Exploring Reality-Based Interaction through Whole-Body Movement

Orit Shaer
Wellesley College
106 Central St.
Wellesley, MA, 02481
1 (781) 283-3093
oshaer@wellesley.edu

ABSTRACT
In this paper, we present a research agenda that focuses on employing whole-body movement as an interaction modality for accessing and manipulating abstract information. This investigation aims to answer various open questions including: What movement qualities could be computationally sensed and how could these qualities be mapped to control digital information? What computational models are required for interpreting simultaneous movements of multiple users? And, is there a universal gesture vocabulary for certain tasks? We briefly discuss three projects that combine whole-body movement with other themes of reality-based interaction such as naïve physics and social awareness in an attempt to answer these questions.

Categories and Subject Descriptors
H5.2. User Interfaces: UIMS, D.2.2 Design Tools and Techniques: User Interfaces.

General Terms
Design, Human Factors.

Keywords
Reality-Based Interfaces, Tangible User Interfaces, Whole-Body Interaction.

1. INTRODUCTION
Over the past two decades, HCI researchers have developed a broad range of new interfaces that diverge from the "window, icon, menu, pointing device" (WIMP) paradigm. Emerging interaction styles include Virtual and Augmented Reality, Tangible and Physical Interaction, Ubiquitous and Wearable computing. While these are often viewed as unrelated fields of research, they share important commonality: leveraging users' existing knowledge and skills of interaction with the real non-digital world to a greater extent than before. These interaction styles employ *themes of reality* such as naïve physics, awareness of surrounding environment, of other people, and of users' own bodies, as well as skills such as locomotion, navigation and object manipulation [6]. They are thereby referred to as *Reality-Based Interfaces* (RBIs) [5,6]. Extending beyond the limitations of a two dimensional display, a mouse and a keyboard, RBIs change interaction with computers from a segregated, specialized activity that mainly engages the users' visual sense to an activity that takes place within the real-physical world and is more similar to interacting with the everyday, non-digital world. By basing interaction on pre-existing real world knowledge and skills RBIs may reduce the mental effort required to operate a system because users already posses the required skills [5,6].

Reality-Based Interfaces support an increasingly rich set of interaction techniques that are based on the senses, knowledge and skills involved in interacting with the non-digital world, including two-handed interaction and whole-body interaction. For example, tangible user interfaces (TUIs) often rely on users' skills of manipulating objects such as grasping, picking up, positioning, and arranging objects. Employing the manipulation of objects as an interaction modality, TUIs leverage users' tactile and kinesthetic senses. Also, many virtual reality applications support movement-based command languages that allow users to interact with a system using simple and natural movements such as walking on a special treadmill for moving around a virtual environment, and head turning for changing a point of view. Such command languages rely on skills that people develop early in life - coordinating the movements of their limbs, head, and eyes [6], as well as on peoples' kinesthetic and proprioceptive senses. Finally, emerging game controllers (e.g. Wii Remote) allow users to play a large variety of games by replicating familiar actions such as throwing a ball, swinging a racket or playing musical instruments.

Common to all of these examples is a direct, one to one, mapping between a real-world action and a virtual movement or command. Such mapping often reduces the gulf of execution [3], the gap between a user's goals for action and the means for executing those goals. However, such mapping is only possible for those aspects of a user interface that imitate the real world. Given that much of the power of using computers comes from the ability to go beyond a precise imitation of the real world, a key challenge is to apply reality-based interaction techniques such as whole-body movement and manipulation of objects to provide access to *abstract* information and commands.

Our research focuses on how whole-body movement could be used as an effective interaction modality for accessing and manipulating abstract information. More specifically, we are looking to combine whole-body movement with other themes of reality such as naïve physics and social awareness to create interfaces that promote collaboration, creative expression and learning. The subtle and complex nature of human movement has made it particularly challenging for computational interpretation. Thus, our investigation of bodily movement as an interaction modality requires perspectives from Computer Science, Psychology and Arts as we attempt to answer various questions including: What movement qualities could be computationally sensed and how could these qualities be mapped to control digital information? What computational models are required for interpreting simultaneous movements of multiple users? Is there a universal gesture vocabulary for certain tasks? How can movement-based interaction be formally specified? And, how should movement-based interfaces be designed to preserve aspects of individual preferences and differences in movement? Following, we briefly describe two of our projects that are aimed at addressing these questions.

2. RESEARCH PROJECTS

2.1 A Computationally Enhanced Playboard

People Pretzel [9] is a computationally augmented interactive art piece that aims to explore the use of whole-body interaction as means for encouraging informal social interaction among community members. Interacting with the People Pretzel play board require users to use their limbs as play pieces to press circles on the board, this playful interaction often results in a "pretzel" of people. Thus, the activity encourages the formation of informal collaborations and social connections. Whole-body interaction with the game board is computationally augmented to produce an improvisational multimedia performance. The system allows community members to choose their level of participation in the social activity as players or as audience thereby enabling each person to take part in the group activity and fostering a sense of community. The board was designed to accommodate players with different body sizes and is elevated from the floor surface to create the feeling of a performance stage. The maximum number of simultaneous players may vary from four adults to seven children. The People Pretzel System consists of four components: a play board, a projector and a video camera that are connected to a computer. Users' limbs position and weight are sensed using an array of pressure sensors connected to a Handyboard microcontroller. We intended to turn People Pretzel into a programmable physical interface that allows users to use a high-level user interface description language to program the system to support a variety of games and personalized feedback. However, we found that the development of a high-level description language that is capable of describing the behavior of whole-body interfaces requires further investigation.

2.2 Using the Wiimote Controller to Explore Collaborative Whole-Body Interaction

The Nintendo WiiRemote integrates motion-sensing capabilities into a tangible device, allowing a limitless range of motion that includes the entire body. In addition it offers a multi-user game experience. The WiiRemote's capabilities, availability, and usability open up new possibilities for Reality-Based interaction research. Using the WiiRemote, we explore the use of whole-body interaction for collaboratively accessing and manipulating abstract information. Specifically, we investigate what set of gestures is appropriate for collaboratively manipulating visual and aural information and what movement qualities could be sensed and mapped to digital information.

Our first application supports collaborative artistic expression, allowing up to three users to actively participate in creating a multimedia art piece. We created several prototypes for this application, each implements novel interaction techniques ranging from free expressive movement to an abstract movement-based language, and include parallel interactions both two-handed and spatially distributed among multiple users. We are currently evaluating the system with both professional and amateur artists to study the gestures performed by users and users' responses to expected and unexpected mapping of movements to digital feedback.

2.3 Extending TUIML

TUIML (Tangible User Interface Modeling Language) [10] is a visual user interface description language that provides developers from different backgrounds means for specifying, discussing, and programming tangible interaction. TUIML combines iconic and diagrammatic approaches while drawing upon Statecharts [1] and Petri Nets [8]. It allows tangible user interface developers to specify the structure and behavior of tangible user interface using high-level constructs that abstract away implementation details. An important benefit of this approach that is based on User Interface Management System Research [7], is that these specifications can be converted into concrete TUI implementations that employ a variety of IO technologies. In addition, such specifications could serve as a common ground for investigating both design and implementation concerns by TUI developers from different disciplines.

TUIML, was mostly designed to specify data-centerd TUIs [2, 4], a design perspective that is primarily pursued within HCI and Computer Science and results in systems that use spatially configurable physical artifacts as representations and controls for digital information [4]. While supporting the specification of continuous and two-handed interactions, to date, TUIML does not provide means for explicitly specifying other characteristics of whole-body interaction such as expressive gestures. We are currently extending TUIML to support the specification of whole-body interaction.

3. SUMMARY

Our research focuses on developing novel interaction techniques, frameworks, and tools for Reality-Based Interfaces (RBIs). We currently explore how to combine whole-body movement with other themes of reality such as naïve physics and social awareness to create RBIs that promote collaboration, creative expression and learning. Our investigation applies perspectives from Computer Science, Psychology and Arts to answer questions regarding the design, implementation, and evaluation of such RBIs. To sense and interpret bodily movement, we employ heterogeneous technologies including various sensors, game controllers, and a motion capture system. We also work on extending TUIML [10] a high-level user interface description language for TUIs, to support the specification of whole-body interaction. Finally, we are looking forward to exchange ideas and experiences with other researchers in this area.

4. REFERENCES

[1] Harel, D. Statecharts: A Visual Formalism to Complex Systems, *Science of Computer Programming, 8(3), 1987, 231-274.*

[2] Hornecker, E. and Buur, J., Getting a Grip on Tangible Interaction: A Framework on Physical Space and Social Interaction. In *Proc. CHI'06*, ACM Press, 2006, 437-446.

[3] Hutchins, E.L., Hollan, J.D. and Norman, D.A. (1986), Direct Manipulation Interfaces. Draper, D.A.N.a.S.W. ed. *User Centered System Design: New Perspectives on*

Human-computer Interaction, Lawrence Erlbaum, Hillsdale, N.J., 1986, 87-124.

[4] Ishii, H. and Ullmer, B. Tangible Bits: Towards Seamless Interfaces between People, Bits, and Atoms, in *Proc. CHI'97*, ACM Press, 1997, 234-241.

[5] Jacob, R., Girouard, A., Hirshfield, L. M., Horn, M., Shaer, O., Solovey, E. T., et al. (2007). Reality-Based Interaction: Unifying the New Generation of Interaction Styles, *CHI'07: Human Factors in Computing Systems, Work in progress paper*. San Jose, California: ACM Press.

[6] Jacob, R., Girouard, A., Hirshfield, L. M., Horn, M. S., Shaer, O., Solovey, E. T., et al. (2008). Reality-Based Interaction: A Framework for Post-WIMP Interfaces, *CHI'08: Human Factors in Computing Systems*. Florence, Italy: ACM Press.

[7] Olsen, D.R. User Interface Management Systems: Models and Algorithms, Morgan Kaufmann, San Francisco, 1992.

[8] Petri, C.A. Communikation mit Automaten, Doctoral Thesis, University of Bonn, Germany, 1962.

[9] Shaer, O., Ziraknejad, B., Camarata, K., Do, E. Y.-L., & Gross, M. D. (2004). A Computationally Enhanced Play Board for Group Interaction, *Pervasive 2004, a Hot Spot paper*. Vienna, Austria.

[10] Shaer, O. Jacob, R.J.K. (2006). A Visual Language for Programming Reality-Based Interaction, IEEE Symposium on Visual Languages and Human-Centric Computing, Graduate Student Consortium.