Presented at ACM SIGCHI TEI'11 (Tangible, Embedded and Embodied Interaction), Work-in-Progress Workshop Proceedings, E.Y-L. Do, M.D. Gross, I. Oakley (Eds.), Madeira, Portugal, pp.37-42, January 23, 2011.

Delicate Interpretation, Illusion and Feedforward: Three Key Concepts toward Designing Multimodal Interaction

Kumiyo Nakakoji
Software Research Associates, Inc.
2-32-8 Minami-Ikebukuro,
Toshima, Tokyo, 171-8513, Japan
kumiyo@sra.co.jp

Yasuhiro Yamamoto
Precision and Intelligence Laboratory
Tokyo Institute of Technology
4259 Nagatsuda, Midori,
Yokohama, 226-8503, Japan
yxy@acm.org

Nobuto Matsubara
Software Research Associates, Inc.
2-32-8 Minami-Ikebukuro,
Toshima, Tokyo, 171-8513, Japan
matubara@sra.co.jp

TEI'11, Work-in-Progress Workshop
Jan 23–26, 2011, Madeira, Funchal, Portugal.

Abstract
This paper argues that *delicate interpretation*, *illusion*, and *feedforward* as three key concepts in designing future multimodal interaction. The human brain has its peculiar nature of integrating information coming through different sensory channels to construct a consistent model of the world. The notion of direct manipulation and feedback based on the truthful reflection of the physical world may no longer be the guiding framework for designing tangible, embedded, and embodied interaction. HCI designers (as well as brain scientists) have very limited understanding on how the brain models the external world by using multimodal information. *TCieX* (Touch-Centric interaction embodiment eXploratorium) has been built to help us experience and understand the combinations of different modes of interaction, and explore the three key concepts in designing multimodal interaction.

Keywords
Interaction design, multimodal user interface, pseudo haptics, delicate interpretation, illusion, feedforward

ACM Classification Keywords
H.5.2. Information interfaces and presentation (e.g., HCI): User Interfaces.

General Terms
Design, Theory

Introduction

Our approach in designing embodied interaction is based on the view that looks at multimodal interaction as a way that one's brain interacts with the external world through his or her different sensory channels.

The human brain has its peculiar way of integrating information given through different sensors to construct a consistent model of the world. Some sensory systems dominate other sensory systems, and if information given through multiple sensors is inconsistent, the information given through a dominant sensory system overwrites the information given through recessive sensory systems. This makes the person sense what is not physically present through the recessive sensors, which we may call an illusion. Pseudo haptics is a typical example [2].

Pseudo-haptics occurs when visual properties and tactile properties captured through the sensory channels exhibit an inconsistency, or a conflict, in terms of the model of the world a person expects to perceive. Visual properties are dominant over tactile properties, and therefore, the person perceives tactile properties different from the actual physical properties so that the perceived visual and tactile properties produce a coherent view of the world. Pseudo-haptics on texture has been widely applied by changing the size and the speed of the mouse cursor displayed on a screen in terms of the user's mouse movement [1]. Watanabe et al. [5] has exhibited the force of the wind, harsh surface, and wavy tin-roof, by changing the visual size of the mouse cursor.

We think that designing multimodal interaction needs to take into account such nature of the human brain in terms of how it models the external world by using information coming through different sensory channels. This might complicate how we design multimodal interaction, but more interestingly it would open up a vast area of opportunities to realize new types of experience for users.

In this regard, we think three new notions need to be taken into account in designing multimodal interaction: *delicate interpretation*, *illusion*, and *feedforward*. Direct manipulation and feedback have been two important notions in designing interaction when using the traditional keyboard and mouse. The two notions essentially deal with the issue of how to accurately communicate the state of the world with a human user through visual representations. Auditory and tactile representations may be combined to reinforce the "accurate" interpretation. When it comes to be concerned with how a brain models the world based on the input data from different sensory channels, the goal of truthfully reflecting the physical reality becomes questionable. The field of brain science is just about to start exploring the area and so far HCI designers have very limited understanding on how to effectively use multiple sensory channels. We need environments where we can build and experience different combinations of multimodality.

In what follows, we first discuss what we mean by *delicate interpretation*, *illusion*, and *feedforward*. We then describe a tool we have been developing to help us experience and understand the combinations of different modes of interaction. The tool, TCieX (Touch-Centric interaction embodiment eXploratorium), currently focuses on the visual dominance of sensory systems over haptics.

Delicate Interpretation, Illusion, Feedforward

This section describes the three key notions that we think becoming essential in designing multimodal interactions.

Delicate Interpretation:
By delicate interpretation, we mean a "liberal" interpretation of the data produced by human behavior.

One of the goals of sensor technologies used in multimodal user interfaces has been how to accurately capture physical action of a user. The physically sensed data, however, may not reflect what the user really meant, intended, or is aware of producing. A simple example is saccadic eye movement. What the user meant is to stare still, but the eyes move at the physiological level.

Delicate interpretation, or liberal, mindful interpretation, is necessary to generate a meaningful feedback to the user when using data collected by external sensors. Touch-based user interfaces signify the relevance of the point to interaction design. Human body movement has certain characteristics, and fingers are no exceptions. When a person thinks he or she is drawing a straight line with an index finger on a touch-sensitive display, the coordinates collected through a series of touched area may not constitute a straight line but a number of crooked segments, not because of the inaccuracy of the touch sensors, but because of the characteristics of the finger movement. Visually displaying the segments in accordance with the coordinates might be the accurate reflection of the user's physical activity, but it would not be what the user really meant to do.

Illusion:
Multi-modal environments have tried to enforce more immersive, more realistic feedback, such as through organic user interfaces, where input equals output [5]. Illusions have been regarded as something to be taken care of in interaction design. Illusion may cause a wrong interpretation of the information presented to a user, and therefore, something not desirable.

The use of illusion, such as the pseudo-haptic feedback, however, makes us consider how a user perceives the world through multiple sensory channels. The physical world is not necessarily the ideal situation for a user. We may need to alternate information on some of the channels so that the user would perceive the world more effectively. We think that properly situated illusion should be more explored and used in interaction design. The notion of direct manipulation in interaction design, then, may need to be re-contextualized.

Feedforward:
People interact with the external world based on the pre-understanding of the world. The human brain plans how much force to put to on the muscles of the forearm before holding a book so that the arm neither tosses up the book nor drops the book. This planning is only possible by looking at the book, with the pre-

experienced knowledge of the relation between the look of a book and its weight.

Interaction design has focused on how to present feedback for a user's action so that the user understands how the user's action has been interpreted by the system, and what the system has been doing in what context. Based on this feedback, the user plans for the next action.

The same presentation of the information might be viewed as feedforward information for the user's subsequent action. Pseudo haptics occur only when the user has built a model between the hand movement and the movement of the visual object. Such setting is necessary for the subsequent weight illusion to take place.

The notion of feedforward becomes essential in designing multimodal user interaction for guiding, persuading, or eluding a user's certain actions.

The TCieX System

TCieX (Touch-Centric interaction embodiment eXploratorium) is a collection of simple interaction test suites that help us experience different combinations of multimodal interactions. It currently focuses on visual and haptic sensory systems.

Figure 1 shows one of the interaction test suites implemented on TCieX, "*two panes*," which currently runs on Apple iPad.

The basic interaction *two panes* provides in the "Trial" mode is that the user touches the lower pane with a finger tip and moves the finger, a ball-like object in the upper pane moves accordingly.

two panes allows the user to create different mapping between the movement of the finger in the lower pane and that of the object in the upper pane by using the right column in the "Setting" mode. A user then actually experiences the interaction with the setting in the "Trial" mode.

For instance, suppose a user moves the fingertip from left to right with the constant speed in the lower pane. The object in the upper pane starts moving faster when the object enters the area displayed with the reddish contour. The degree of redness represents the scale of speeding-up. Selecting one of the four radio buttons (flat, Gaussian-curve, bell-curve, and triangular shapes) determines how the acceleration is applied. Reversely, when the object enters the bluish contour area, the object starts slowing down. Changing such mapping (what [2] calls the Control/Display ratio) make us feel a hole (by speeding up) and a bump (by slowing down) on the surface in the upper pane (i.e., pseudo-haptics).

With the Setting mode, one may change where to put such colored contour areas with what size and where the apex is. When the user touches the upper pane and holds the fingertip still, a color-gradient contour appears. It can either be reddish or bluish, depending on the "+" or "-" option the user selects in the right column of the pane.

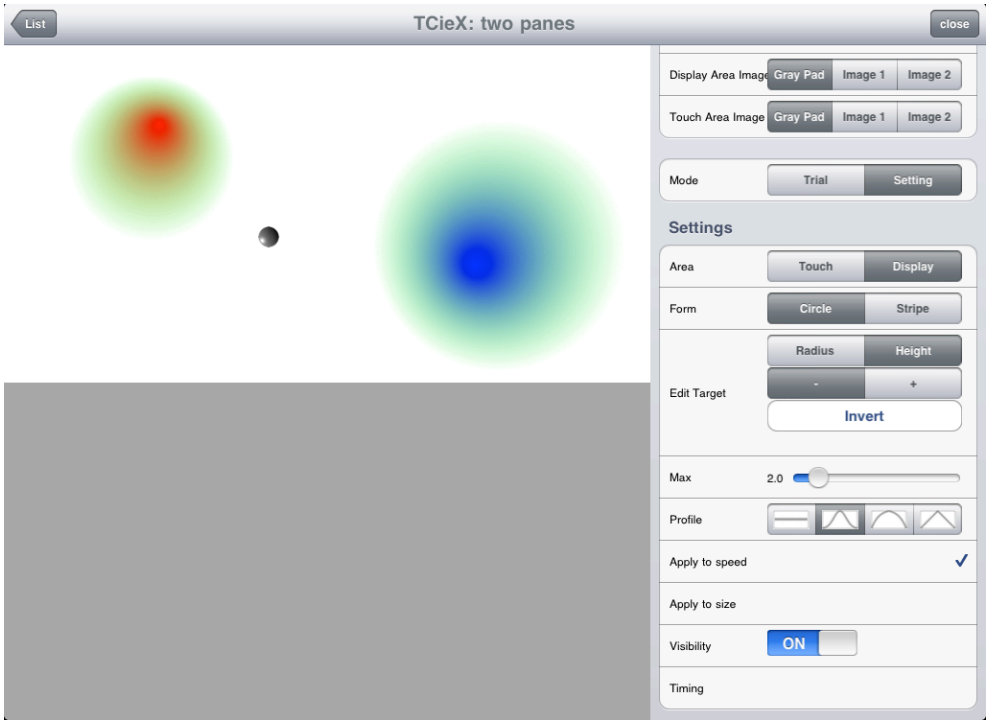

Figure 1. *two panes*, one of the interaction test suites of TCieX

One may turn off the visual display of the contour, by turning the visibility off. We may also change the visual size of the object in addition to changing the speed of the object movement. Then, the movement of the object remains the same, but with dynamically changing the visual display. We may feel the interaction with the object a little differently as reported in [1].

We may even apply the contour drawing in the lower pane. When a bluish contour is created in the lower pane, mechanically it is not the movement of the object that starts slowing down, but it is the interpretation of the movement of the figure tip's movement as slowing down.

Discussion

TCieX is still at an early stage. It currently has two dozens of test suites, or exploratorium, to explore different modes of interactivity such as *two panes* described in the previous section.

What we want to demonstrate by building TCieX is a way to explore how different visual and haptic modes affect how we experience the interaction. By allowing a user of TCieX to explore different modes with different parameters varying the visual and haptic sensations, we are hoping to help the user to better understand how to combine visual and haptic properties for building his or her own application system.

One application area we have been thinking to apply such multimodal interaction is to communicate weight [3]. For instance, we may apply the technique as a way to give a feedback to a doctor engaging in remote operation. The force put on the knife of a remote operation robot can be communicated with the doctor through visual and auditory feedback. As another example, one may communicate how a product under design weighs with remote team members in a distributed design meeting. As a third example, the weight should not necessarily be that of a physical object, but could be associated with a conceptual property. Programming component that has significant impact on other components could be assigned heavy weight so that a programmer may perceive the weight of importance of the component when editing it.

In designing a system with multimodal interaction, the visual, audio, haptic, olfactory, and even gustatory information displays become much more complex than the traditional keyboard, mouse and LCD-based interaction because we do not have much understanding on how the brain interprets the information coming through multiple sensory channels. As interaction designers, our job is not to understand the mechanics of the brain, but to understand how the brain interprets and models the world so that we can take an advantage of the nature. It is not about brain interface in the narrow sense. Multimodal interaction systems use a person's sensory systems as instruments for the brain. Such concerns would open up the wide area of research in human-computer interaction, especially in tangible, embedded, and embodied interaction.

Acknowledgements

This work was supported by JST, CREST.

References

[1] Lecuyer, A., Burkhardt, J.M., Etiennne, L. Feeling Bumps and Holes Without a Haptic Interface, The Perception of Pseudo-Haptic Textures, Proceedings of CHI2004, Vienna, Austria, (2004) pp.239-246.

[2] Lecuyer, A. Simulating Haptic Feedback Using Vision: A Survey of Research and Applications of Pseudo-Haptic Feedback, Presence: Teleoperators and Virtual Environments, (2009) Vol.18, No.1, pp.39-53, MIT Press.

[3] Nakakoji, K., Yamamoto, Y., Koike, Y., Toward Principles for Visual Interaction Design for Communicating Weight by using Pseudo-Haptic Feedback, Proceedings of Create 10 Conference, Edinburgh, UK, (2010) pp.68-73.

[4] Vertegaal, R., Poupyrev, I. Organic User Interfaces: Introduction to Special Issue, Communications of the ACM 51(6), (2008) pp.26-30.

[5] Watanabe, K., Yasumura, M., Realizable user interface: The information realization by using cursor, Proceedings of Human Interface Symposium, (2003) pp. 541-544, (in Japanese).