Moving and Making Strange: An Embodied Approach to Movement-Based Interaction Design

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There is growing interest in designing for movement-based interactions with technology, now that various sensing technologies are available enabling a range of movement possibilities from gestural to whole-body interactions. We present a design methodology of Moving and Making Strange, an approach to movement-based interaction design that recognizes the central role of the body and movement in lived cognition. The methodology was developed through a series of empirical projects, each focusing on different conceptions of movement available within motion-sensing interactive, immersive spaces. The methodology offers designers a set of principles, perspectives, methods, and tools for exploring and testing movement-related design concepts. It is innovative for the inclusion of the perspective of the mover, together with the traditional perspectives of the observer and the machine. Making strange is put forward as an important tactic for rethinking how to approach the design of movement-based interaction.

Categories and Subject Descriptors: H5.m. [**Information interfaces and presentation [e.g., HCI]**]: Miscellaneous.

General Terms: Design

Additional Key Words and Phrases: Design methodology, embodied interaction, felt experience, kinaesthetic, making strange, movement-based interaction design

ACM Reference Format:
Loke, L. and Robertson, T. 2013. Moving and making strange: An embodied apporach to movement-based interaction design. ACM Trans. Comput.-Hum. Interact. 20, 1, Article 7 (March 2013), 25 pages.
DOI: http://dx.doi.org/10.1145/2442106.2442113

1. INTRODUCTION

As the design of interactive technologies is now faced with the challenges of encompassing human experience in all walks of life, new approaches, methods, and tools are required that enable designers to delve more deeply into the nuances of human experience and articulate the issues arising from a renewed focus on the body and human agency. The fact of human embodiment shapes how we are and can be in the world and our capacity for action within it. Human embodiment both demands and underpins an approach to interactive technology design, in which meaning arises from our interactions in the world that are always anchored in and mediated through our living bodies [Merleau-Ponty 1962; Robertson 1997; Svanaes 2000; Dourish 2001]. The recognition that all human actions (including cognition) are embodied actions is fundamental to recent trends in interaction design research.

Yet despite this growing focus on the lived, experiential body there is still a distinct lack of attention given to the central role of movement in perception and cognition, in

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© 2013 ACM 1073-0516/2013/03-ART7 $15.00
DOI: http://dx.doi.org/10.1145/2442106.2442113

our agency to act in the world and our experience of it [Merleau-Ponty 1962; Sheets-Johnstone 1999]. Studies of the lived body and the phenomenon of thinking in movement by phenomenologists Merleau-Ponty and Sheets-Johnstone have provided theoretical tools for HCI researchers to counter this oversight (see Robertson [1997] for one of the early applications of Merleau-Ponty's phenomenology to technology design and use). Merleau-Ponty's assertion, "to move one's body is to aim at things through it" [1962, pages 160–161], suggests the instrumentality of the moving body in acts of perception, particularly perception of the external world. The importance of the kinaesthetic sense as vital to self-perception and awareness is argued for by Sheets-Johnstone [1999]. These ideas have been taken up and applied in interaction design research by an active community of researchers working in what we will refer to as movement-based interaction design (see PUC special issue on movement-based interaction [Larssen et al. 2007c]).

This emerging field brings the moving body to the fore of the design process and, in doing so, requires a reexamination of existing approaches to designing interaction, which may have been developed to prioritize other factors. Gestural and whole-body interaction is now possible with the currently available range of motion-sensing technologies that take human movement as input. Design approaches that incorporate an understanding and valuing of the moving body and felt, kinaesthetic experience can contribute to creating conditions for technology-mediated human experience anchored in the sensing, feeling, and moving body—an *embodied approach* that takes full account of the central role of the body and movement in lived cognition (see Levisohn and Schiphorst [2011] for an account of how movement and somatic awareness are vital to experience-oriented approaches to technology design).

We offer a design methodology of Moving and Making Strange for the design and evaluation of movement-based interactions with technology, composed of a set of principles, perspectives, methods, and tools. Our approach is phenomenologically motivated, giving primacy to the first-person, lived experience of movement, where the body-in-motion and its felt, kinaesthetic experience are the generative source and medium for exploration and evaluation of dynamic, qualitative concepts for design. A major contribution of the methodology is its inclusion of the perspective of mover (i.e., the first-person experience of moving), together with the traditional perspectives of observer and machine. The emphasis on understanding the felt experience of moving and keeping it alive within a human-centered design process that shifts back and forth between the multiple perspectives of mover, observer, and machine is an effort to provide a balance to the extensive amount of existing research from a technology-centric perspective (e.g., computer vision and motion analysis).

This article presents, for the first time, the design methodology of Moving and Making Strange in its entirety, with the explicit purpose of making the knowledge, perspectives, methods, and tools available and reusable to the interaction design community. It brings together the full set of activities currently available within the methodology and places them within the context of particular stages of the design process and the specific kinds of design knowledge being sought. It articulates the relations between the various activities and the constituent methods and tools, highlighting the design knowledge and design artifacts produced and transformed through the application of different perspectives.

The following section grounds our methodology in related work on designing for movement-based interaction, with particular attention given to those working with the moving body and felt, kinaesthetic experience. In Section 3, the notion of making strange—a core principle of our design methodology—is introduced and defined to highlight its important tactical role for rethinking how to approach the design of movement-based interactions with technology. It can enable us to understand how our

bodies generate and become familiar with both new and habitual movements. Section 4 describes the development of the design methodology through brief summaries of the three empirical projects that informed it. Together these sections provide a context for the design methodology of Moving and Making Strange, which is presented as a coherent whole in Section 5. We conclude the article with suggestions for continued development and extension of the methodology into emerging areas of interaction design practice and research. The electronic appendix contains samples of exercises from some of the activities of the design methodology, for those that wish to apply the methodology to their own projects.

2. RELATED WORK IN MOVEMENT-BASED INTERACTION DESIGN

There is growing interest in designing for movement-based interactions with technology, now that various sensing technologies are available that enable a range of movement possibilities from gestural to whole-body interactions. Designers and researchers are exploring new ways of understanding and working with movement as input to interactive technologies. A full review of the different approaches to designing movement-based interactions with technology would make a valuable contribution to the literature and the development of this important area of technology design. Here, though, we can only introduce some of the major foci of recent work and broadly map how our own methodology fits within it.

Two key principles that distinguish embodied approaches to movement-based interaction design are conceptualizing movement as a design material and designers developing bodily movement skills [Hummels et al. 2007; Larssen et al. 2007b]. In conceptualizing movement as a design material, the moving body is viewed as a creative material that requires physical exploration and can generate unexpected responses and insights. Several researchers have turned to dance, performance, and somatics for first-person methodologies and attentional strategies that can be applied to working creatively and expressively with the moving body in interaction design [Donovan and Brereton 2004; Schiphorst and Andersen 2004; Klooster and Overbeeke 2005; Djajadiningrat et al. 2007; Hummels et al. 2007; Jensen 2007; Jensen and Stienstra 2007; Larssen et al. 2007a, 2007b; Moen 2007; Schiphorst 2007; 2011; Loke and Robertson 2010; Ross and Wensveen 2010; Levisohn 2011; Levisohn and Schiphorst 2011].

Hand in hand with understanding movement as a design material is the need for designers to develop bodily movement skills. As Hummels et al. [2007] plainly state in their *Design Movement* approach, designers must acquire bodily mastery of movement-related knowledge, sensibilities, and skills in order to become experts in movement-based interaction design. They have developed a set of methods and tools for enabling designers to work with the expressive meaning of the moving body such as the choreography of interaction, digital gestural design tools, interactive installations, and interactive tangible sketching [Klooster and Overbeeke 2005; Hummels et al. 2007]. This is in accord with the approach we are advocating, although our focus was not on digital design tools to support designerly, user, and product expressiveness, but on providing structured approaches to developing movement sensitivity and skill informed by dance and movement improvisation.

With both of the principles discussed before, the foregrounding of the kinaesthetic sense is vital in developing movement-based design sensibilities. The kinaesthetic sense is recognized as crucial to the experience, performance, and training of the body in dance and movement improvisation. Blom and Chaplin [1988] describe kinaesthetic awareness as a primary perception and self-awareness of the body in motion. Understandings of bodily experience of physical activity (unmediated by digital technology), such as yoga, golf, and skateboarding, are being used to inform the design of whole-body

interactions with technology in an effort to improve the quality of interaction (e.g., Larssen et al. [2007b] and Tholander and Johansson [2010]). Larssen et al.'s [2007a] *feel dimension* of technology interactions highlights the ongoing process of "constant monitoring [of] how it feels to do what I'm doing, trying out and evaluating different feelings and measuring the effect of those feelings as actions in the world." Schiphorst [2007] highlights the role of somatic awareness in the quality of felt experience and suggests how this aspect of embodiment can function in an experience-oriented approach to design. The *kinesthetic interaction* framework [Fogtmann et al. 2008] brings the kinaesthetic sense to center stage. The framework aims to reveal bodily potential in relation to three design themes: kinaesthetic development, kinaesthetic means, and kinaesthetic disorder. These themes are intended to provide three different perspectives on how the bodily movements of users can be viewed in interaction. A similar approach to the kinaesthetic development theme supports users building bodily skills through technology use [Buur et al. 2004; Djajadiningrat et al. 2007].

A number of conceptual design frameworks exist that offer different perspectives and ways of framing the interaction between people and interactive computing technologies. Some approaches provide a range of sensitizing concepts that frame and conceptualize movement in a variety of ways. The *multimodal interaction space* framework [Bongers and Veer 2007] is useful for its multimodal approach to understanding interaction and the different levels of conceptualizing movement from the physical, sensing level to goal-directed activity. The *kinesthetic interaction* framework [Fogtmann et al. 2008] contains a set of design parameters: engagement, sociality, movability, explicit motivation, implicit motivation, expressive meaning, and kinaesthetic empathy, which support a practical exploration of the possibilities for addressing bodily potential in the design of interactive systems. The *interaction quality* framework [Ross and Wensveen 2010] supports consideration of the expressive qualities arising from the composition of Laban movement/space/time parameters that can feature in the behavior of interactive products. Eriksson et al.'s [2007] framework for camera-tracking applications employs a vocabulary for describing movement limited to body parts, shape, position, and orientation. The *tangible interaction* framework [Hornecker and Buur 2006]) offers a comprehensive approach to the design of interactive spaces and artifacts, where the body and its movements are considered in relation to collaborative, social spaces. It has a strong orientation to tangible interactions taking place in social, physical contexts. This is a useful broadening context for movement-based interactions. These various ways of framing and conceptualizing movement overlap in part with a set of concepts of the moving body that go with our methodology: the body as anatomy and physiology, as expression, as knowledge, as physical skill, as felt experience, and as social and cultural [Loke and Robertson 2011].

Other frameworks focus on the mapping of interaction, often exploiting the properties of sensor technologies and achieving innovative mappings between user actions and system effects. The *interaction frogger* framework [Wensveen et al. 2004] views person-product interaction in terms of the couplings between the person's action and the product's function through the use of inherent and augmented information. They aim to enrich the action possibilities by taking full advantage of a person's perceptual motor skills in tangible interaction. The *expected, sensed and desired* framework [Benford et al. 2005] was developed to assist in the design of moveable, physical interfaces. It does not explicitly deal with human movement but can be adapted to focus on the movements of users instead of interfaces (see Loke et al. [2007] for an application of the adapted framework to the analysis of movements of people interacting with Eyetoy games). The *sensor-based experience* framework [Rogers and Muller 2006] aims to inspire the design of sensor-based interactions by exploiting the unique properties of sensors and encouraging physical activities that promote exploration, discovery, and

Table I. How the Methodology Fits with Existing Frameworks and Approaches

Approach	Body/movement as design material	Designers developing movement skills	Concepts of body/movement	Design representations of movement	Mapping interaction	Evaluation	Exploring sensing technologies
Moving and Making Strange methodology	X	X	X	X	X	X	–
Design Movement approach [Hummels et al. 2007]	X	X	X	?	X	?	?
Experience-oriented approach [Schiphorst 2007]	X	X	X	?	?	?	?
Interaction Frogger framework [Wensveen et al. 2004]	–	–	X	–	X	X	?
Expected, Sensed, Desired framework [Benford et al. 2005]	–	–	–	–	X	X	X
Sensor-based Experience framework [Rogers and Muller 2006]	–	–	–	–	X	X	X
Tangible Interaction framework [Hornecker and Buur 2006]	–	–	X	–	X	X	–
Multimodal Interaction Space framework [Bongers and Veer 2007]	–	–	X	–	X	X	X
Kinesthetic Interaction framework [Fogtmann et al. 2008]	?	?	X	–	–	X	–
Interaction Quality framework [Ross and Wensveen 2010]	X	–	X	–	X	X	–

reflection. These frameworks use the perspectives of user actions and corresponding system effects to help orient designers to the particular issues and concerns of both users and systems in interaction. These correspond respectively to the observer and machine perspectives of our design methodology of Moving and Making Strange but consider only the external view of user actions. The unique feature of our methodology is the addition of the *mover* perspective, which enables a focus on the first-person experience of movement for interaction *in relation* to the observer and machine perspectives.

The majority of conceptual design frameworks tend to focus more on sensitizing concepts for analyzing and designing interactions, and less on the *how* (that is, the method) of working with the concepts in a bodily way. The how of working with the moving body and the kinaesthetic sense is an underdeveloped area for which our methodology aims to provide some constructive, practical advice for designers. Our approach is compatible with, and extends, the existing body of approaches surveyed earlier to more comprehensively equip designers with a rich repertoire of tools and techniques.

A selection of existing approaches and their relation to our Moving and Making Strange design methodology is mapped in Table I. The key activities and commitments that an embodied approach to movement-based interaction design should pursue are listed across the top of the table. This set of criteria results from transforming the traditional human-centered approach to interaction design through the lens of movement and the kinesthetic sense. Each approach is then evaluated to see if it supports these or not. An "X" indicates yes, a "–" indicates no, and a "?" is used when it is not clear from the published work.

3. MAKING STRANGE

Making strange, or defamiliarizing, is a basic strategy in artistic expression [Danto 1981], creative design practice, and in ethnography [Marcus and Fischer 1986]. The

term defamiliarization was introduced by Victor Shklovsky, a member of the Russian formalist school of literary theory. In his essay, *Art as Technique*, published in 1917, he proposes that the method of defamiliarization is used in art and literature to remove the automatism of perception. For example, turning a picture upside-down interrupts our habitual patterns of visual perception and allows us to see the composition from a new perspective [Edwards 1979]. Alternatively, we could turn our body upside-down to gain a similar, yet different change in perspective! Edward de Bono [1994] advocates a similar approach with his set of thinking tools that aim to counteract the natural tendency of the mind to operate within engrained patterns of perception.

In design, the cultural probes of Gaver et al. [1999] employ the basic strategy of defamiliarization by prompting participants to reflect on their everyday lives through the materials comprising the probes. Djajadiningrat et al. [2000] also work from a stance of making strange with their interaction relabeling method for the design of aesthetic interactions with products. Here possible interactions with an existing mechanical device are mapped to functions of a future electronic device. The use of unrelated devices enables innovative design thinking outside of the standard interaction style and opens up the spectrum of actions that can be used.

Geertz [1973] describes anthropology's preoccupation with the exotic as a device for making the familiar strange. Two forms of defamiliarization are prevalent in anthropology: epistemological critique and cross-cultural juxtaposition [Marcus and Fischer 1986]. The breaching experiments of Garfinkel [1967] were designed to disturb familiar ways of perceiving everyday life and are a form of epistemological critique. An example of cross-cultural juxtaposition can be found in Bell et al.'s [2005] work with defamiliarizing narratives, constructed from ethnographic data on a range of cultures, to provide alternative viewpoints for helping them rethink assumptions built into domestic technologies.

The notion of "making the familiar strange" is described in relation to the moving body by the phenomenologist Sheets-Johnstone [1999]. Through varying our normal movement patterns and processes we can unsettle our habitual perceptions of the world and ourselves. One way of reacquainting ourselves with familiar or habitual movements is to do a familiar movement differently, to perform the movement with a range of kinetic variations and so reveal the specific felt quality of the original movement. Sheets-Johnstone [1999] describes this process with the act of walking:

> "Changing not only our leg swings, for instance, by initiating movement from our ankle joints by a spring action rather than from our hip joints, but changing our arm swing, the curvature of our spine, the cadence of our walk, the amplitude of our step, and so on."

Similarly, performing a movement outside or on the periphery of our everyday realm, such as learning a new physical skill or performing an unfamiliar movement such as falling, can also bring us into a fresh encounter with our movement possibilities and break us out of habitual ways of thinking about movement. In phenomenology as practiced by Sheets-Johnstone, the aim is to identify the essential characteristics of movement phenomena through the application of free variation. But in design work we can work with the same technique in a different way. Through free variation, or making strange, we can open up the possibilities for movement and the corresponding forms of felt experience.

4. DEVELOPMENT OF THE METHODOLOGY

The design methodology emerged through a series of empirical projects conducted over a six-year period. The projects were devised with the overall objective of identifying and crafting methods and tools for understanding, generating, experiencing, representing, and evaluating movement and its felt experience in the design of

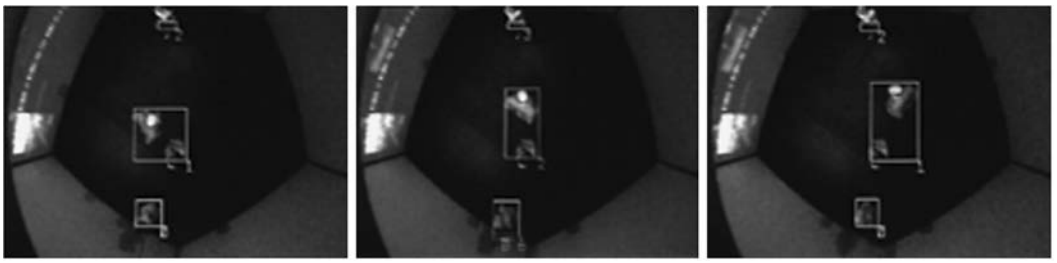

Fig. 1. Overhead images of actual audience inside the Bystander room (the technology perspective).

movement-based interaction. The application domain was interactive, immersive spaces, built on video-based motion-sensing technologies. Each project focused on different situations of design and different conceptions of movement in order to gain an adequate understanding of a proposed design approach to movement-based interaction that prioritizes the lived experience of movement. Each project will be briefly introduced to provide enough background to understand the development of the design methodology. While our focus here is the presentation of the methodology as a whole, interested readers can find more detailed accounts of individual projects in previously published work. We have included appropriate references within the accounts of each project that make up this section.

4.1. Project 1: Eyetoy

The first project served as a preliminary exploration of some existing tools that could be adapted for understanding, analyzing, describing, and representing human movement as input. It comprised an analysis of an existing movement-based interactive product, Sony Playstation2© Eyetoy™, to examine the movements of players interacting with the Eyetoy games. The Eyetoy games were treated as a prototype of future movement-based interactive, immersive systems that could be interrogated about the kinds of movements that worked, or not, within these systems. A set of existing interaction analysis and design frameworks were critiqued for how well they supported or could be adapted to address movement-based interactions (see Loke et al. [2007]). An example of applying the Laban structural notation and effort description to analyzing the player's movements is given in Loke et al. [2005]. The beginnings of a set of design tools—the use of the Laban effort description and an adaptation of Suchman's [1987] analytic framework to support movement analysis—were developed out of this project, for possible inclusion in the design methodology.

4.2. Project 2: Bystander

The second project was part of a much larger design research project to develop *Bystander*, an interactive, immersive artwork built on video-based, motion-sensing technology that presents complex data through visual imagery, text, and sound. A major research focus in this project was to extend traditional human-centered design approaches, methods, tools, and techniques to the design of novel interactive, immersive spaces available for public use in gallery and museum settings. Bystander utilizes human presence and movement as input (Figure 1) and this aspect of its design and development provided the second project that informed the development of the design methodology of Moving and Making Strange. In Bystander, movement is conceptualized as patterns of motion and stillness of the visitors. These are interpreted by the system as indicators of the level of audience engagement with the interactive artwork, which in turn drives the system's behavior and display.

For the purposes of this methodology, our focus was on constructing design representations to explicitly address moving bodies in social contexts and on the subsequent use of these representations for design reflection-in-action through physical immersion and enactment of movement in the prototype environment. A set of design tools—movement-oriented personas and scenarios, spatial movement schemas written in Labanotation, and the Interactivity Table (an adaptation of Suchman's analytic framework)—was produced and incorporated into the design methodology. A more detailed account of this project is found in Robertson et al. [2006], Loke and Robertson [2009], and Robertson and Loke [2009]. The work in it explicitly addressed the external and technology perspectives of human movement.

4.3. Project 3: Studies with Trained Dancers

In the third project we conducted two studies with trained dancers and physical performers to explore ways of working with the moving body as a creative material and design sensibility in movement-based interaction design. These studies prioritized the first-person experience of moving and sought to capture and articulate this perspective. A constructed design situation focusing on the early stages of design, with an emphasis on design research, was the vehicle for the project. We drew upon our previous experience with Bystander to inform the proposed system under design: a choreographic work sited within a video-based, motion-sensing interactive, immersive space. The default physical and technical configuration for the space was a four-screen projection system and an overhead video camera for sensing the activity in the space. We worked with dancers and performers trained in a range of practices, including acrobatics, Butoh, contemporary dance, Feldenkrais, movement improvisation, physical theater, and stilt-walking. Most of the participants were trained in more than one of these areas. The first study was of the falling body by skilled movers. The second study explored ways of inventing and choreographing movement within the proposed system.

The aim of the first study was to explore and document the act of falling from a first-person, experiential perspective and from an external, observational perspective. Falling was chosen as an action that we all have experienced but is not yet made familiar in interaction design. In this study we viewed skilled movers as the ethnographic exotic [Geertz 1973], in order to defamiliarize everyday movements.

In the second study the methods that dancers, trained in movement improvisation and performance making, used to generate, choreograph, and document movement were examined as sources of potential methods for designers. An inspirational resource kit was trialled as a tool for inspiring and documenting the movement ideas and choreography. The representations of the moving body from the external view (including the use of the Laban effort/shape description), initially trialled in the first study, were applied to this study and further extended. The movement was analyzed from the three perspectives of mover, observer, and machine. A more detailed account of this project is found in Loke and Robertson [2010].

The results of the three projects were further reflected upon to develop the emerging design methodology detailed in Section 5. One of the motivating criteria for deciding what would appear in the methodology was the desire to provide designers with a way to work with movement as a material for design in a nuanced fashion. The methodology aims to provide methods and tools for generating, evaluating, and performing movement-related concepts through embodied skills and sensibilities. The methods and attentional strategies imported from dance, performance, and somatics have been carefully selected and modified to suit the interaction design context. The idea is that designers can quite quickly begin working with the tools and techniques to develop their movement-related design sensibilities, without requiring years of formal dance/performance training.

4.4. Design Research Validation

All of the methods and tools presented in the design methodology were used and/or developed within at least one of the three research projects. Validation through actual use in specific design situations (whether in research contexts or "real-world" situations) is established practice in interaction design research in HCI [Forlizzi et al. 2008]. The first project provided preliminary findings on the application and usefulness of Laban movement analysis and the adaptation of Suchman's analytic framework as a design tool.

The second project, Bystander and the third dance project provided various forms of validation of the methods and tools through actual use within collaborative design teams. In Bystander, the methods and tools applied and developed in the project were used and evolved in collaboration with the design team. We used tried and true methods for user-centered design in HCI, that were then extended to explicitly address moving bodies. The use of these methods and tools (together with extensive user research and iterative prototyping) contributed significantly to a robust and functioning interactive artwork that went on to be exhibited in a range of public exhibition spaces. Moreover, these user-centered design tools were successfully inserted into an otherwise nonuser-centered design process and taken, by one of the artists involved, into her ongoing professional practice in new media arts production.

In the third project, a participatory design approach was followed and in the second study in particular, we worked with three trained dancers who contributed to collaborative exploration of the proposed choreographic work. Their participation in the formation of appropriate design representations was vital for ensuring a shared language between interaction design researchers and dancers. The application of the methods for exploring bodily knowing and creative generation of movement material derived from this project remain to be explored in future projects.

Validation of design methods and tools (including representations) is defined as "validation through continued use and through applicability to new design situations" (refer to Forlizzi et al.'s [2008] criterion of extensibility). Continued validation in different design situations could eventually make such new methods and tools part of a designer's normal toolkit. With this in mind, we anticipate further, continuing validation and development of the methodology and its constituent methods and tools.

5. MOVING AND MAKING STRANGE: A DESIGN METHODOLOGY

Our design approach is one of a nonprescriptive, open process of inquiry and exploration (instead of going straight to product) that is compatible with the phenomenologically-inspired design approaches to which we are committed. The design methodology provides a set of principles, perspectives, methods, and tools for designing and evaluating movement-based interactions with technology. It is intended as a "toolkit" for designers, from which they can select and adapt methods and tools, or add their own. The methodology is motivated by the following set of principles: making strange, direct bodily experience, multiple perspectives, openness to phenomena, and creativity. The principle of making strange, in particular, has a prime place in the methodology. As discussed in Section 3, making strange is a tactic for disrupting habitual perceptions and ways of thinking, or in this case, moving, sensing, and feeling. It enables designers to arrive at fresh appreciations and perspectives for design, grounded in the sensing, feeling, and moving body.

The methodology is structured around the three perspectives of mover, observer, and machine (Figure 2). They are designed to make clear the trajectory between the perspective of the mover (in the act of moving), the perspective of an observer (such as the designer or the mover during reflection on design), and the perspective of the

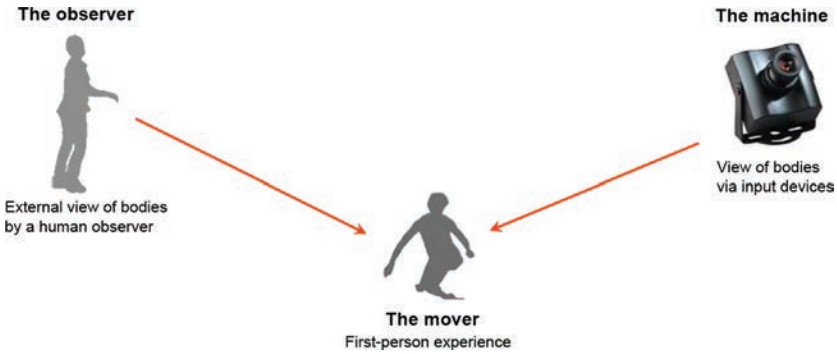

Fig. 2. The three perspectives in the design methodology.

machine (because ultimately if movement is to be effective input to a computer system, the machine must be able to detect and interpret it correctly). Each perspective offers orientation, guidance, methods, and tools at each stage of designing. A method outlines how to do something and may include the use of specific tool(s). A tool can be a representation, a manual device, or a computer-aided design tool that aids thinking and collaboration.

The methods and tools are organized by activity. A diagram of the activities and how they are related is given in Figure 3. This diagram can function as a navigational aid to the methodology. The activities are numbered purely to assist identification; the numbering does not indicate a linear order. Table II then provides the set of methods and tools utilized in a specific activity and the particular perspectives and data offered by that activity. The methodology offers multiple entry points: by *perspective* or by *activity*. Each perspective will be briefly introduced before elaborating the methods and tools used in each activity.

5.1. By Perspective

5.1.1. The mover. The mover perspective ensures designers are accountable to the felt, lived experience of the mover and to the potential users of technology. The perspective of the mover generates first-hand, first-person experience of the moving body. That is, the perspective recognizes the epistemological primacy of the body as the source of knowing about movement; it is where skills are developed for performing, attending to, and articulating movement and its felt experience. The methods and tools to support this perspective include a set of techniques for experiencing and reenacting movement. See activities no. 1, no. 2 and no. 3.

5.1.2. The Observer. The observer perspective provides the view of the body from the outside as seen by another person. The understanding and framing of movement can come from a range of different and complementary views including, but not limited to, the biomechanical, expressive, social, cultural, and ecological (see concepts of the body in Loke and Robertson [2011]). It enables the designer to stand in for other people in the environment and to embed the moving body in various domains and contexts of use. The mover can also be in the position of observer of her own movements, for example, during review of recorded movements. The methods and tools to support this perspective work with a range of representations of observed movement. See activities no. 4 and no. 5.

5.1.3. The Machine. The machine perspective focuses on the sensing and interpretation of the moving body by the computer, as determined by the choice of input sensors and

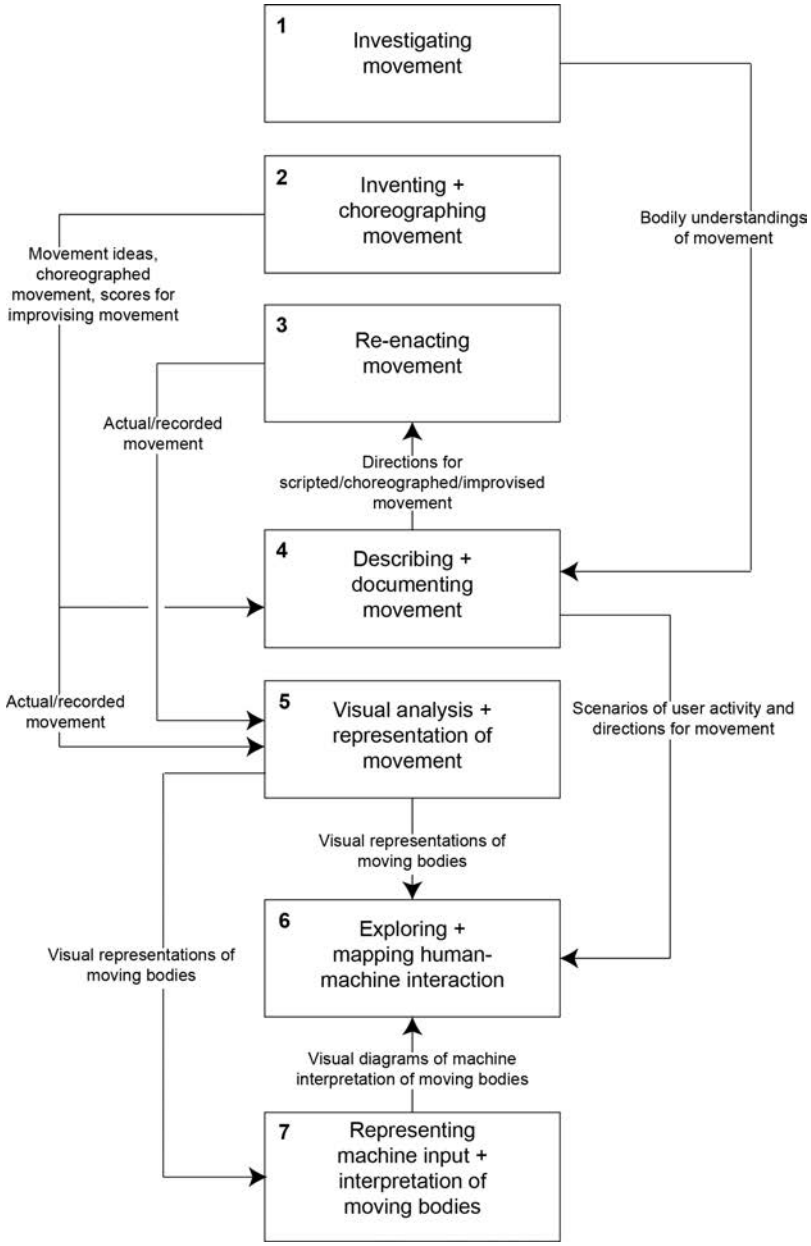

Fig. 3. This diagram shows the key activities promoted by the methodology. The labels on the arrows indicate the data generated by an activity and the direction of the arrow indicates the flow of data from one activity to another.

processing algorithms. It ensures designers are accountable to the machine view of the movements of users and that appropriate mappings are made between user activity and machine interpretation and response. The methods and tools to support this perspective facilitate a close and detailed examination of the mapping and interpretation of movements of the body as input into interactive technologies. See activities no. 6 and no. 7.

Table II. Summary of Activities, Methods and Tools and the Perspectives/Data they Offer in the Design Methodology

Activity	Method/Tool	Perspective/Data
#1 Investigating movement	Experiential structure of movement Playing with everyday movements and gestures Scoring Generating movement from imagery	First-person perspective and experiential data on process and felt sensation of movement.
#2 Inventing and choreographing movement	Working with parameters and qualities of movement: 1. Scoring 2. Variations on a traditional movement form or gesture From words/concepts/images	First-person perspective and experiential data on movement possibilities, forms, patterns, motivations and corresponding felt sensations
#3 Re-enacting movement	Re-enacting movement-oriented scenarios and scripts, movement scores and directions for choreographed movement.	First-person perspective and experiential understandings of movement during user testing/evaluation.
#4 Describing and documenting movement	Describing user activity: 1. Movement-oriented scenarios and scripts 2. Directions for skilled or choreographed movement Documenting choreographed movement: combination of images, text and sketching.	Observational perspective documenting the movements of people and the motivations for movement.
#5 Visual analysis and representation of moving bodies	Movement sequences and silhouettes. Laban movement analysis: Effort/Shape descriptions Spatial movement schemas in Labanotation floorplans.	Observational perspective for visually analyzing and representing human movement. Observational data on the sequencing and bodily organization of the body-in-motion, the expressive qualities of movement and the spatial/social interactions between people.
#6 Exploring and mapping human-machine interaction	Interactivity table	Mapping between human movements and machine, combining the observational and machine perspectives.
#7 Representing machine input and interpretation of moving bodies	Machine input schemas	Machine perspective of the input and interpretation of moving bodies.

5.2. By Activity

Each activity is described in terms of purpose, including the perspective and kind of data offered by the methods/tools and the relations between the various activities. Each method/tool is described, including examples of specific usage of the methods and tools drawn from the previous research projects.

—*No. 1 Investigating Movement*. This activity is concerned with accessing the experiential, moving body directly with one's own body. This is achieved through movement inquiry and practices of making strange. One can begin an inquiry into the potential movement possibilities and felt sensations of one's own body by performing a familiar movement differently or by performing an unfamiliar movement. We can also select physically challenging or unorthodox movements, such as falling, for investigation as

Table III. Definition and Examples of the Experiential Structure of Movement for the Act of Falling

Experiential structure of movement	Definition	Examples of participant description
Movement process/technique	The process of the movement and the technique for performing the movement are inter-related. Process is the dynamic unfolding of a bodily movement in space and time. The process may be split into distinct stages for a given movement, depending on the complexity of the movement. Technique is an established means for directing or informing the movement process.	*Initiating the fall* Finding pathways into the floor. Finding steps to take you off-centre. Momentum of dropping down. *Controlling the fall* Internal muscular lift to slow down. Working in opposite direction to the fall. *Contacting the ground* Relax and soften. Letting my body roll into the ground.
Sensing and awareness – internal and external	What senses are actively engaged and how; the senses include the visual, aural, tactile, and proprioceptive/kinaesthetic; awareness and relating of internal and external environment.	Aware of your body within a larger space. You need that visual to know where you are in the space, to remember what plane you are on, especially when you've thrown yourself off-centre.
Felt quality	The particular sensation or feeling as experienced in the whole or part of the body.	Sense of weight, like a sack of potatoes. Suspension and precariousness.

a way of making strange. The movement inquiry can be deepened through repetition of movements to consciously access in-the-moment sensations and process.

The methods and techniques presented here provide ways of exploring and improvising with the moving body to cultivate skill and a refined awareness of the sensing, feeling, and moving body. They form but a small part of an established repertoire of movement improvisation techniques from dance and performance practices. The bodily understandings of movement gained from these techniques provide a foundation for the activity (no. 4) of describing and documenting movement. Just as importantly, the creative potential of the experiential, moving body is opened up and available for use in the design process, feeding into the activity (no. 2) of inventing and choreographing movement.

Experiential structure of movement. Conducting movement inquiries with skilled movers provides finely nuanced understandings of particular kinds and forms of movement. A structure for analyzing movement from the first-person perspective provides details of the movement process/technique, internal and external sensing and awareness, and the felt quality of the movement. An example is given in Table III for the act of falling by skilled movers (Project 3).

Playing with everyday movements and gestures. Everyday movements and gestures can be the starting point for exploration of new movement possibilities and experiences. A movement can be performed with kinetic variations of speed, scale, and direction to produce different patterns, dynamics, and qualities of movement. Speed varies from slow to fast. Scale varies from small to large. Direction varies relative to the body axis or to the axis of external space. The principle of making strange is activated in this technique, as a habitual movement is defamiliarized through the application of kinetic variations. This in turn creates new imaginings of our movement possibilities.

For example, you can take a simple, everyday gesture such as swinging your arm up and down. You can vary the performance of the gesture by moving your arm to and fro very slowly and smoothly or with a jagged stutter. The focus here is on the relation

between the movement and the felt sensation of movement. Experiment doing this with your eyes open or closed and note how this changes your awareness of the process and sensation of the movement. A Butoh technique makes strange with the everyday act of walking, by slowing down the pace of your walk to as slow as possible. This speed change brings sharply into focus how our body organizes itself in walking and the precariousness of our balance at this very slow speed. The act of walking becomes a negotiation of weight transfer and balance.

Scoring. The method of scoring used in movement improvisation provides a structure for generating and patterning movement based on a set of parameters or constraints that can be varied as desired. Parameters or constraints related to speed, duration, timing, scale, direction, focus, use of space, relation to others, use of props, and so on, can be added to the score. Multiple people can use the same score or work with different scores simultaneously to generate varying patterns of movement. Imagery or qualities of movement can be incorporated into the score. For example, a simple score dealing with motion, stillness, and speed has four elements: (i) walking at normal pace, (ii) walking very slowly, (iii) standing still, and (iv) moving in place. The timing, the change in pace, the direction, the location, the transitions, and so on are left up to the performer(s).

Scores can be used for improvising movement to explore movement ideas for interaction, or for generation and enactment of movement in user testing. They are a simple yet extremely powerful way of generating semistructured patterns of movement. They can be used for playing with everyday movements and are accessible to unskilled movers.

Generating movement from imagery. A different kind of technique uses imagery to shape body movements and generate distinct movement qualities, such as "like a heavy stone" or "like a floating feather". The image can be localized to a part of the body, extended beyond the physical body, or be outside the body in space. For example, you might move your leg as if it contained a viscous fluid or your bones were brittle twigs. Or you might imagine that a long string was pulling you up by the crown of the head towards the heavens. Imagine moving through mud or that the air surrounding you is extremely cold. The focus is on generating felt sensation in the body corresponding to the image, which in turn informs how you move. The more fully you commit to the image, the more convincing the expression. You become the image. The use of imagery for generating movement can be considered a way of making strange. Embodying images in this manner allows us to experience the felt sensation of our moving bodies in a radically different way to the everyday and may result in novel concepts for design work.

—No. 2 Inventing and Choreographing Movement. In future movement-based interactive spaces, we will need different kinds of movements with meanings that are, as yet, unthought-of. These new movements may be improvised, choreographed, emergent, or structured movement systems. Methods for inventing and choreographing movement are part of the practices of making strange through movement inquiry and overlap in part with the techniques for investigating movement in activity no. 1.

Ways of inventing and choreographing movement can be broadly split into two categories: (1) working with parameters and qualities of movement and (2) through inspiration from concepts, text, images, and other means of intellectual thinking that is then translated into movement. A design imperative for generating meaningful movements is the importance of providing a specific and well-defined context or domain. This activity feeds into activities (no. 4) describing and documenting movement and (no. 5) visual analysis and representation of moving bodies. This is an area of the methodology that can be substantially expanded in the future by continuing to work with choreographers and movement improvisation practitioners.

Working with parameters and qualities of movement. The activity of inventing and choreographing new movements can begin with the sensing, feeling, moving body. The method of scoring used in practices of movement improvisation provides a structure for generating and devising movement based on a set of elements or parameters that can be varied as desired. For example, a simple score consists of three elements; walking, standing still, and squatting. Parameters or constraints related to speed, duration, timing, scale, focus, use of space, and so on can be added to the score. Scores can be used for improvising movement while exploring movement ideas for interaction or for generation and enactment of movement in user testing (see no. 3). Another approach is to begin with a traditional movement form or gesture. This form or gesture can then be choreographically developed by varying the parameters and qualities of movement, such as scale and speed.

From words/concepts/image. Methods for inventing and devising movement can begin with a word, concept, or image. These can generate or inspire a movement impulse, kinaesthetic sensation, a particular way of moving, spatial arrangements of the body in relation to itself, other bodies and the body in space, and so on. Choosing a specific context or domain is critical to generating meaningful movement. A specific and well-defined context gives structure and meaning to movements. See activity (no. 4) on choreographic documentation for more.

—*No. 3 Reenacting Movement*. Reenactment of scripted, choreographed, or improvised movement provides actual movement for use in testing and evaluation of the design of interactive systems. Enactment enables design reflection and refinement that is anchored in a bodily understanding of what it is like to act, move, perceive, and respond in interaction with such systems. It provides designers with first-hand experiential data on the interactional viability of particular forms and patterns of movement. Felt, bodily experience can be garnered from architectural qualities of the interactive space such as the sense of scale, enclosure, and spatial arrangement. The visual and sonic outputs of the system can be experienced kinaesthetically as well as visually and aurally. The effects of interaction between people on their actions, movements, and perception can be gauged. Enactment of movement grounds the imaginings of user behavior and experience in actual bodies.

Design descriptions and representations of movement provide structures for generating movement. These include movement-oriented scenarios and scripts, movement scores, directions for choreographed movement, and spatial movement schemas. An example is provided next of movement scores to be used in user testing. This activity feeds into the activity (no. 5) of visual analysis and representation of moving bodies.

Movement scores. Movement scores can be combined with traditional personas and scenarios for use in user testing when loosely structured patterns of movement are required. The choice of parameters in the score is highly flexible and can be manipulated for each persona in a given situation. Three examples of movement scores for generating movement in user testing of an interactive, immersive space like Bystander are given in Table IV. The order and timing of these elements are not prescribed and are improvised during actual performance of the score. More complex scores can be devised incorporating more parameters and constraints on the movement, as well as interactions with other people. The scores were based on observations of actual people in exhibition spaces and in Bystander itself.

—*No. 4 Describing and Documenting Movement.* The movements of different kinds of users or participants, in interaction with machines, can range from the everyday to highly skilled or choreographed movement. We need language to describe movement that captures and evokes the wide range of possible understandings of movement for

Table IV. Movement Scores for 3 Personas

A simple score for a user persona representing an older woman, Val, may consist of three elements:
1. standing still
2. walking slowly to another location
3. slowly turning around to follow the visual effects of the system
A score for a user persona representing a young child may consist of elements, where parameters of time, relating and direction are implied.
1. running around in all directions
2. sudden plonking onto the ground
3. grabbing onto a person they know
4. dragging the companion around
A score for a user persona representing the kind of visitor that prefers to find a comfortable position and remain there may consist of elements like:
1. stand on spot
2. turn head then body to follow visual effects
3. minimal shifting of position to accommodate the infringement of another person

Table V. Movement-Oriented Scenario for Two Personas, Val and Betty

This scenario explores the situation where a couple of people enter the *Bystander* room, which is currently empty. The characters, Val and Betty, are representative of older, retired people with a keen interest in the arts. They embody the fifth type of audience behaviour - *serious, quiet and contemplative engagement*. They enter the space and stand just inside the entry. A key event then occurs where a teenager attempts to enter the room but is blocked by Val and Betty. The teenager embodies the first type of audience behaviour - the *head-poker* (i.e., someone who just looks in or enters briefly and then leaves). After the head-poker leaves, Val and Betty move around the space, firstly towards the centre and then towards one of the walls. They tend to move slowly with periods of stillness, as they observe the flock circling the room, revealing sets of images and texts. They chat and occasionally point things out to each other.

use in interaction design. We can focus on the activity of users, their physical and social interactions, the functional character of their movements and actions, the mechanics of their movement, the spatial patterns and organization or the expressive quality of their movement, for example. Or we may wish to focus on the details and nuances of performing particular kinds of movements. A range of tools for describing movement includes movement-oriented scenarios and scripts, directions for choreographed movement, and choreographic documentation. These descriptions of movement can be used to reenact and generate movement for testing and evaluation (no. 3). They can also be used for exploring and mapping human-machine interaction (no. 6).

Movement-oriented scenario. Scenarios written in the third person are traditionally used in interaction design to describe the activities of users in specific contexts and settings, either actual observed activities or future imagined activities. These traditional scenarios have been extended here to include movement-oriented characteristics. An example from the Bystander project is given in Table V.

Movement-oriented scenarios can be turned into scripts for action. An example of scripted movement for the a foresaid movement-oriented scenario is given in Table VI. For this particular system, it was important to differentiate the activity and movements of the users and their spatial paths, position, and orientation, so we could determine and test the limits of the input detection system.

Directions for choreographed movement. A choreographer may provide textual directions capturing the detail and nuance of performing movement. These descriptions detail the specifics of how the body moves in space and time, rhythm, timing, repetition, the form and phrasing of the movement, the use of imagery and the interaction with

Table VI. Script Corresponding to the Movement-Oriented Scenario

Time Min:Sec	Scenario and Key Events	Activity: Movement/Stillness	Spatiality: Path/Position/Orientation
01:00	*Slow-moving, contemplative visitors*. Betty and Val about to enter empty room.	Betty and Val enter room together and stand fairly still looking around with heads turning.	Stand just inside entrance.
01:30	*Head-poker*. Young teenager enters, blocked by Betty and Val, so leaves.	Young teenager enters room, then exits.	Just inside entrance.
02:00	Betty and Val decide to stay and watch more.	Betty and Val walk towards centre.	Straight path towards centre.
02:30–04:00	They watch the flock.	Slowly turning to watch flock, taking 1 or 2 steps each way.	Stand in centre facing wall w2.

Table VII. Directions for Choreographed Movement

Act 3 - Swooning in Ecstasy, Section 2
The four performers begin to weave around the space, performing a *lifting limb* motif with both arms. One arm lifts the crook of the elbow of the other arm, then slides along the arm and then pushes the limb away in some direction. At certain points in the space, a performer may drop from standing to the *sitting buddha* position in front of an audience member. Or a performer may slowly crumble to the ground from standing. They slowly rise again, using the image of being pulled up by a string at the crown of the head.
The lifting limb motif of lifting, sliding, pushing works in a triadic structure. It is something that builds in pace over three repetitions. "It's a lift, slide, push to work into a swooning. That way you can start working around people (audience members). It's probably a bit more chaotic: staggering, fleeting energies. It is possible for the performer to work three levels with the 'lift, slide, push' phrase, once developed."
The final phase becomes a sitting in front of people - like the Buddha. It is a weighted drop from standing into a squatting position. An aura of stillness is maintained until the position is shifted.

other movers in the space. The example in Table VII is from Project 3, where initial ideas for choreography within an interactive, immersive space were explored.

Choreographic documentation. Tools for documenting the movement ideas and choreography in forms that retain the essence of the movement or motivation and are accessible to both choreographers and designers include the combined use of text, images, and sketching. One technique for documenting choreographic ideas is to work with a set of images and texts related to the thematic context of the work; the seed material can play an inspirational, as well as documentary, role. An example from Project 3 is given in Figure 4, where the choreographers were provided with seed material (images, text, music) on the theme of the Divine and Bodily Experience; in turn, they documented their choreographic ideas using elements of the seed material.

—*No. 5 Visual Analysis and Representation of Moving Bodies*. Visual representations of the moving body enable closer examination of the moving body from an external or machine perspective. The focus is on what a particular movement looks like, how it is performed, and what happens to the body during the execution of the movement. The Laban system of movement analysis and notation can be applied to describe and visually represent the movements of an individual body and group choreography.

The data gained from this kind of inspection can assist with the design of machine interpretations of the input and bridge the interface between human-centered design approaches and technologically-driven implementations. Assuming that video sensor technology is used for the input of human movement (given our research focus on interactive, immersive spaces built on video-based motion-sensing technologies), we

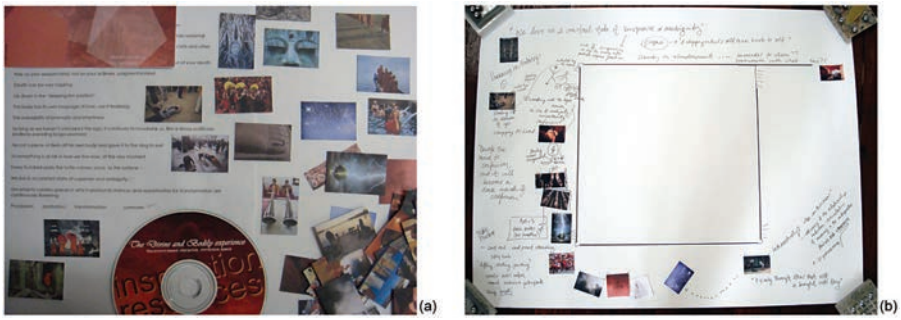

Fig. 4. (a) Seed material; (b) documentation of choreography using the seed material.

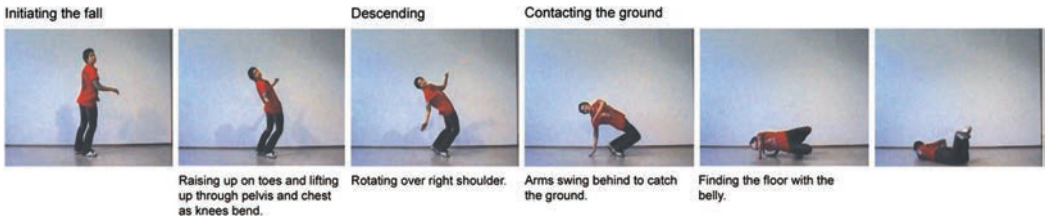

Fig. 5. Movement sequence for the act of falling.

have a stream of visual data to work with. The visual data can be analyzed to identify the changing spatial shapes, positions, and trajectories of moving bodies and their relation to other bodies, props, and the external environment.

The tools presented here include movement sequences and silhouettes, effort/shape descriptions, and spatial movement schemas. These tools provide a rudimentary baseline of visual representations of the moving body. These visual representations can be transformed in many ways to bring out different aspects of the moving body in space and time. This activity feeds into (no. 6) exploring and mapping human-machine interaction and (no. 7) representing machine input and interpretation of moving bodies.

Movement sequences and silhouettes. Movement sequences extracted from video data focus on the key postures and organization of the body through its trajectory in space and time. The movement sequence can be presented in a number of formats to provide different kinds of emphasis and information. Silhouettes highlight the changing spatial shapes made by the body in motion. An example of an annotated movement sequence for the act of falling from Project 3 is given in Figure 5.

Effort/shape descriptions. Laban movement analysis can be used to describe the dynamic, expressive elements of movement. The energy content of a movement can be analyzed with effort dimensions. The spatial shaping of movement can be analyzed with shape categories, describing the static form and the changing relation of the body to itself and the environment. Figure 6 illustrates the same movement sequence in silhouette with Laban effort/shape descriptions.

Spatial movement schemas. These are visual representations of spatial paths of individual or multiple people moving through a space. They can be drawn informally or using Labanotation symbols for group choreography [Hutchinson 1977]. Using Labanotation symbols, the position, orientation, direction, and path of movement, and the sequencing of multiple bodies can be visually represented. An example of a spatial movement schema from the Bystander project is given in Figure 7. It corresponds to

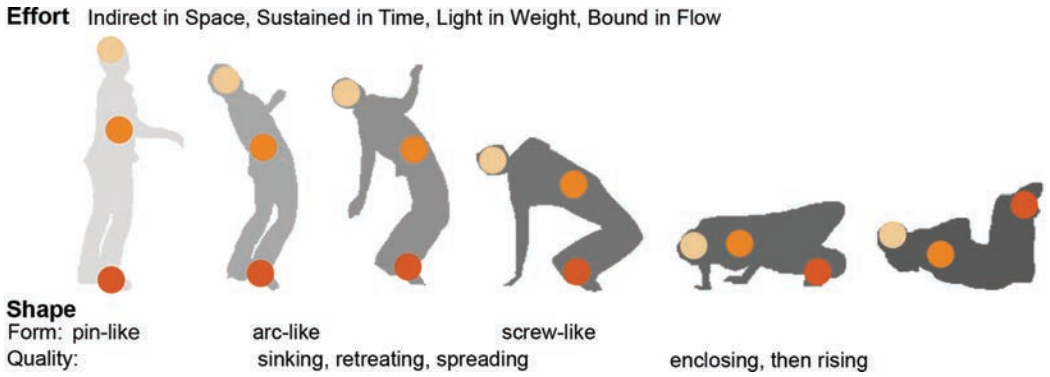

Fig. 6. Silhouette sequence with effort-shape descriptions.

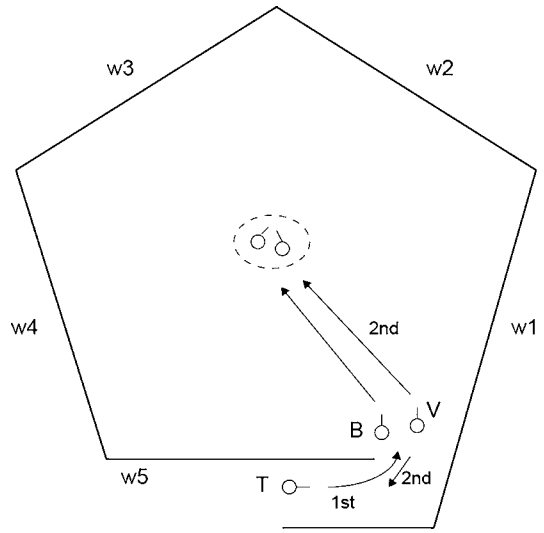

Fig. 7. Spatial movement schema.

the movement scenario and script in Table V and Table VI, respectively. More detailed discussion of movement schemas can be found in Loke and Robertson [2009].

—*No. 6 Exploring and Mapping Human-Machine Interaction.* When designing an interactive system, one of the core activities is exploring and mapping the interaction between humans and machine. This is the essence of HCI, the input-processing-output loop that enables the computer to participate in the mutually coherent process we describe as interaction [Suchman 1987]. For movement-based interactive, immersive spaces, the focus is on mapping between human movements and the sensing of these movements by the machine and its subsequent response. The questioning of the relations between conceptions of movement and assumptions built into machine interpretations of moving bodies lies at the heart of our design approach. The interactivity table design tool—an adaptation of Suchman's [1987] analytic framework—can facilitate this inquiry. Suchman's analytic framework hinges on the notion of the resources available for perception and action by human and machine. For a fuller discussion of the extension of Suchman's analytic framework for use as a design tool, see Robertson and Loke [2009].

Table VIII. Suchman's Analytic Framework Adapted as a Design Tool

The User			The Machine		
Actions not available to the machine		Actions available to the machine	Effects available to the user	Internal machine behaviour not available to the user	
Scenario and Key Events	User Perception	User Activity: Movement/Stillness	Machine Effects (Audiovisual)	Machine State	Machine Perception

Table IX. User Perspective of the Interactivity Table

	Time Min:Sec	Scenario and Key Events	User Perception	Activity: Movement/Stillness	Spatial Movement Schema
Scenario 1	01:00	*Slow-moving, contemplative visitors*. Betty and Val about to enter empty room.	See flock revealing on wall, w2.	Betty and Val enter room together and stand fairly still looking around with heads turning.	1
	01:30	*Head-poker*. Young teenager enters, blocked by Betty and Val, so leaves.	What they see depends on whether or not the room perceives the head poker	Young teenager enters room, then exits.	2
	02:00	Betty and Val decide to stay and watch more.	See flock moving, some images and text unfold.	Betty and Val walk towards centre.	
	02:30–04:00	They watch the flock.	See flock moving, more images and text unfold.	Slowly turning to watch flock, taking 1 or 2 steps each way.	

The interactivity table design tool. This presents the interaction between user and machine from the perspectives of the user and the machine. It can be organized in a flexible way to enable documentation of user activity in terms of action/movement and perception (internal/external), alongside machine interpretation and response (Table VIII). It enables designers to explore, reason about, evaluate, and refine the design of the interactivity between the active, moving bodies of human users and computer-based interactive systems using human movement as direct input. It makes explicit any design assumptions about user behavior that become embedded in computer-based interactive systems. An example of the interactivity table from the Bystander project is shown in Table IX and Table X. In practice, they form a single table.

The interactivity table is an integrating representation, as it brings together the various activities and tools from the design methodology that are more or less human or machine focused (see Figure 3). The representations constructed from both the observational and machine perspectives can act as boundary objects [Star 1990], or bridging representations, between the movements of users and the input and interpretation of these movements by the machine.

—No. 7 Representing Machine Input and Interpretation of Moving Bodies. The machine interpretation of the input depends on the specific application and the sensor technology employed. For video-based sensors, the input is a dynamic stream of visual data of moving bodies, which can be broken down frame by frame. Designing the machine interpretation of the input rests on conceptual decisions about how to interpret moving bodies in the system under design. For example, in Bystander, the system interpreted the presence and movements of people in terms of densities and degrees of

Table X. Machine Perspective of the Interactivity Table (matching Table IX)

Time Min:Sec	Flock/Sound behaviour	Room State	Machine Perception	Design Questions
+01:00	Flock coherent presentation on wall, w2.	State 1.	Detection of 2 figures, some motion.	What is considered 'still'? Standing still may realistically translate to slow, peaceful, gentle body movements and locomotion within a very small area.
01:30	Flock coherent presentation.		Ingress of 1 figure.	Has this person been detected? May want dead zone at entry.
02:00	Does it change?	State change?	Detection of 2 figures moving towards centre.	Is this sufficient movement to trigger a state shift to state 2?
02:30–04:00	Flock behaviour depends on answers to design questions.		Detection of 1-2 figures at centre.	Does position matter to the room?

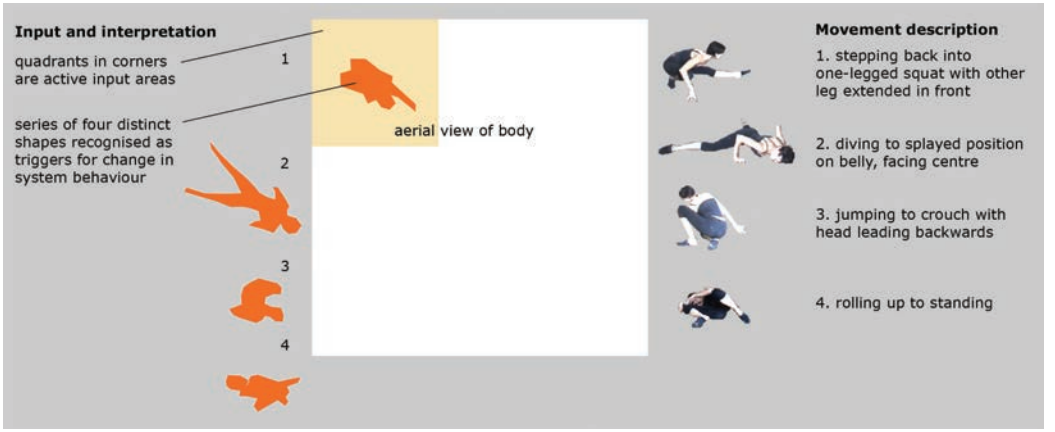

Fig. 8. Machine input schema for interactive dance work.

motion. Visual representations of the machine input and interpretation can be constructed to assist in the mapping of human activity/movement in relation to machine behavior. One specific representation used in this research is the machine input schema.

Machine input schemas. These are used to visually represent the input mechanisms and corresponding interpretation of the input. They rely on the visual analysis and representation of moving bodies. Diagrams documenting the movements of users, such as the spatial movement schema diagrams or movement sequences, can be annotated or overlaid with interactive options, detailing the choice of input mechanism, interpretation of the input, and corresponding system response. A series of these machine input schemas may be required if longer temporal and dynamic patterns of movement are to be recognized. For example, identifiable patterns of movement could be clustering and dispersion of bodies, periods of relative stillness, straight-line trajectories, slow-moving or fast-moving bodies, and changing spatial shapes, textures, and rhythms.

An example of a machine input schema from Project 3 is given in Figure 8. The choice of machine input and interpretation of moving bodies in this case is the recognition of

a series of four distinct spatial shapes of the body-in-motion within a nominated quadrant of the physical space, which then triggers certain effects such as changing visual imagery and sound. The part of the methodology for representing movement is contingent on the specific sensor technologies employed for sensing movement. The kinds of visual representations of moving bodies depicted in the methodology are strongly related to the use of video-based motion-sensing technologies for input of human movement. The use of other kinds of sensors such as accelerometers, pressure mats, lasers, ultrasound, etc., would require different forms of visual representation.

6. CONCLUSION

While detailed accounts of the development of different aspects of its methods and tools have been previously published [Loke et al. 2005, 2007; Robertson et al. 2006; Loke and Robertson 2009, 2010; Robertson and Loke 2009], this article has presented an overview of the design methodology of Moving and Making Strange in its entirety, with the relations between different parts of it explained. This has enabled the full scope and richness of the methodology to be articulated. This article provides a complete account of a coherent approach to interaction design that enables a systematic and principled development of movement as input for interaction. It is unique for its methodical treatment and transformation of the traditional human-centered interaction design process through the lens of movement and the kinaesthetic sense.

The methodology is distinctive for its commitment to the lived body and the potential use of the moving body as a creative material and sensibility for design. The methods and tools offered by our design methodology can provide resources for exploring, generating, and testing design concepts and prototypes, grounded in sensory movement experiences. Movements can be explored and documented from the three perspectives of mover, observer and machine to allow movements to be transformed in a principled and systematic way to become input into sensing technologies. A major contribution of the methodology, reflecting its phenomenological roots, is the inclusion of the mover perspective to ensure that the felt, lived experience of movement is an essential and important consideration in the design of movement-based interactions with technology. Our methodology can be combined with existing interaction design approaches, thus extending the work of others to more fully incorporate the first-person perspective of those who use the technology.

The current limitations of the methodology are an underdeveloped machine perspective and a focus in the original design domain on whole-body interaction using video-based motion sensors. This can be remedied by bringing in approaches that explore various sensing technologies as a material for design (e.g., Sundström et al.'s [2011] *inspirational bits*). How these two approaches to designing interaction can work in practice is an interesting and open question. The general principles of the design methodology motivate a design approach that can also be readily extended into other kinds of technologies and design contexts, not just movement-based interactive technologies built on video-based motion sensors. Other kinds of input sensors will provide additional opportunities for applying, extending, and further validating the methodology. The design methodology of Moving and Making Strange can provide a general framework for conducting technology design and research, grounded in an embodied approach that privileges the human body as the source of movement and the site of its experience.

ELECTRONIC APPENDIX

The electronic appendix for this article can be accessed in the ACM Digital Library. It contains a sample of exercises contained in the design methodology. Exercise 1 is

on kinetic variations of movement. Exercise 2 is on generating movement through imagery. Exercise 3 is on developing skill in applying Laban movement analysis.

ACKNOWLEDGMENTS

We thank our reviewers for their valuable feedback on this manuscript.

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Received October 2011; revised March 2012; accepted August 2012