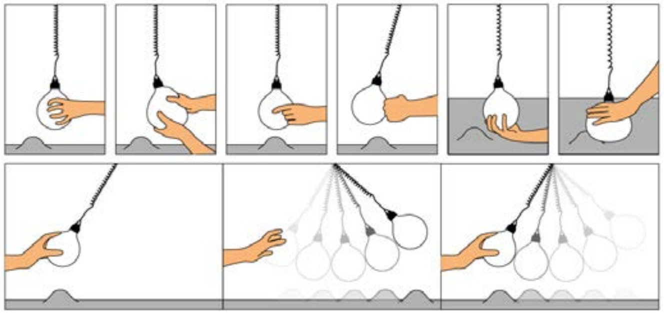

Figure 7. Types of manipulation using SqueezeBall.

SqueezeBall: Squeezable interactive controller

SqueezeBall can be connected to a coil wire hanging down from about 2m above the top of a table. Kinect detects the XY position of SqueezeBall according to its depth and shape. The outer material of *SqueezeBall* is flexible rubber and the inside is filled with cotton. A MPR121 Capacitive Sensor Board and four CDS sensors that are inside of the ball are able to capture the pressure and position of the user's hand grasps. *SqueezeBall* provides visual feedback via an LED and tactile feedback via two vibration motors. The values of the sensors can be transferred to a PC via Arduino Pro mini (Figure 8).

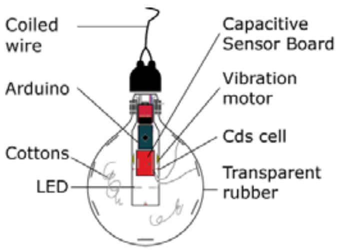

Figure 8. SqueezeBall.

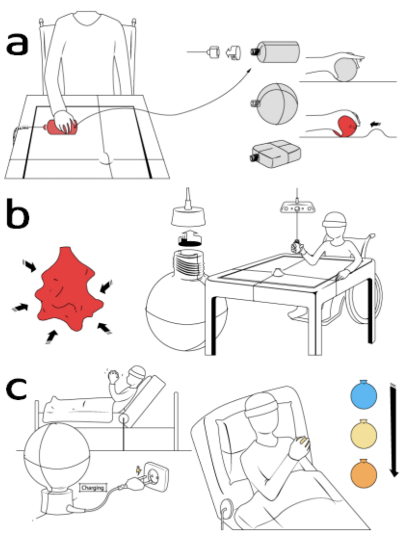

Figure 9. Interaction scenario a) table-top mode b) hanging mode c) manual mode

INTERACTION

Interaction Scenario

Through observation, we learned the requirements of the different roles that an SCI can play, depending on *whether or not it is used during an intervention*. We thus propose three interaction modes of the interface. First, a tabletop mode enables the user's arm to be placed on the surface of a table. Patients with a severe degree of impairment, in particular, have a limited space of interaction. Such patients have difficulty lifting their arms into the air without help. They can interact with MoleBot directly with their hands or indirectly via the tabletop mode. Second, the hanging mode provides ergonomic support that facilitates their interactions, so that patients with a lesser degree of impairment can lean their arms on the hanging interface, or even move their arms. Third, the manual mode allows the user to perform exercises alone and to express their emotions via squeezing after an intervention. (Figure 9)

Magnetic and Lateral Force Interactions

By the integration of an SCI and a squeezable controller, kinesthetic interactions including bodily actions such as punching, moving, and pulling vertically. The interfaces also allow tactile interactions that activate fine motor skills with MoleBot via magnetism and lateral force. An SCI such as Recompose [1] mainly allowed for vertical manipulation, while our system focuses on lateral force manipulation .This system enables the user to apply force to the interface horizontally. For instance, users can make MoleBot stop by using their hand or by using the squeezable controller by pushing the plastic mole laterally. Furthermore, MoleBot can push and pull objects on the surface via lateral force interaction.

CONCLUSION AND FUTURE WORK

In this paper, we explored the possibilities involved in employing an SCI for the enrichment of bodily experience in a therapeutic context. This is an ongoing project. Thus, we need to develop our concept more concretely to include both hardware and software and to conduct user studies in order to determine the effects of an SCI upon bodily experience in therapeutic contexts. Our next step will be to conduct a pilot test based on this system.

ACKNOWLEDGEMENT

This paper was supported by KAIST ICC S&T leading primary research (N10120035).

REFERENCE

[1] Blackshaw, M., DeVincenzi, A., Lakatos, D., Leithinger, D., and Ishii, H. Recompose. *Proceedings of the 2011 conference extended abstracts on Human factors in computing systems - CHI EA '11*, ACM Press (2011),1237.

[2] Lee, N., Kim, J., Lee, J., Shin, M., and Lee, W. MoleBot. *ACM SIGGRAPH 2011 Emerging Technologies on SIGGRAPH '11*, ACM Press (2011), 1–1.

[3] Li, Y., Fontijn, W., Markopoulos, P. A tangible tabletop game supporting therapy of children with Cerebral Palsy. *In Proceedings of the 2nd International Conference on Fun and Games*, Springer, Berlin, (2008).

[4] Waelen A., Timmermans, A., Seelen, H., Tetteroo, D., and Markopoulos, P. Tag-exercise creator: towards end-user development for tangible interaction in rehabilitation training. *In Proceedings of the 4th ACM SIGCHI symposium on Engineering interactive computing systems* -EICS '12. ACM, New York, NY, USA, 293-298.