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Appendix F: Bound In Publications

The following published material represents research conducted during the registration period of the degree of Doctor of Philosophy.

Publications bound in are listed below, and appear in the following order:

Schiphorst, T., “Body Matters: the Palpability of the Invisible Computer”, Leonardo, Special Issue: Materials for Creativity, Accepted for Publication, In Press, Spring 2008.

Schiphorst, T., Motamedi, N., “Applying An Aesthetic Framework of Touch for Table Top Interaction”, *IEEE TableTop Interaction 2007 Proceedings*, Newport, Rhode Island, October 10-12, 2007, pp. 71-74.

Nack, F., Schiphorst, T., Obrenovic, Z., KauwATjoe, M, Bakker S., Rosillio, A., Aroya, L. “Pillows as Adaptive Interfaces in Ambient Environments”, *HCM’07,* Augsberg, Germany, Sept 28, 2007, pp. 3-12.

Schiphorst, T., “Really, Really, Small: The Palpability of the Invisible”, CC07, Creativity and Cognition Conference, Washington, DC, June 13-15, 2007, pp. 298-301.

Schiphorst, T., Frank Nack, Michiel KauwATjoe, Simon de Bakker, Stock, Lora Aroyo' Angel Perez Rosillio, Hielke Schut, Norm Jaffe, “Pillow Talk: Can We Afford Intimacy?”, TEI (2007), Tangible and Embedded Interfaces Conference, February 15-18 2007, Baton Rouge, Louisiana, pp. 23-30.

Aroyo, L., Nack, F., Schiphorst, T., Schut T., and KauwATjoe, M. “Personalized Ambient Media Experience: move.me Case Study”. Conference on Intelligent User Interfaces (IUI) 2007, Hawaii, Jan. 28–31, 2007, pp. 298-301.

Schiphorst, T., “Affectionate Computing: Can We Fall in Love with a Machine?”, MultiMedia Impact, *IEEE Multimedia*, January – March 2006, pp. 20–24.

Schiphorst, T., “Breath, skin and clothing: Using wearable technologies as an Interface into ourselves”, International Journal of Performance Arts and Digital Media, PADM 2 (2) pp. 171-186, Intellect 2006.

Schiphorst, T., “exhale: breath between bodies”, ACM SIGGRAPH 2005, August 1-4, 2005, ACM, New York, NY, pp. 62-63.

Schiphorst, T., “Soft, softer, softly: whispering between the lines”, Book Chapter, *aRt+D: Research and Development in Art*, V2_Publishing, NAi Publishers, V2 June 2005, Rotterdam. ISBN 90-5662-389-3.

Schiphorst, T., Jaffe, N., Lovell, R., "Threads of Recognition: using Touch as Input with Directionally Conductive Fabric:”, altCHI, CHI 2005, CHI April 2005, Portland, Oregon.

Ascott, R., Cox, D., Dolinsky, M., Gromala, D., Novak, M., Rogala, M., Schiphorst, T., Slattery, D., Vesna, V., Artist Round Tables, ACM SIGGRAPH 2004 Art Gallery (Los Angeles, California, August 08 - 12, 2004). S. Gollifer, Ed. SIGGRAPH '04. ACM, New York, NY, pp. 131-134.

Cunningham, M., Vaughan D., Schiphorst, T., Carolyn, B., Kuhn, L., "Four Key Discoveries: Merce Cunningham Dance Company at Fifty", Theater, Vol. 34, No 2, 2004, Yale School of Drama, pp. 105-111.

Schiphorst, T., Andersen, K., "Between Bodies: using Experience Modeling to Create Gestural Protocols for Physiological Data Transfer", altCHI, CHI 2004, CHI April 2004, Vienna.

Wakkary, R., Schiphorst, T., Budd, J., "Cross Dressing and Border Crossings: Exploring Experience Models Across Disciplines", Extended Abstracts of ACM CHI 2004, April 2004, Vienna, pp. 1709-1710.

Chen, T., Fels, S., Schiphorst, T., "FlowField: Investigating the Semantics of Caress", ACM SIGGRAPH 2002 conference abstracts and applications, Siggraph '02, pp. 185.

Jeremijenko, N., Schiphorst, T., Mateas, M., Strauss, W., Wright, W., Kerne, A., "Extending interface practice: an ecosystem approach", ACM SIGGRAPH 2002, July 21-26, 2002, ACM, New York, NY, pp. 90-92.

Schiphorst, T., Kozel, S., "pulp fashion | wearable archi[ves]tectures", proceedings, V2- anarchiving conference, Rotterdam, July 2002, http://deaf.v2.nl/deaf/03/ 221-117-229-207-116-102-152-49-79-100-19-11-14-99-208-171.py (online essay)

Schiphorst, T., Lovell, R., Jaffe, N., "Using a Gestural Interface Toolkit to Interact with a Dynamic Virtual Space", Extended Abstracts, ACM CHI 2002, Ap 2002, pp. 754-755.

Schiphorst, T., "Body Interface, navigation sense and state space", The Art of Programming, Sonic Acts Dec 2001, Digital art music and education, Amsterdam Paradiso, pp. 48-55.

Schiphorst, T., "Intentional Grammars", Cast01 // Living in Mixed Realities, Conf Proc, September 2001, http://netzspannung.org/cat/servlet/CatServlet?cmd=netzkollektor&subCommand=showEntry&lang=de&entryId=41301

Schiphorst, T., Fels, S.S., "Affect Space, Semantics of Caress", Cast01 // Living in Mixed Realities, Conference Proceedings, September 2001, http://hct.ece.ubc.ca/publications/pdf/CAST01.pdf

Schiphorst, T., Siggraph Panel, Siggraph 2001, panel moderator in *Designing Experience: collaborative spaces in art and design,* with Ron Wakkary, Susan Kozel, Steve DiPaola, Alice Mansell and Thecla Schiphorst.

Schiphorst, T., “Body Matters: the Palpability of the Invisible Computer”, *Leonardo, Special Issue: Materials for Creativity*, In Press, Spring 2008.

Body Matters: the Palpability of the Invisible Computer

by Thecla Schiphorst

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ABSTRACT

The body matters. As computer interaction becomes more intimately connected with our everyday experience, lying closer to our skin, embedded in our clothing and literally touching our lives, we need to account for the body and its experience as it physically materializes through our technology. This paper explores embodiment and ‘body experience’ in designing for invisible computing. Weiser [Weis1994] has suggested that invisible computing calls for design methods that focus on the ‘whole person’, and that this greater focus necessitates engaging in a dialogue with the arts and humanities. This paper contributes to the discourse of embodiment within technology and introduces a framework from the field of *Somatics*. Somatics offers an account of experience enacted through first-person methodologies incorporating technical expertise and reflection-in-action that has the attributes of being “rigorous in its own right”[Scho1983]. Its frameworks are rooted in its historical ties with performance and movement practices, and can be traced to philosophical underpinnings within contemporary phenomenology and pragmatism. An emerging discourse within human-computer interaction is evidenced by an extra-ordinary wealth of literature exploring experience, embodiment, subjectivity and felt-life. This exploration is accompanied by research questions that are attempting to re-balance our understanding of the relationship between subjective and objective knowing, making and doing. *Somatics* brings with it epistemologies of practice and embodied approaches to learning and interacting that focus on attention, context and awareness. I present a set of design examples that demonstrate ways in which Somatics (and its roots in performance) can be applied to technology design within HCI.

INTRODUCTION

Our physical technology continues to grow smaller and smaller. This is the foreseeable result of a continual process of miniaturization, yet this continuing ‘disappearance’ marks a cognitive and creative shift from seeing to feeling, from the visible to the invisible. It is here that the experience of the body matters. This is an opportunity to engage the full range our sensing and experience in new ways. As a privileged 'sense' of the enlightenment, vision has influenced the definition of knowledge, validity and experience [John1987, Gibs1966]. Yet, invisible computing is moving us toward perceptual palpable interfaces. Embodied computing can take fuller advantage of all of our senses accessing a richer and more fully articulated human being. Weiser's [Weis1994] definition of invisible computing includes a return to the 'whole person' engaging with practices in arts and humanities and focusing on experience. This aligns with the growing acknowledgement within HCI of the value of designing technology *as* experience [McCa2005].

The Palpability of the Invisible

If our goal is to increase legibility, coherence and social relevance in relationship to the 'whole human' then we need to develop richer sense-making models for interaction. We need to align techniques of active embodied practices with technological rigor and imagination. The metaphor of palpability refers to the increasing physical yet invisible embodiment of technologies. Palpability refers to an intensity that is perceivable and felt. Palpable interfaces describe those which 'make sense' of felt-life. Gibson refers to the senses as *active* seeking mechanisms for looking, listening, touching, and understanding information in the world, where the role of kinesthesia is inseparable from perception, constantly co-operating in and coordinated with acts of perception. Perception is active attention [Gibs1966]. Although the computer and the interface may be 'disappearing', our world and our bodies are continuously present and made even more visible through our participation. Active sensing results in learning to trust a greater range of sensory data and does not rely solely on visual perception. The invisible computer necessitates the development of new models and metaphors that support design, creativity and use.

THE DIALOGUE BETWEEN SUBJECTIVITY AND REASON

We are witnessing a reformulation within human computer interaction centered in the need to create richer models of human experience. The relevance of theories that account for embodied reasoning is gaining significance in HCI. As our technology 'disappears' into the seams of our world we are moved to understand, contextualize and integrate the consequence of this physical and metaphoric shift. There is an outpouring of interest in knowledge and methods that originate from within a seemingly endless variety of fields. We are seeing the influence of Cognitive Science [John1987], Sociology [Nard2001], Phenomenology [Merl1969, Dour2001], Psychology [Gibs1966], Neurophysiology [Dama1999], Performance Practice such as Theatre [Boal1992, Sche1985] Dance [Kjöl2004, Schi1997b] and Somatics [Cohe1994, John1995, Laba1974], Reflective and Contemplative Traditions [Yasu1987, Depr2003], and Critical Theory [Mass2002]. This trend is bridging methodologies by synthesizing ways that we imagine, validate, and evaluate our discoveries.

The Body in the Mind

Sensory design that accounts for 'the body in the mind' can broaden and expand approaches to interaction design. In Cognitive Science the theory of embodied image schemas have found relevance within human computer interaction [Hurt2007] in their ability to support and design prototypes for intuitive interaction. Image schemas arise from the embodied nature of our everyday experiences [John1987] where thinking and acting are inseparable from imagination. Among other researchers that advocate the embodied nature of rationality are Gibson [Gibs1966] in his exploration of the senses as perceptual systems, Damasio [Dama1999] in his descriptions of the neuro-physiological coupling of feeling, thought and action, Polanyi [Poly1983] in his treatise on the tacit dimension of knowing, Putnam [Putn1981] in his philosophical argument that value is inextricably tied to reason, and Johnson [John1987] who describes truth as relative to embodied understanding. If subjectivity can be seen to provide a rigor of 'felt-life' that co-mingles and informs our objective methodologies, we can use the notion of embodiment as a precursor to rationality. "How imagination can be both formal and material, rational and bodily – is that there is not an unbridgeable gap between these two realms in the first place. Once we not longer demand a disembodied (or nonphysical) rationality, then there is no particular reason to exclude embodied imagination from the bounds of reason" [John1987, p.169]. Seeking a balance between objective and subjective knowing provide one of the possible methodological explorations in designing for experience.

The Focus of Experience within HCI

A recent issue of *Interacting with Computers* published a special issue on the emerging roles of performance within HCI and interaction design [Maca2006]. Examples of approaches to interaction design that express experience through embodied goals [Moen2007] attention to sensing systems [Schi2006], aesthetics [Cand2006, Schi2007], and awareness or situated contexts [Schm2002, Such1987] is proliferating and creating a growing vitality within the research community. McCarthy and Wright have suggested placing 'felt-life' in the centre of

HCI and sketch an approach for its instrumentality [McCa2005]. In her approach to interaction design Larssen explores how movement feels rather than how it looks, borrowing strategies from movement analysis and performance [Lars2007].

SOMATICS AS AN EXPERIENCE TRADITION

Somatics is a field of study that explores the lived *experience* of the moving body. As an experience tradition that defines knowledge through embodied practice, Somatics can contribute to the discourse of HCI, particularly with regard to the body in everyday life. Contemporary Somatics refers to a set of body-based disciplines that have flourished largely outside of academia, and include practitioners such as Rudolph Laban and F.M. Alexander. Somatics offers an account of experience enacted through first-person methodologies incorporating technical expertise and reflection-in-action that is rigorous in its direct approach to practice. Its frameworks are rooted in its historical ties with performance and movement practices, and can be traced to philosophical underpinnings within contemporary phenomenology[1] and pragmatism[2] and to ancient concepts of the 'self' that date back to Hellenistic[3] traditions and Eastern philosophic thought[4]. The historical development of Somatics is congruent with concepts of first-person experience as located within phenomenology (Husserl and Merleau-Ponty), contemporary Embodied Cognition and Neurophysiology. Somatics complements (and differs from) these academic disciplines in its direct application of physical practices and techniques. Within Somatics technical practice is centered in first-person, self-reflexive, attentive and intentional *technical enactments of experience*. These techniques are structured to transform experience through directed

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[1] For example Elizabeth Behnke who founded the Study Project in the Phenomenology of the Body in 1987, focuses on first-person Husserlian phenomenological practice.

[2] The American philosopher John Dewey whose approach to pragmatism and experience has recently entered the literature of user experience within HCI, studied with F.M. Alexander, one of the 'father's' of Somatic training, for over twenty years. Dewey credits his work with Alexander's in the development of a number of his later philosophical frameworks.

[3] This refers to an analysis of Foucault's "care of the self" in his late work, *The Hermeneutics of the Self*, in which Foucault's textual analysis of ancient history of Hellenistic thought, suggests that the Delphic prescription "know yourself", which has been understood to be the founding formula of the history of philosophy, should be understood as being formulated in a kind of subordination to the precept of "the care of the self' from the point of view of a history of practices of subjectivity (first-person practices); that to know the self one must "attend to the self, not forget the self, take care of the self". Foucault suggests this as an "event in thought" where knowledge in a philosophical sense is subordinated to subjective physical practices that transform the self. He distinguishes this position from 'Knowledge' as it was transfigured in "the Cartesian moment", which he states functioned historically in two ways: re-qualifying the importance of "knowing the self" while "discrediting the practice of 'the care of the self'." This original Hellenistic form as Foucault presents it, of activating the knowledge of the self through the practices of the 'care of the self' has a great many resonances with the form of contemporary Somatic epistemologies of practice.

[4] In Eastern Philosophy, the concept of self-cultivation is seen as a practice toward the goal of unifying mind and body. This is achieved through a set of rigorous technical first-person practices based on the somatic self, awareness (or attention) and cultivated within a somaesthetics of experience, see Yuaso Yasuo, *(1987)*. *The Body: Toward an Eastern Mind-Body Theory,* SUNY Press. The notion of self-cultivation is resonant with technical practices of Somatics.

attention. The design examples presented here characterize select technical practices, illustrating their instrumentality in technology design. These examples illustrate the intertwining of performance and Somatic practice and lay the groundwork for the use of technical practices of embodiment within the field of Human Computer Interaction. One of the goals is to re-balance our understanding of the relationship between subjective and objective knowing, making, and doing.

In Somatic practice learning to access and direct attention is a central theme. One could say this is akin to becoming an 'Expert User' in attention techniques. Ginsberg [Gins2005] offers examples that illustrate the value of attention skills. Other fields such as phenomenology and cognitive science [Depr2003] share these goals and practices. At the simplest level, retraining the sensorimotor system, and re-enlivening sensorimotor pathways is a mechanism for retraining embodied habits and perceptions. An example includes slowing movement down as much as possible in order to increase awareness of one's physical state. This technique is practiced in Noh and Butoh traditions, as well as movement therapies that work to retrain sensorimotor habits. Consciously slowed motion enables the body to shift its attention to an immersive state in relation to its environment, where attention is intensified and sensory details are sharpened.

Augusto Boal terms this type of experiential exercise *de-specialization.* He states that in our every day lives "the senses suffer. We feel very little of what we touch, listen to very little of what we hear, and see very little of what we look at. We feel, listen and see according to our specialty. The adaptation is [both] atrophy and hypertrophy. In order for the body to be able to send out and receive all possible messages, it has to be re-harmonized [through] exercises and games that focus on *de-specialization*." [Boal1992] Boal's goals in theatre are to create imaginative, social and political agency. His work is premised on the notion that agency at the bodily level (agency of the self) enables agency at the social and political level. Many exercises in Somatics and performance focus on this idea of retraining attention in order to increase awareness and agency through the body, and can be applied to many levels of awareness that extend beyond the personal.

A Role for Somatics within HCI

In the performance domain, Dance Analysis and Somatics construct models directly from the *experience* of the moving body. From the Somatics perspective, knowledge is constructed *through* experience [John1995] and requires that experience be directed or focused through *awareness*. When sensory stimuli no longer result in a perceptual motor response, the body's sensorimotor system has reduced its ability to act. In Somatics this would be termed "somatic amnesia". However, when experience is specifically directed through the focus of attention, knowledge acquisition takes place. This is referred to as "Somatic learning", an activity expanding the range of what Hanna [Hann1988] terms volitional attention. Csikszentmihaly [Csik1990] has acknowledged that human experience operates within a limited field of attention, while Somatics considers attention to be generative enabling it to be augmented and increased through a process of somatic learning.

What Somatics Offers Felt-Life

Somatic Techniques and Experience Traditions share a common set of goals. Rudolf Laban's movement analysis systems [Laba1974] are examples of movement typologies based in experiential practices of dance [Schi1997, Schi2004] that model qualities and modes of movement. These typologies can be applied to gestural recognition and modeling qualitative movement characteristics such as intentionality, interest, attention and body state. They present potential experience models for the classification of aspects of movement, and define a means to approach embodied design. Participatory design, experience design, performance, theater, dance and Somatics share a common focus in modeling or representing human experience. These domains share the ability to articulate sensorial quality, emotional response and experience through movement.

CASES + STRATEGIES FROM ART AND DESIGN

Experience is felt, palpable, perceived and lived. How can these concepts be used in design processes that cultivate attention? Somatics techniques increase the *resolution* of our attention and the *resolution* of our experience. Can user experience be designed to such a degree that experience itself becomes personalized developing degrees of skill and refinement to the use of our own body states, refining the inseparability of mind from body? Can user-experience be designed to acknowledge shifting focus between the world the self? And can it explore the concept of generating user attention rather than competing for limited attention space of the user?

Three Cases are presented that apply somatic principles. In Case One, the use of a series of design workshops is used to illustrate an exploratory approach to creating an interaction model through participants attention to their own lived experience. In Case Two, the physiological data of breath is used in order to create a heightened and empathic connection between shared participants wearing networked garments. In Case Three, touch and tactile quality recognition is used to explore qualitative interaction where experience, intimacy and play are a central theme.

Case One: whisper[s]: wearable body architectures

This case illustrates the outcome of a series of exploratory workshops[5]. The goal was to explore how people pay attention to their own body state and share that state with others in a space. A range of techniques were used to train attention or awareness. The workshops relied on improvisation, props, ritual space, and placebo objects. Very little digital technology was introduced at this stage. The central theme of the workshops was asking participants to employ simple acts of 'paying attention'. For example participants were asked to listen, notice, touch, move, feel. Participants were asked to imagine and visualize; focus on bodily experiences such as breath, heartbeat, stillness, and slow motion movement. We wanted to design experience that could be replicated, re-enacted, and re-played in the context of a public art installation using wearable computing technology. The public art space was an environment that could be simultaneously intimate, playful, and social, while sharing a level of awareness of the participant's 'selves'. A set of examples from three of the five workshops is described below.

Figure 1 Experience Modeling connection and extension

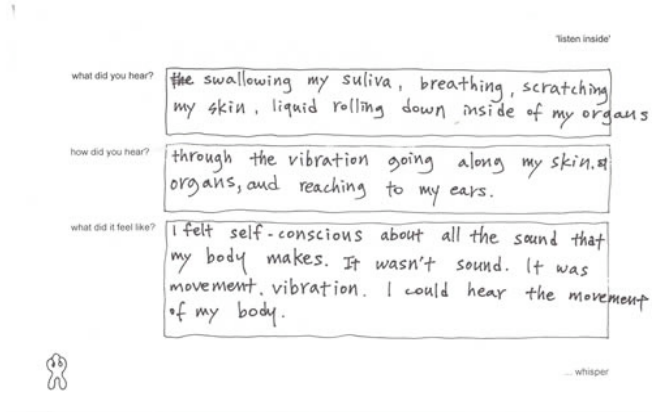

Figure 2 Response Card Example

The <listen> workshop

One of the major themes is the notion of 'paying attention' to one's self. The design for the installation centered on measuring physiological data as a representation of oneself: data that we do not normally pay attention to in everyday life, but can easily access. How do we perceive directing attention to our body data? Participants were asked to find a place for themselves in the space and to remain silent. Each participant was given a pair of earplugs and they were then left alone with themselves with no further instructions for about 15 minutes. Each participant was handed a card (see fig. 3). The card asked the questions: What did you hear? How did you hear? What did it feel like?

In the space of experience, this is the simplest of experiments. By depriving the body of its external hearing it can become aware of the internal sound otherwise made invisible by the louder external sounds. We are removed from our own ears, but not from our hearing. In performance, artists like Pauline Oliveros and Augusto Boal have created practices such as "deep listening", and "listening to what we hear", which probe and access these very same questions of experience. The responses to the very simple question on the cards: *What did you hear?* focus on access to this level or resolution of experience. Responses indicated the participants' discovery of the internal soundscape.

'Heartbeat; earplugs as they settle, breath, slapping sounds from others in the room; humming noise; myself; contact with my own body'

This seems to trigger strong emotions ranging from slight unease to feelings of fear or elation in the answers to the question: *What did it feel like?*

'I felt self-consciousness about all the sound that body makes; it wasn't sound; it was

movement, vibration. I could hear the movement of my body'

Some workshop participants were able to recognize that listening occurs not only through the ears, but also through the bones, the resonant cavities of vibration in the body, that the body is a metaphor for listening, and that, what is heard is not only sound, but movement, vibration, feeling, and sensation.

The <between> workshop

<between> explored the ability to transfer invisible data to another person and the willingness to enter into an exchange of information that is otherwise private and unknown. In order for such a transfer to work, the participant needs to engage or invite trust not only to the other, but also to the 'listening' self.

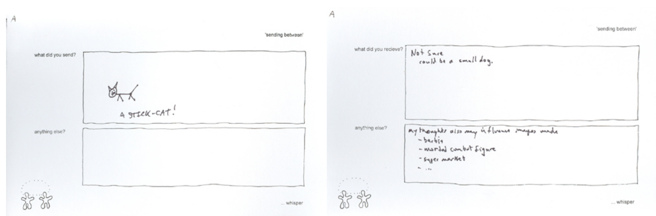

Figure 3 Sending and Receiving Invisible Signals

At the beginning of the workshop, the participants were asked to move in slow motion, as slowly as possible. They were then left to move very slowly for 10 minutes without speaking.

In Dance practices such as Butoh, this technique is utilized to enable the body to shift its attention to an immersive state in relation to its environment, what Csikszentmihalyi would term 'flow', where attention is intensified, and sensory details are sharpened. In neurophysiology and psychology experimental studies show that the slowing or stopping of movement changes the conscious states we normally have and allows for observing the constant shifts of thought, sensation, or expands the ability to observe characteristics of basic experiencing [Gins2005].

The <extend> workshop

We wanted to continue to investigate issues of privacy and trust using physical objects that could mediate the interaction through physical gesture. In <extend> the participants were given ordinary medical stethoscopes and a small booklet with ten identical pages.

'I felt like I was inside myself the pounding amplified my perception of myself, yet my

breathing made me feel close'

By introducing the stethoscopes we gave access to another type of body data. More importantly, we introduced the possibility of sharing this data with someone else. The design of the stethoscope with a 'listening' end and a 'probing' end allows for the data to be shared by either probing someone in order to investigate their data, or giving someone the earpiece to offer them a particular sound. This latter gesture of offering inverts the interaction model of probing or surveillance, to an interaction that invites intimacy, trust, and peer connection.

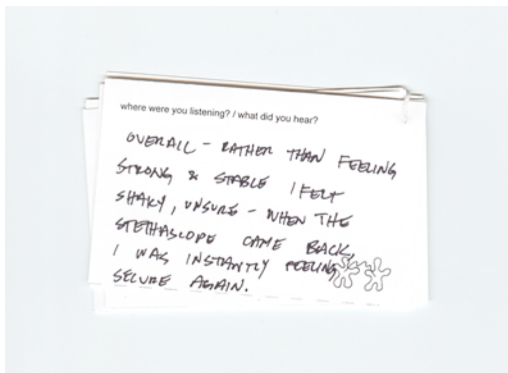

Figure 4. Response Card Sharing Physiological Data

The <phase>Workshop

By creating protocols that facilitate sharing and exchange there is a potential blurring of the boundaries between the participants as well as between what is inside and what is outside. We investigated this blur between inside and outside by asking participants to put on men's shirts. The shirts were given sticky Velcro patches to apply connection points anywhere they wished. The participants were encouraged to experiment with moving as each pair of shirts offered different possibilities for movement and control. The cards asked the questions: How did you extend yourself? How did you move?

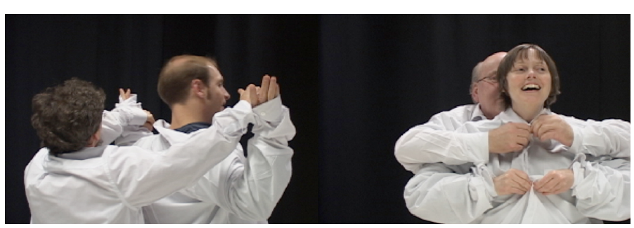

Figure 5. Extension | Creating One Larger Body

How did you move?: *'Held hands with someone other than my husband; became silly; enjoyed the unusual and unknown; became aware of another's movement'*
How did you move?: *'I found myself thinking of our 'body' as a complete unit - it just had this other piece I wasn't controlling; the attached arm felt very unusual once I got complete control back'*
How did you move?: *'I was no longer just myself, I had to extend myself to become a part of a whole; as a whole we had to work together; when we failed it was almost disappointing because we were apart'*
Here we see several examples of body extension. The workshops series as a whole contained a broad range of experience results that enabled us to construct an interaction model for an art installation. We continually returned to the artistic aim: that 'paying attention' to one's self enables a re-direction of attention with a greater access to optimal experience [Csik1990].

Case Two: exhale: (breath between bodies)

exhale: breath between bodies is an interactive art installation where group breath is shared between eight networked skirts. This example illustrates how our own body data can be used to create and share awareness in an intimate way in a social space. Each exhale skirt is sewn from lush vibrant raw silk in rich saturated colors. The skirts are lined with small vibrators that synchronize in correspondence with the participants' breath rhythm. Breath can be shared (given and received) through the use of RFID tags sewn into pockets in the side of the skirts. An LED array on the surface of the skirt illuminates the breath rhythm. Exhale creates a palpable interface where physical vibration created by small motors and the tiny movement of air created by small fans respond intensely and physically providing alternate 'physical displays' for the body [Weis1994].

Figure 6 exhale 'skirt trees' hanging in space

The exploration of breath in exhale is based on the notion of creating body states through somatic awareness. Shared breath creates empathic connections between participants and causes vibrations in the linings of the skirts, and light to respond to breathing patterns. Damasio [Dama1999] has studied the connection of 'feeling states' in the body and asserts that a given feeling state is associated with specific physiological patterns (such as breath rhythm) along with a set of processes including thought patterns and emotion. His research suggests that these 'feeling' body-states are an inter-connected set of feeling, thought, emotion and physiological functioning: each of these being present and affecting the other. He asserts that the induction of a body-state can be brought about through attention to *any* one of the inter-connected patterns: so that attention to physiological patterning (for example breath) can induce a body state. This inter-connectedness between physical data, and the state of the body creates a complex but coherent set of body-data and experience.

Figure 7. exhale skirt with LED array and RFID

Case Three: soft(n) tactile networks

($soft^n$) is an interactive public art-installation based on exploring emerging network behavior through interaction between a group of 10 soft networked objects. Each soft object has a specially designed hand sewn tactile surface that recognized 12 tactile qualities based on Laban's Effort Analysis. This illustrates how somatic movement systems based on quality of experience can be computationally applied to human computer interaction. The Parameters that determine the tactile qualities are shown in Table 1. Implemented tactile qualities include jab, knock, touch, caress, glide, tap, pat and float. One can think of ($soft^n$) as a counterpoint to, or a critique of, the hard: a survival strategy for interaction that allows misplaced action, mistake, forgiveness, a bad attitude, weakness, and stillness, giving in.

(soft^n) allows critique through the computational act of quality, where the quality of caress defines the interaction and response from each object. The objects have three states, inactive (sleeping), active (listening to other objects in the family) and inter-active (being touched or thrown about).

Figure 8. soft(n) tactile networked objects

	Parameter				Modifier		
touch-effort	pressure intensity	time duration	size area	number	space (speed)	path (direction)	disposition (pressure)
tap	soft	short	small	ø	stationary	n/a	n/a
pat	soft	short	big	one	stationary	n/a	n/a
touch	soft	long	small	one	stationary	n/a	n/a
stroke	soft	long	ø	ø	travelling	straight	ø
glide	soft	long	ø	ø	travelling	wandering	ø
hold	soft	long	big	one	stationary	n/a	constant
poke/jab/flick	hard	short	small	one	stationary	n/a	n/a
knock	hard	short	medium	one	stationary	n/a	n/a
slap/punch	hard	short	big	one	stationary	n/a	n/a
press	hard	long	ø	ø	stationary	n/a	constant
knead	hard	long	ø	many	ø	ø	varying

Figure 9. Laban Touch Qualities extracted from input surface

The soft objects respond to tactile caress by actuating light, sound and vibration. Small tonal sounds, sighs and melodic 'dialogue' is shared between the objects when they are touched. The objects form an ecology of sound, vibration and light. Each *(soft^n)* touch pad is hand sewn using a specially constructed combination of conductive fiber, conductive foam and everyday needle and thread. This illustrates the ability to use domestic cottage industry approaches to 'hand-made' input devices that share algorithmic intelligence with other tactile heuristics normally applied to consumer input devices [Schi2006, Schi2007]. The group of soft objects that are strewn about, and tumbled within, a public urban space, are networked to one another, and create a group-body, based on tactile input. The *(soft^n)* objects communicate wirelessly to each other within their network.

(soft^n) includes the development and testing of an Interaction Model based on input heuristics of touch, based on Laban effort shape analysis, a somatics system of movement analysis.

SUMMARY

This paper has offered a framework from the field of *Somatics* particularly with regard to the body in everyday life. The design examples use Somatics techniques in the design of embodied interaction. In Somatics the body matters and defines our subjective selves within experience. The notion of palpable yet invisible interfaces is viewed in the light of emerging exploration within HCI that explore experience, embodiment, subjectivity, and felt-life. The call to experience can be explored through valuing subjectivity and the foundational constituent knowledge of embodied approaches within interaction design. One of the promises of the invisible computer is that by its very disappearance, we are left with ourselves in our world, and the opportunity to perceive ourselves more clearly in connection to our own felt-life. Perhaps the invisible computer can make visible connections to ourselves that we were not able to perceive when the mechanisms of physical technology were 'in the way' obscuring our lines of sight and insight.

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BIOGRAPHICAL INFORMATION

Thecla Schiphorst is an Associate Professor in the School of Interactive Art and Technology at Simon Fraser University, in Vancouver, Canada. She is a Media Artist and Designer who has exhibited internationally in numerous venues and festivals and the recipient of the 1998 PetroCanada Aware in New Media, awarded biennially to a Canadian Artist for their contribution to Innovation in New Media Technologies.

Applying an Aesthetic Framework of Touch for Table-Top Interactions

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Abstract

In this paper, we propose a conceptual framework for understanding the aesthetic qualities of multi-touch and tactile interfaces for table-top interaction. While aesthetics has traditionally been defined as the visual appearance of an artifact, we promote a tactile aesthetics that is firmly rooted in the experience of use and interaction. Our model of tactile aesthetics comprises four distinct yet overlapping areas: 1.) Embodiment which grounds our framework within the larger philosophical context of experience. 2.) Materiality which emphasizes the importance of the physical shape, form and texture of interactive systems. 3.) Sensorial Mapping which is the creation of appropriate cross-modal relationships between touch and our other senses. 4.) Semantics of Caress which is the investigation into the meaning of touch which can then inform computational models of gesture recognition. We apply this framework to evaluate a series of tactile and multi-touch artworks and discuss how our model can benefit the design of future multi-touch systems.

1. Tactile Aesthetics

In an era where 'emotion' and 'experience' are key descriptors of interactive systems [1] [9], there is a growing recognition in HCI that considering aesthetics may be useful when designing for experience [3] [12]. But traditional aesthetic theory poses a problem for interactivity. Primarily concerned with visual appearance, these theories are incompatible with interactivity because of the large role that tactility, the body, and usability have in mediating the user experience. In response, many HCI researchers [3] [12] turned to 'pragmatist aesthetics', a theory where the emphasis is on the aesthetic experience of physical use [16]. What is missing, however, is an aesthetic framework which connects pragmatist aesthetic theory with decisions derived directly from interactive art practice. From interactive art we can learn how to apply strategies used by artists to create emotional and meaningful experiences with technology.

In this paper, we propose a model of tactile aesthetics that has resulted from identifying four recurring and entwined themes emerging from our work with multi-touch tabletop artworks. The first theme is the overarching philosophy of *embodiment* which grounds and contextualizes our work in experience design [2]. The second theme is *materiality* which stresses the importance of the physical shape, form, and texture in mediating an aesthetic experience. Our third theme is *sensorial mapping* which is the potential of combining touch with appropriate visual or audio feedback to simulate a rough haptic sensation. The final theme is *semantics of caress* which is the investigation into the different meanings encoded in touch and gestures. Since our framework emerged from our artistic practice, we explain our model by sharing a narrative on the trajectory of our work in tabletop interactive artworks. The development of our tactile aesthetics begins with the interactive artwork *BodyMaps*, and is then traced to the *Soft(n)* project. Finally, we conclude by outlining current and future work in multi-touch tabletop interfaces.

2. Experience of BodyMaps

Bodymaps is an interactive table installed in the center of a darkened gallery room with speakers distributed around the four corners and hung from the ceiling on either end of the table. As an interactive artwork *Bodymaps* was designed specifically to direct the users attention to their tactile sensations, inviting a 'purpose-free' exploration of active touch, and using the synthesis and simultaneity of the visual and auditory material to invoke an intensified and heightened sense of affect and 'connection'. As an artwork this was intended to move interaction experience more toward 'phatic' technologies [18] that emphasize the experience of connection rather than information content, thereby creating a more deeply resonant emotional space. A table was selected (rather than a bed or another furniture object) because of its metaphoric use as a familiar everyday domestic object and its flexible open-ended use in social settings such as gathering, sharing, eating, working and celebrating.

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In *Bodymaps*, the gallery visitor sees an image of a body projected from above: it lays still and silent on the surface of the table. Images and sound utilized in *Bodymaps* enable an open interpretation, and its metaphorical use of visual material such as water and fire, sheets or tablecloths allow multiple meanings and emotional associations [15]. This design strategy is commonly used in artistic practice as a way of poetically evoking experience and thoughtful reflection. It is a mechanism to provoke experience utilizing the pleasure of direct sensation to bring imagination and memory into play. Contemporary artists such as Bill Viola and Paul Sermon have used similar strategies to achieve poetic and resonant experience. As someone approaches the table, they hear the sound of a single drop of water dripping from directly above the table. When the user reaches out to touch the table, proximity and electromagnetic field sensors detect the presence, proximity, and location of the hand as it hovers above the surface. This triggers the sound of water being splashed and mixed in direct correspondence to the user's hand movement. The sonic sensation is one of water running through the fingers. Once the user physically touches the table's surface, they feel the warmth and sensual texture of the silk velvet inviting them to caress and stroke the fabric. Touching the projected body causes her to move in a direct relationship to the user's gesture (Figure 1). For example: stroking her shoulders causes her turn on her side, while tickling her feet forces her to roll off the table. As the intensity of the touch increases (with greater pressure, speed and area covered), the room fills with layered and ambiguous sounds such as crying, laughing, sighing or breathing. This multi-layered reactive space immerses the user in a sensual and affective sound and image-scape. As the user steps back from the table, the imagery and sound slowly begin to fade, waiting to be touched again. When all tactile interaction stops, everything becomes quiet. All that remains is the sound of a single drop of water dripping from above.

Figure 1: Bodymaps installed in a gallery

3. Embodiment

The first theme is the philosophy of embodiment and how 'being-in-the-world' is critical for understanding experience in HCI [2]. In the context of multi-touch interfaces, we know that gestures in the physical world are rich and intricate and can be mapped to create more intuitive gesture commands [11]. Being aware of the capabilities of tactility is essential for creating interfaces which utilize the full resolution and bandwidth of touch, such as the skin's ability to detect temperature, proximity, weight, and volume [7]. With *BodyMaps*, one of the explorations was to create an interface that invoked a tactile response in people and allowed them to interact with the system with a gesture repertoire beyond the typical binary 'touch/release' input range common in interactive systems. Since people intuitively feel surfaces by moving their hands across the texture in order to gather information on the object [4], the piece was designed to respond to this temptation. As a result, the sensor hardware embedded inside the table had to be able to detect presence, location, and the proximity of hands as they hover across and touch the surface creating two levels of tactile engagement. The material used for the construction along with the appropriate visual and sonic sensory mapping played a large role in compelling people to interact with the piece.

4. Materiality

The second theme in our framework is the importance of materials in mediating an aesthetic interaction similar to the role materials have in traditional arts and crafts. The specific form of the table including its height and scale was designed with a strategy to enable ambiguity and open interpretation [15]. The height of the table is slightly lower than a dining table so that its physical correspondence to a human body could also begin to suggest alternative objects (such as a bed or a coffin). In the case of *BodyMaps,* it was critical to identify a material that had the affordance of caress [5] and encouraged users to explore the surface with their hands. After an extensive search where numerous natural fabrics were prototyped and evaluated according to these parameters, the final selection was to use white silk-velvet. This fabric possesses several properties that made it suitable for compelling a tactile response in users. First, stroking across the surface changes the direction of the knap leaving behind a shadow. This can be erased with a stroke in the opposite direction, or it can be left has a visual memory of touch. Also, silk-velvet captures and retains body heat making the table surface warmer to touch. When combined with the material's softness, this encourages gentler and slower gestures. The net result of these properties gives the textile display a high degree of tactile resolution.

The resolution of textile displays is measured using different metrics than conventional computer screens or projections. Whereas optical performance is the main criteria for conventional displays, textile displays are evaluated for their haptic quality or how the material feels. Understanding the trade-off between technical resolution and affective resolution is an aesthetic decision and one that impacts the overall experience of the system [6]. While the degree to which materials impact the experience is still not entirely known, the choice of material still has tremendous impact not just on the technical performance of the system, but on the overall feel and experience. Selecting materials primarily for their optical purposes may be critical for multi-touch projection systems, but this choice should not neglect or ignore the material's tactile attributes.

5. Sensorial Mapping

The third theme in our framework is sensorial mapping where touch is combined with appropriate visual and sonic feedback to simulate a synesthetic haptic sensation. This effect has been shown to exist even with lower level tactile inputs such as a mouse with appropriate visual changes in the graphical cursor [17]. In *Bodymaps*, the relationship between touch and audio-visual senses occur on two separate layers of the user experience (Figure 2). The first occurs when a hand penetrates the electro-magnetic field that blankets the area above the surface. This triggers the sound of water splashing and mixing which is mapped to the user's gesture, simulating the haptic sensation of running fingers through water. People can interact with the piece by feeling this virtual fluid sonically before they eventually touch the table when they feel comfortable. Touching the velvet surface is the second layer of the sensorial interface. A projected image of a body responds directly to the relationship of the user's touch. If someone touches her shoulder she will turn on her side, or if someone tickles her feet she will roll off the table. At this point another audio layer is added as sounds of natural human emotions such as sighing, breathing, and crying grows louder as the amount of contact on the body intensifies. Since the audio is ambiguous, the user is open to interpret their actions and meaning [15]. We observed that there was often a heightened affective response of users to the interface, and participants reported being very moved, or becoming reflective as a result of the interaction. Sensorial mapping differs from haptic interfaces in that instead of creating a direct physical relationship between two sense modalities, it is implied and left to the user to make the connection and 'feel' inside their body and mind.

Figure 2: Two layers of tactile interaction: hovering and touching the surface

6. Semantics of Caress

The final theme in our model is the development of our work in building a taxonomy of affective 'tactile gestures' based on the semantics of caress. This resulted originally from direct observations of participants' interaction with Bodymaps, and has been developed and tested through a number of interactive art prototypes and devices. We observed and documented patterns of commonality in the tactile gestural *quality* used in the system. For example, people tended to jab the surface harder and user quicker gestures when they were impatient or they would use gentler and longer gestures during moments of strong affect. Analyzing movement quality has been used in choreography and in movement analysis[8]. We formalized observations by studying the quality of multi-touch gestures. Initially, implementation of our qualitative semantics was based on definitions from Laban-Effort-Shape Analysis [8] (Figure 3) which was computationally mapped onto the Tactex MTC Express multi-touch tablet using computer-vision signal processing for recognition [14]. Afterwards, these same heuristics were applied to custom-made multi-touch foam pads that were sewn into a family of pillow objects for the *Soft(n)* project [13]. *Soft(n)* is an interactive art installation with 12 networked pillows that communicate to one another and to their users based on touch qualities. Each pillow was able to recognize different touch qualities and respond to touch input. Our work in classifying the qualitative touch gestures compliments existing taxonomies which focus on gestures for graphical manipulation, CSCW, and other task-oriented commands [10] [17] [19].

touch-effort	Description
tap	A soft, short, small, touch, usually rendered with a single finger.
pat	A bigger version of "tap" and a soft version of "slap". Usually rendered with an open hand or palm.
hold	A lingering, soft, big, touch. A "hold" has an encompassing feel.
touch	"Touch" is a small version of "hold". It is an indication of comfort and is rendered with the fingers, hand, or palm.
stroke	A traveling touch, soft but directional, rendered with fingers, hand or palm.
glide	A traveling, meandering, touch. Soft and directionless and rendered with the fingers, hand, or palm.
jab	A hard, short, small, touch. A hard poke by a finger or blunted object. Also known as "poke".
knock	A medium-sized, fist against, rapping hard. In our scheme, it is different than "jab" and "slap" in size only.
slap	An open-handed, hard, short, touch. In our scheme, a large version of "jab" and "knock".
press	This is a long, hard, touch.
rub	This is a moving, hard, touch.
knead	Kneading involves many fingers moving hard and in a slightly wandering fashion.
other touch-efforts not attempted in this system:	
punch	This is like a "knock", but is different in intensity and slightly different in timing.
flick	This is like a "jab", but is slightly different in shape over time. A "flick" travels slightly in relation to a "jab", which is more stationary.

Figure 3: Touch efforts with corresponding metrics for computation

7. Discussion & Future Work

In this paper, we outlined the beginnings of a conceptual framework for evaluating the tactile aesthetics in table-top interactions. The main strength of our model is that it originated directly from artistic practice. However, we will need to use our model to assess other designs and artworks to gauge the validity of our framework. We also plan to expand and refine some of the ideas we presented. Currently, we are in the midst of a project where we are networking multiple multi-touch tables in remote locations. In this research, we are interested in adapting or expanding our affective gesture library to include touch efforts that connect people separated by location. This will also involve expanding our gesture library to include bimanual multi-touch interactions for larger surfaces. In addition, we want to include research into the qualitative semantics of 'feel'. Just as we encode meaning in the gestures we make and in the way we touch, we also decode meaning from objects that we feel, and in the way we are touched. Indeed, as aesthetic theory is still in its infancy in HCI, our work on tactile aesthetics can only grow and improve.

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Pillows as Adaptive Interfaces in Ambient Environments

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ABSTRACT
We have developed a set of small interactive throw pillows containing intelligent touch-sensing surfaces, in order to explore new ways to model the environment, participants, artefacts, and their interactions, in the context of expressive non-verbal interaction. We present the overall architecture of the environment, describing a model of the user, the interface (the interactive pillows and the devices it can interact with) and the context engine. We describe the representation and process modules of the context engine and demonstrate how they support real-time adaptation. We present an evaluation of the current prototype and conclude with plans for future work.

Categories and Subject Descriptors: H.5.2 [**User Interfaces**]: Haptic I/0, Input devices and strategies, Interaction styles, User-centered design

General Terms: Design, Human Factors

Keywords: Human-centred computing, Input devices and strategies, social interaction, haptic sensing, presence, tactile UIs, tangible UI, user experience design

1. INTRODUCTION
Designing ambient technology introduced into the potentially intimate personal space of a user is a complex problem, as a large range of design variables need to be addressed. Such technology inherently requires the ability to detect and understand the user's activity, body state and identity [2, 12]. A difficult and general problem with Ambient Intelligence is thus to translate low-level signals from the environment to meaningful environmental adaptation for the end-user.

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The aim of the work presented in this paper is to address this problem by exploring interfaces that go beyond direct manipulation. The interfaces we are interested in are based on everyday objects in adaptive ambient environments, such as the home or public, urban, and social spaces, i.e. lounges at cafes, bars. In this context adaptation is based on the input from a sensor-enhanced object with one or more low-level input streams, such as galvanic skin response (GSR), touch quality in form of pressure, or heartbeat. The environment tries to interpret this input, e.g. to identify excitement or detect an action, so that it can adapt itself in the most useful matter, e.g. adapting the environment to serve the mood or adapt the functionality of an object to support the currently performed task.

The key concepts investigated by our work include mobility, connectivity, invisibility, and configurability. We have developed a set of small interactive throw pillows containing intelligent touch-sensing surfaces, in order to explore new ways to model the environment, participants, artefacts, and their interactions, in the context of expressive non-verbal interaction. The long-term aim of our work is to establish a framework for ambient environments that is configurable by users either by integrating already established interaction and adaptation solutions for particular objects (such as the pillow) or designing new ones by themselves.

We first outline the motivation for choosing pillows as interfaces, based on a scenario situated in a living room. The main part of the paper provides an in-depth look at the technology used to turn a pillow into an interactive item according to the described scenario. We describe the structural layers of our system architecture and related technical detail. For providing the reader with an easy to grasp description of a pillow's abilities as well as of the feedback loop within the environment, we describe a subset of the living room scenario. Finally, we discuss the related body of work in the context of evaluating our approach and conclude with plans for future work.

2. MOTIVATION AND SCENARIOS
A problem with adaptive ambient environments is to interpret the **current user context** so that either appropriate **support of performed tasks** can be provided or the environment can be adapted to **improve or serve the user's mood**. In many cases it is both aspects that need to be addressed at the same time.

The aim of our work is to develop technology that facilitates environments to be adaptive to present parameters. We address four key issues, namely the representation of context, the selection of parameters that allow us to detect user actions as well as the user's mood, define efficient and non intrusive ways to collect those parameters and to define means to utilise these parameters for proper adaptation.

Context

Assume a user is in a private living room. There might be several interfaces running simultaneously, such as the TV, the stereo and the browser on the PC. Context-aware systems have to be aware of the user, interpreting hints, such as user position and actions performed, to find out which of these attracts the focus of the user's attention at the moment.

Context represents not only the material world, of which the user is a part, but also the user's cognitive state (i.e. attention, emotion). For example, the user might watch a program on TV and the system discovers a constant low attention rate. The reason might be that the program is bad but it could also be that the current light setting is irritating the user and thus distracts his or her attention.

The **first requirement** for our system is to represent the current state of the environment through descriptions of the various agents as well as the relations between them. The current state of the environment is therefore always a snapshot of the most recent event, which needs to be related to those events that already happened. A key issue is here the method to represent change.

What to Measure?

The two basic notions to be monitored in our approach are actions and cognitive states. Actions allow us to detect the user's focus of attention. The action performed immediately also tells something about the application utilised. Measurement of biometric data facilitates us to draw conclusions about the cognitive state of the user.

The **second requirement** of our system is to establish a key description set of

- user specificities, such as preferences for actions or strategies, likes and dislikes for content, etc,
- biometric data sets, e.g. containing touch efforts, GSR, heartbeat and methods of mapping those to high-level semantics.

How to Measure?

Collecting data, such as actions, is rather simple as technology is the general means to interact with audio-visual content. Logging this interaction is common practice. The collection of very personal data, such as GSR, pressure or heartbeat, is a sensitive matter. First, the required data needs to be reliable and thus feature extraction mechanisms on a meta level, such as the analysis of video surveillance, is by far not good enough for the time being. As we wish to support people in everyday environments it is also not suitable to treat them as guinea pigs in a laboratory by connecting them to sensors via cables.

The **third requirement** for our system is that taking measurements in an ambient environment needs sensors that collect biometric data. The sensors need to be made available through objects that invite the user's touch preferably for a longer time. Moreover, the object needs to be useable in private as well as public environments by a large variety of user groups, i.e. children, teens, middle-aged adults and the elderly, and thus need to be also easily moveable between locations.

What to Adapt?

The reason for the adaptation of the environment is to either support the performance of the user in task processes with respect to the particular application the user is currently busy with or to adapt particular environmental parameters to improve or serve the user's cognitive state.

The fourth requirement for our system demands methods that map the results collected from the context descriptions to adaptive strategies, which address

- the currently used object itself or related objects depending on the task to be performed,
- environmental parameters, such as lighting or noise, for supporting, enhancing or calming the current cognitive state of the user.

Living Room Scenario

We developed an environment that addresses the outlined four requirements in a home scenario[1]. The home scenario (see Figure 1) is based on the living room where the user consumes or interacts with different media sources. The environment is understood as an experience space, which the user should be able to explore freely without being overstrained or unchallenged. We utilize a set of small interactive throw pillows as the sensor-enhanced every day objects.

Figure 1: The living-room in the home scenario.

For example, the user might sit on the sofa, cuddling the preferred pillow, and watches a TV program. As the system has detected that the remote control is out of reach (context model) it has turned the surface of the technologically enhanced pillow into a remote control. The user makes frequent use of it, i.e. changing channels and uses the fast forward button. All that indicates a state of unexcitement, which is further confirmed through biometric data collected from the biometric sensors on the pillow. The action related data as well as the biometric feedback could now be used by

[1] We designed a second scenario, using the same framework, which is situated in a café/lounge environment, where participants are invited to re-mix a set of moving images projected in large scale on the walls within the café through the physical interaction with a set of the small interactive pillows. The focus of this work lies on an environment that is aware of users and objects but not necessarily knows much about them. This work integrates somatics and gesture interaction with textiles and interactive object design [16]. A description of this environment can be found in [5].

the adaptation engine to improve the excitement level of the user by suggesting to play a game. The result is another change of the functionality of the pillow surface, turning it into a play console. While playing the same data sources can be used to detect a level of cognitive awareness, which facilitates the environment to turn a part of the pillow into an alert interface, stating through soft vibrating and a text message, that the news channel on the PC provides interesting information related to the article the user was reading before she started relaxing in front of the TV. The aim of the home scenario is to explore the interaction between a single but well-known user and a single object interaction and its possibilities to influence the overall environment.

In the living room scenario there are a number of potential objects, such as chairs, sofas, teddy bears, blankets, pillows, watches or remote controls, that, enhanced with sensors and actuators, can serve as input and output devices. Yet, only a few fulfil the needs described in requirement 3.

Chairs and sofas are certainly touch-sensitive but their problem is their static nature. Teddy bears or alike would be excellent options with respect to their haptic sensibility. Yet, their user group is limited. Objects like a watch or the remote control are promising because they are hold or worn for a longer time. Yet, the way in which they are used is very limited.

Blankets and pillows are ideal candidates. Both are applicable in various surroundings and scenarios according to the user's needs. They can be found in the home environment as well as in public, urban spaces. More importantly, both evoke metaphors of intimacy and affection. Their surfaces of textiles or light-emitting material ask for touch. Finally, both can be, depending on its configuration, act as an input- as well as an output-device.

Our decision to use a pillow as a primary object of investigation was rather a question of pragmatics, as a blanket is too thin to hide batteries, boards, sensors, etc. Thus, for our prototype environment we decided for a pillow, of which a prototype is portrayed in Figure 2.

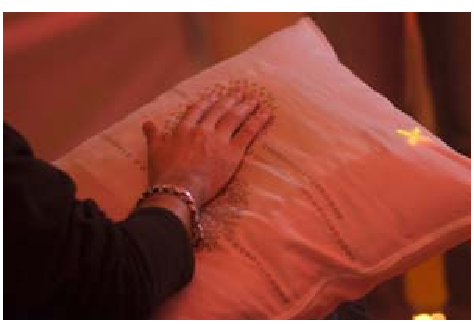

Figure 2. Pillow with actuators touchpad, LED display and vibrator.

3. MOVE.ME SENSORS, ADAPTATION AND FEEDBACK

In this section we introduce the technology developed for the pillow and the main technical developments of the *move.me* environment. The descriptive examples are taken from a subset of the implemented living room scenario. The subset scenario covers three states of a pillow, namely **sleeping state**, **game state** and **device state**, as well as the transitions between them, i.e. **waking up**, **tune in** and **fading out**.

The main aspect of our prototypical ambient environment, called *move.me*, involves three parts:

- The user
- The interface, which contains the interactive pillow as input sensor and output devices, such as a vibrator, light-emitting diodes, screen, sound system, lamp.
- The context engine, which provides the analysis of the current state of the environment on which it might suggest an adaptation strategy, is a back-end server.

With respect to its interaction design our approach extends Don Norman's traditional execution-evaluation model [9] beyond the user's view of the interaction by including not only the interface but the entire elements necessary to judge the general usability of the interactive system as a whole. This allows placing the environment in different social contexts with an overlap on particular task.

As *move.me* is a reactive environment, we adapt for the context representation strategies from case-based reasoning (CBR) [1], in particular those strategies that trace the history of actions [7] to provide the means for a systems to adaptively interact with a user. Our real-time adaptation cycle is very similar to the reasoning process in CBR, which is often represented as a cycle composed out of five steps: elaborate (establish target case), retrieve (compare with existing cases), reuse (adapt the target case), revise (identify unspecified knowledge) and retain (establish new case in the case data base). We apply this cycle to the interpretation of sensor data. We start with a set of raw data, on which we then elaborate, based on user and environmental data (both together form our context), how to perform contextualized adaptation. The adaptation as well as the context history are then stored and are used in the ongoing process of ambient user adaptation.

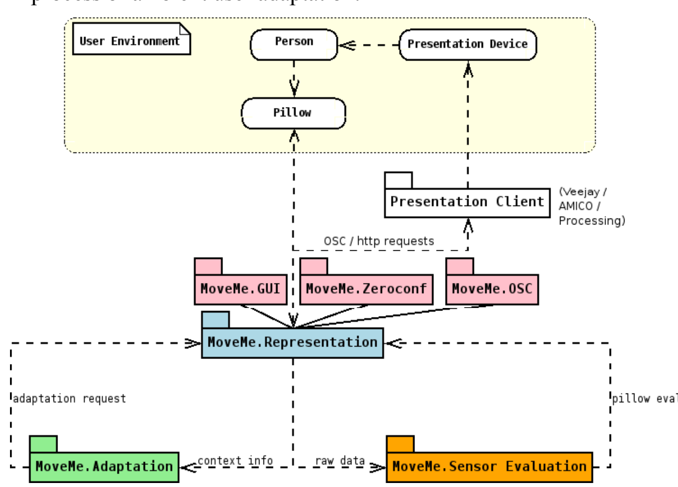

Figure 3: High-level architecture of the ambient environment, where the User environment box represents the room with client (e.g. the pillow) and everything outside this box represents the server or central system.

In the remaining part of the section we outline the various modules of the *move.me* environment, as portrayed in Figure 3, namely:

- *Sensors*, i.e. the input sensors of the pillow

- *Sensor evaluation module*, which instantiates the device drivers for every detected pillow and evaluates incoming raw data. Its main task is to perform some statistical analysis (some low-pass filtering and mean value calculations) in order to keep the overhead of processing load low (the Sensor Evaluation box at the bottom right in Figure 3)
- *Context module* that consists of data structures describing the current context with respect to users, devices and the interactions between them. (the Representation box in the lower middle of Figure 3)
- *Communicator module*, (the presentation client as well as the Zeroconf and OSC box in the middle of Figure 3) which enables the flexible connection of all components, and provides interfaces towards external systems, such as a the TV, a laptop, the stereo, the light sources, etc.
- *Adaptation engine*, which uses data from the context module to establish a mapping between detected action and the appropriate environment adaptation. It also conveys instructions about the source to be adapted and the means of adaptation to the other components (the Application box at the bottom left in Figure 3).

The central system (sensor evaluation module, context module, and the adaptation engine) is developed in Python (ver. 2.4) and runs on GNU Linux and on Apple OSX 10.4 in combination with Fink. The Communicator part of the system is implemented as a Java application based on the AMICO (Adaptive Multi-Interface COmmunicator) framework (http://amico.sourceforge.net/).

In the following sections we describe the various modules in more detail.

3.1 Pillow Sensors

A pillow in our environment is the main medium for collecting sensor data, and providing limited feedback to the user. A pillow can be equipped with any of the sensors and actuators displayed in Figure 4.

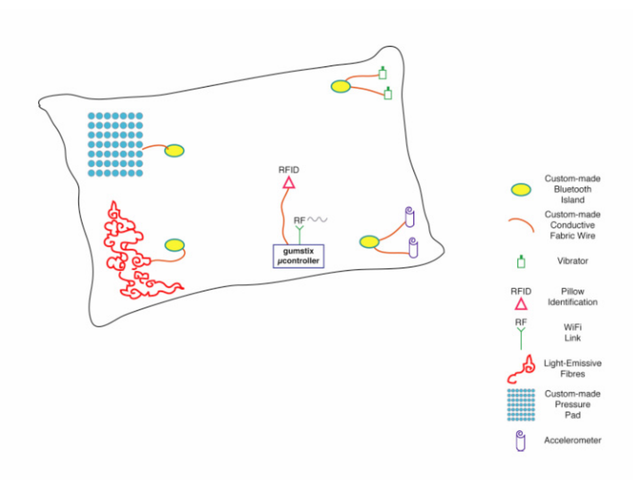

Figure 4: Pillow technology

Figure 5 portrays a particular pillow prototype, equipped with a touchpad (large rectangle on the pillow in Figure 5), a LED display (smaller rectangle below the touchpad) a vibrator (the little round box to the bottom left of the pillow) and a Gumstix[2] Connex Linux computer expanded with a SIOS (Sensor Input Output System) daughter board plus the RFDI reader (the part left of the pillow). This prototype is shown without a cover. Complete prototypes with cover are shown in Figure 6.

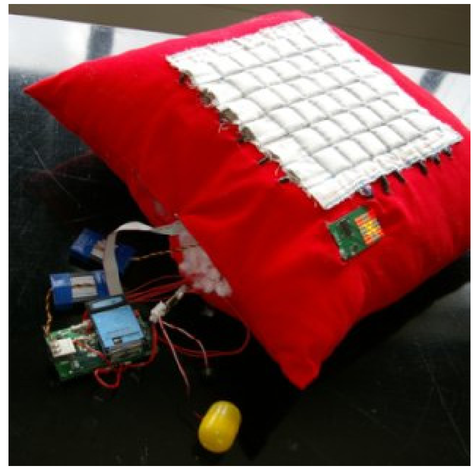

Figure 5: Functional pillow without pillow cover, exposing the technical components

Figure 6: Fully functional prototype pillows with covers

The main sensor we apply is a touch-based interface for measuring pressure. Beepers, vibrators and light sources, either in form of light emitting fibres or as a LED display, provide localized feedback.

The touch-pad itself is a simple grid (64 sensitive regions) of carbon impregnated open cell polyethylene foam. This material exploits the characteristic that electrical resistance of the foam drops as the density of the foam increases. We utilize this behaviour to identify a point of contact or applied pressure. We exploit this behaviour to identify a point of contact or applied pressure. I2C is used to read and steer the pressure sensor circuitry. To control the Led display we use the SPI Bus. Please note that the current pillows connect the various hardware parts via wires instead of the bluetooth islands as suggested in Figure 4.

The processing unit located inside the pillow is a Gumstix[3] Connex Linux computer expanded with a SIOS (Sensor Input Output System) daughter board developed by the V2_lab. The Gumstix filters the incoming pressure data and communicates these in discrete packages to the server application. The communication between pillow and server uses the OpenSoundControl (OSC) protocol. We employ OSC because it is a simple protocol widely used by other applications. Thus, using OSC enables us to talk

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[2] Gumstix is a registered trademark by Gumstix inc.; http://www.gumstix.com

[3] Gumstix is a registered trademark by Gumstix inc.; http://www.gumstix.com

easily with many other platforms, as long as both sides agree over the semantics of messages send. When switched on the pillow automatically propagates itself on the network, sending its IP-address and port number, using a combination of Zeroconf networking (http://www.zeroconf.org/) and an OSC Querying System. This allows listening programs to detect and register the pillow and start receiving or sending messages.

For identifying users in the closer surroundings of the pillow each pillow contains an RFID reader (SonMicro CY8C0105-B5 RFID Module). The module also acts as a Writer, allowing us to include personal codes into programmable RFID-Tags, which users of the environment wear as bracelets or which are via small tags embedded within each pillow.

Emphasizing the sensual aesthetic of a pillow, covers are designed to encourage connection in an associative and intuitive way. Pillowcases are made out of conductive fabric textiles, such as silk organza [15], which allow qualitative recognition of touch on the surface of the pillow. They are also transparent enough so that icons displayed on an LED are still visible. Pillow prototypes are portrayed in Figure 6.

Pressure is the essential type of data we process to extract a caress and its effort. We have identified a set of parameters that can be extracted or calculated from the information that the response area provides over time. At the moment we utilise the following pressure input parameters: **touch intensity**, **size** (the size of the interaction object that touches the pad), the **speed** of the touch and the **direction** of the touch.

3.2 Data Evaluation and Abstraction

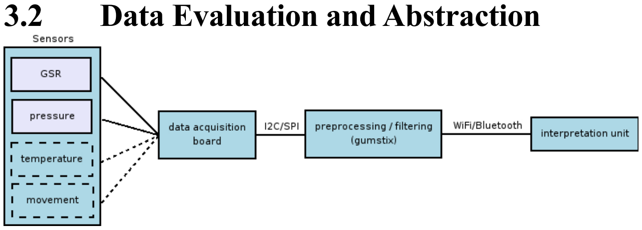

Figure 7: Schematic overview of dataflow from sensors to the interpretation unit in the central system

The pillow itself only provides a basic filtering of the signal which is then transmitted, as described in Figure 7, along with additional information, such as which other pillows or users are near this pillow, to the central system, where all the other processing happens (e.g. calculating time and space variables), The transition rate for the data of the differently sized pads available (3x3, 6x6, and 8x8) is between 20 to 32 Hz.

Once the data for pressure, size, speed and direction is received by the central system the sensor evaluation module performs a first abstraction on the data. The way that incoming sensor data is analyzed depends on the context and the configuration of the pillow. For example, if the pillow contains a pad that allows measuring pressure and an accelerometer for computing movement a different abstraction scheme is provided as output compared to a pillow that only contains a pressure pad. This means that the system treats each individual pillow configuration/setting differently, as it also does for users. Only at a later stage the individual views are combined to the global context view.

When analysing streams of data, here the input data for every taxel of the pad (a taxel is one of the different tactile grid cells), it is desirable to keep a history of past events especially when we are looking for trends in the data [11]. However, storing the whole dataset and re-iterating over the last n samples whenever a new sample arrives quickly becomes inefficient as n grows. We, therefore, apply a method that keeps a history of past events without actually storing them but summarizing instead the entire set of (or the last n) past events in a few critical parameters. If we calculate the mean, standard-deviation, minimum and maximum value over the past events, we can compare the value of the current event with a set of threshold values generated from the history of past events. Incoming values are first compared with the current set of thresholds, and then they are used to update them. Thus for every taxel of the pad we can calculate the current state based on the following calculations:

output	condition	meaning
0	x < min	x is lower than ever before
1	min < x < (mean-sd)	x is very low
2	(mean-sd) < x < mean	x is lower than average
3	mean < x < (mean+sd)	x is higher than average
4	(mean+sd) < x < max	x is very high
5	x > max	x is higher than ever before.

where X represents the current input signal from the pillow on the taxel and the output value (output) represents the type change to the taxel since the last measurement.

During our evaluation sessions (see Section 4 for details) we found, however, that a pure threshold-based approach often leads to unpredictable pillow behaviour.

We therefore introduced an additional evaluation step, which is based on the idea of utilising the Centre of Gravity (or Centre of Mass) to determine the average pressure point location of the touch pad. Giving every cell a mass proportional to the pressure applied (we define the cells variance as its mass) we can compute the COG as the average of the cells positions in the matrix weighted by their masses. If there is no change in action the COG converges to the absolute centre, which is simply the average of all locations weighted by 1. We use this property to determine the start and end of events. From the COG we also derive direction and speed.

Although this approach proves to be more flexible and lends itself for a more precise fine-tuning of the detection of action and its location, at this point we cannot distinct (using COG alone) between a positive (pressed) or a negative (released) event. If a pressure is sustained for long enough the COG will converge to the absolute centre and a release will trigger a new event. Thus, at the moment we simply have more events to cope with.

The results of the sensor evaluation provide a localized event description, as changes can be related to taxels, in form of a matrix that represents all taxels of the touch pad, where every taxel is identified as started, running or ended (a sort of second order of gravity). This description of position and event status is send to the corresponding session buffer of the context module, where the next level of abstraction on the results is performed.

3.3 Context representation

The **Context Module** describes the current (present) status of the environment with respect to resident users, devices and the interactions between them.

User as well as device profiles are loaded into the Context Model once their RFID is detected. For each detected user or object a memory structure is established (**Context User Model (CUM)** and **Context Device Model (CDM)**), which reflects only those characteristics that are relevant for the current context.

User characteristics are, for example, the user identifier, the current biometric status, current action, current interest (i.e. leasure as derived from the playing mode of the device mainly used at the moment), current location, as well as descriptions of likes and dislikes with respect to the potential media to be consumed and the related presentation devices.

Device characteristics include the device IP, its input sensor set, its actuator setup, current activity, current state for every input sensor and output actuator, its current location, and particular behaviour descriptions, such as adaptability with respect to input sensors, where adaptation here, for example, means automatic functionality changes of regions on a touchpad). Note, it is the sensor set and the behaviour descriptions that trigger the instantiation of the device drivers and are thus partially responsible for the type of sensor evaluation. For example if a pillow is in the 'device state' the touchpad of the pillow might be organised as described in Figure 8.

0	1	2	3	4	5	
Top left	Top left			Top right	Top right	0
Top left	Top left			Top right	Top right	1
		Center	Center			2
		Center	Center			3
Botto m left	Botto m left			Botto m right	Botto m right	4
Botto m left	Botto m left			Botto m right	Botto m right	5

Figure 8: Region pattern for a 'device state' of a touch pad

Depending on the associated role of the device, e.g. the touchpad functions as a remote control, the provided events for the region (see section 3.2) will be interpreted differently.

The reason why we provide devices with similar description structures as those for users is so that devices themselves can become proactive towards users. At the moment we only store simple data, such as user id, action performed and its duration but we wish to explore further in that direction (see section future work). It is also important to mention that the CUM and CDM are subsets of the general user or device model, which contain the overall description of the user or device. The user model might also contain descriptions of relations to friends, which might not be applicable for the current context of watching TV alone in the living room.

An instance of a CUM or CDM will be deleted from the context model in the very moment the related agent (user or object) is not part of the context any longer. A reason might be that the user left the room or that an object is switched off or removed from the room. In that case the context module also updates the general user or device model.

An appropriate representation of the current status of the environment requires that the model is constantly refreshed. We have noticed during our user tests (see section 4. Evaluation) that the average adaptation rate that causes a latency of around 0.2 seconds is not perceived as slow by users. A quicker adaptation call-back would put unnecessary load on the computer system, and would not produce better user experience.

Yet, both CUM and CDM are rather static schema, providing a current situational "snapshoot", with which it is difficult to observe and track the dynamics of the environment. We introduced, therefore, the concept of a session, which monitors the interactions between a user and a device or between devices over time. A session is a data structure containing the identifications of the agents involved in the interaction, the start/end time of the session, the recorded sensor data, and resulting derivations such as type of pillow activation, pillow state and user state.

Thus, a session provides a unified view on a series of interaction events exchanged among agents. As long as a user interacts with a pillow, the session records all detected changes of user and pillow and the relations between these changes, e.g. which action influenced which change. The session description is in a way a 'case' composed out of events. At the moment the current event and the recent history of events are used by the adaptation engine to determine user state changes, which are used to propose adaptation strategies if required. In the future we would like to post process session description for further automatic improvements of the user model as well as improvements of the adaptation behaviour.

A session is instantiated by the Context Module once a device detects the ID of the user and the pillow sensors register relevant data. For example, a use case in which the user utilizes the pillow to control a presentation of an audio system is described by two sessions: the user interacting with a pillow (session A: userID – pillowID) and the pillow interacting with the audio system (session B: pillowID – AmplifierID). Sessions are closed, either once the interaction stops or when the user leaves the context. Why is this distinction relevant? There are cases where several users might share a device, e.g. several users touch a pillow. In such a case, where more than one user is detected by a device, the one using the device the longest is considered the prime user. If the prime user leaves the context, the session is terminated. Simultaneously a new session is opened, though, where the user being second in the list will automatically assigned prime user. It is at the device to indicate this change to the remaining users. Once a session is terminated it is stored in the History Model.

The **History Model** is our approach towards an individualized long-term memory of the interaction patterns for every user and device. It is updated once a session has been terminated. The model contains at the moment two data sets, namely **identification** [userid or deviceid / context type / indate / outdate] and **session** [agent1 / agent2 / context type / actionlist / datalist / adaptationlist]. The identification set is automatically instantiated when a user enters a context. This set serves as cross check source for the adaptation engine to evaluate user behaviour. The session set describes every interaction the user or device was involved in (pattern, duration). The data set stores the collected biometric data (thresholds, duration) and the adaptation list contains the adaptations performed by the adaptation engine based on the data in the same time frame (adaptation method, success value, duration). At the moment we only keep track of sessions, and thus make them accessible to the adaptation engine, in form of a sqlite2 SQL database. Real instant or post evaluations (e.g. at the end of a day, week, month, etc) still need to be developed.

The outlined representation structures serve as input sources for the adaptation engine to determine if an adaptation is required and in case it is, which type of adaptation needs to be performed.

Before we explain the adaptation engine we first briefly describe the *Communicator module*, (see Figure 3) as it serve as the output source for the adaptation engine.

3.4 Communication between objects

As the pillow can be used as an output device the environment needs to be able to easily establish a connection between the pillow and the presentation device it might be connected to. For connecting the pillow server with other multimedia component, we use the Adaptable Multi-Interface COmmunicator (AMICO) AMICO is a generic platform, used to support rapid prototyping with OSS components in different domains [reference removed for double blind review]. The proposed brokering infrastructure is based on the publish-subscribe design pattern. It is well suited for integration of loosely-coupled parties, and often used in context-aware and collaborative computing. When using simple data structures, the loosely coupled approach can be highly adaptable, so that new applications can both reuse existing data in the repository and add their own data without breaking the infrastructure. This approach is also fault tolerant, as components run as independent processes. In the loosely coupled model, components can run on different machines in a distributed environment. Components communicate by exchanging events through a shared data repository consisting of named slots. Components can update the slots, and register for notifications about changes.

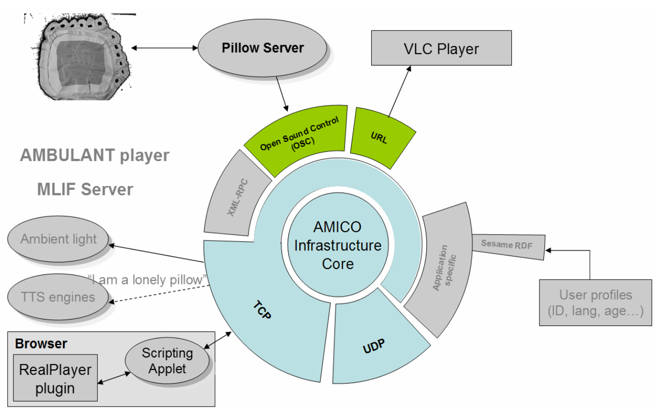

Figure 9: ***Configurations of AMICO middleware for integration of the pillow server with other multimedia components.***

Figure 9 illustrates how this infrastructure is used to connect the pillow server with other multimedia components. We have integrated the pillow server with the infrastructure through the OSC interface, which is also used for the communication between the pillow's hardware and its driver software. AMICO uses the outcome of the adaptation engine, namely commands for the multimedia players[4], controlling sound intensity and playback, as well as sending a message to the user, which have been generated on the basis of the discrete actions provided by the pillow.

3.5 Adaptation and Feedback

In our environment adaptation focuses on three major processes, namely **stimulation**, **relaxation** and **representation**. *Stimulation* describes the attempt to either engage a non-active user into an interaction with the environment or to increase a low-base activity. *Relaxation* tries to reduce the amount of activity or excitement. *Representation* aims to present the state of the environment and the user in a visible and audible form, to give the user a feedback about actions and their effects. The adaptation engine, therefore, constantly evaluates data from the Context Module, and reacts on changes only if they are outside the provided constraint set.

The adaptation process is based on the idea of a finite state machine (FSM), a model of behaviour composed of **states**, **transitions** and **actions**. The states are defined by CUM and CMD descriptions, and the session structure from the Context Module. The transitions are based on the constraints set by the administrator, which, in case of our home scenario, can be everybody in the house. At the moment we implemented a system with a single constraint set for a room but the aim is to later provide constraint sets applicable for every single individual.

We employ two types of constraints. The first type covers excitement levels, ensuring that a certain upper or lower excitement threshold is not crossed. The other type of constraints are time constraints, which describe for example the duration in seconds the system should wait to suggest new activities or the time interval for verifying that a suggested action is indeed performed by a user. These constraints are set by a user and become part of the user model, in the preference section. This is one of the possibilities of the user to control the system, which enforces a certain trust in its capabilities to adapt.

If a constraint cannot be fulfilled, the adaptation engine utilises actions to ensure, for example, that the tolerated excitement levels is reached again within the temporal constraints defined by the user[5]. Actions describe the adaptation performed at a given moment. An action features an instruction for the behaviour of an object, e.g. instructions for the vibrator of a pillow to vibrate in a particular pattern suggesting a particular information code. An action might also trigger a number of events at the same time, such as changing the TV channel.

Actions are organised in form of rules and context scripts. The organisation of rules is based on context scripts. In our environment the scripts are designed by us and thus represent an already established interaction and adaptation solutions for a particular object, namely the pillow. As the language for the rule set is simple, it is, however, also feasible to assume that users can improve or enhance the behaviour set or designing new ones for different objects.

For a single user single object interaction the knowledge base is rather simple. Elsewhere [reference removed for double-blind review] we described that this approach also works well for more

[4] We used several multimedia players, included VLC player, connected through HTTP interface, the AMULANT SMIL player, connected through XML-RPC interface, and RealPlayer player embedded within Web page and connected with out infrastructure.

[5] It is the user who determines the actual meaning of the thresholds, where the system only reacts on them. This reduces the inference level of the system greatly.

complex settings, such as interaction between a group of people and one object, a group of people and several objects, etc.

The general structure of rules in *move.me* is as follows:

<proposition> ::= if <input-statement> then <output-statement>

<proposition> ::= if <input-statement> then <output-statement>
else <output-statement>

An input statements can consist of an input fact, a negated input fact or multiple nested input statements. Input facts correspond to the states that result from the sensor evaluation module. They might look as follows:

<input-fact> ::= <corner-touch>

<input-fact> ::= <c1-touch>

<input-fact> ::= <not-pressed>

Output facts correspond to a particular device, i.e. the LED, the vibrator, etc. as well as to the commands to be sent to the AMICO presentation client. Note, a naming synchronization between AMICO and our environment is necessary so that the actions can be performed accordingly. Output facts for animating an icon might look like this:

<output-fact> ::= <show-play>

<output-fact> ::= <blink-wait>

<output-fact> ::= <animate-icon-7>

where show triggers a single icon, blink repeatedly turns it on and of with short intervals, and animate displays a predetermined sequence of related icons. Note, a set of so far 30 icons is preloaded into the sensor board.

Actuators, such as the vibrator or a loudspeaker, provide parameters related to their modality space. Examples for a vibrator (buzzer) or loudspeaker or look like this:

<output-fact> ::= <buzz-soft>

<output-fact> ::= <buzz-gradual-increase>

<output-fact> ::= <beep-note-G3>

<output-fact> ::= <beep-increasingly-louder_C1>

The three parameters are flexible enough to be configured endlessly and thus it is the design of the rules themselves that provides the sense-making. It lies in the hand of the user to determine the behaviour of the environment, which adds to its trustworthiness.

Let us describe the adaptation mechanism based on the state model portrayed in Figure 10, which represents the pillow states **sleeping**, **game** and **device**, as well as the transitions between them, i.e. **waking up**, **tune in** and **fading out**.

We already mentioned that the adaptation engine constantly evaluates data from the Context Module, and reacts on change. Assume that the system detects that a user enters the room (detection of the RFID tag). The context will load the user data relevant for the scenario (i.e. living room) and wait for new interaction sessions. If none is established within the time threshold for inactivity provided by the user parameters the adaptation will try to engage the user into an activity. All actions to be executed here fall into the *stimulation* category.

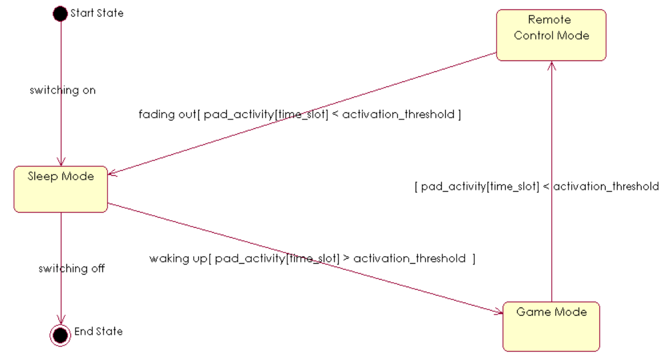

Figure 10: Potential pillow states and transitions between them.

'Stimulate user' activates a list of action scripts, of which one might cover attracting the user to the nearest pillow. As a result the adaptation engine will sent a command to the closest pillow (location information taken from the device model and the user model) via AMICO as shown in the result slot of the rule below:

precondition	**result**
<sleep-state>	<purr> every 30s <show-asleep> every 30s <amico-sleep-mode>

This rule stands for: let the pillow make a gentle purring sound (a buzzing pattern), show a pattern of z's on the LED and let that continuously run.

The adaptation engine observes the context model for signs of contact, i.e. the standard deviation of sensory data rises above a given threshold. If that is not the case within a given time span then the adaptation engine would try another strategy, which means utilize a different action provided by the stimulation set. Note in such a case the system would store the given context, e.g. type of category (stimulate), user id, strategy chosen, and the result (negative) in the adaptation part of the history model. For the rest of the example let us assume that the user responds according to the provided strategy.

After the user has started to interact with the pillow, the adaptation engine will first notify the user that this interaction is recognized (category: representation), as illustrated with the following script:

precondition	**result**
<sleep-state> and (standard_deviation > threshhold) for > 0s	<transition-buzz> <show-loading> <amico-waking-up-mode>

where <transition-buzz> is a short sequence of buzzes identical for each transition. <show-loading> displays an animated icon that slowly fills the display with burning LEDs. Internally the state of the pillow is now set 'waking-up'.

Realising that a session is instantiated the adaptation now attempts to instantiate an activity between user and pillow. The user activity list of the user model describes the preferred action states of the user, e.g. TV, Game, PC, etc. Depending on the rank within the list as well as the last state performed during the last session of the time the user was present in the context (living room), the adaptation engine picks a state, for example the game state. Thus, it sends a command to AMICO requesting to show the game icon on the pillow.

The adaptation engine now waits for a particular time (not more than 5 seconds) and checks if the standard deviation of the relevant cell on the touchpad changes, meaning that the user acknowledged that she wishes to play. As a result the engine instantiates a “go” icon (category: *representation*) and starts a game accordingly. Note, the device model is now updated that the pillow acts as a game console of type synthesizer.

We have implemented a little sound synthesizer the user can play. The sound is a function of the center of gravity, acceleration, speed, the percentage of taxels that are pressed, and the intensity (the percentage of total pressure intensity). We are not playing actual frequencies but notes. The audio output is a simple Pulse Width Modulation circuit. In that case the adaptation engine performs the task of a game engine as well as the observer of the user. Once the adaptation engine detects low activity on the touchpad, it tries to initiate a new stimulation by suggesting an action change from Game to TV.

The user can now use the touchpad now as a remote control, where the functionality of the cells might be as such:

active fact	**result**
<clockwise-movement> and length > n	<amico-play-movie-next> <show-next>
<clockwise-movement> and length > n	<amico-play-movie-prev> <show-previous>
<c2-touch>	<amico-fullscreen> <show-fullscreen>
<c3-touch>	<amico-volume-up> <show-volume-up>
<c4-touch>	<amico-volume-down> <show-volume-down>
<c1-touch> and <c2-touch>	<amico-pause> <show-pause>

The synchronization between the pillow remote control and the TV is completely handled by AMICO. The adaptation engine now investigates the two established sessions, namely user and pillow and remote control and TV set. The main input will nevertheless be from the pillow, as this provides the biometric data from the user.

If the user leaves the context, which the adaptation engine realizes through closed sessions and the disappearance of the user id from the list of present users, then the adaptation engine applies a pillow transformation (category: representation) by letting the pillow fade out of the remote control state into ‘sleep state’.

precondition	**result**
<remote-control-state> and <number-of-events> > 0 and (standard_deviation < threshhold) for > 30s	<showunloading> <amico-fading-out-mode> <transition-buzz>

postcondition	**result**
<remote-control-state> for > 30s	<sleep-state>

If the adaptation engine does not detect any action, i.e. the standard derivation remains 0 for a defined amount of time or there are no users in the list of present users for a defined amount of time, then it sets all registered objects into state of stand-by.

4. EVALUATION

We performed one elicitation study on the initial prototype, as presented in Figure 2, as well as a test at the demo event of the funding agency that supports this project, where participants had the chance to experiment with a set of pillows as described in Figure 1, 6 and 7..

The qualitative elicitation study [5], took the form of a one-day participatory workshop with 10 users (3 females, 7 males), and covered:

- A hands-on free exploration session with a medium-fidelity pillow prototype.
- A “Wizard of Oz” simulating the complete intended functionality of the system.

The participants’ experiences during both sessions were video taped and later analysed.

Apart from showing that the current architecture is stable and functional, especially in terms of mobility and connectivity, the workshop provided two major findings. First, the initial interactive exploration of the pillow lead to the users' full engagement with the system even when the feedback in form of iconic messages on the pillow’s LED display was slow. Second, in the interview session, users indicated that they would appreciate the idea of device memories and the long-term memory of the system, even though we where not be able to test these elements during the workshop.

The presentation of the pillow functionality at the symposium showed that the adaptation based on stimulation, relaxation and representation is sufficiently sound to let users understand how the environment reacts on their actions without explicit training session. Moreover, it could be demonstrated that the rule set can be adapted on the fly, even though the coding was done by one of our group members based on the wishes of the visitors.

Because both cases our test sample are rather small, we were only able to perform a qualitative evaluation of the system. However, we have taken these findings as general guidelines, which will allow us to make educated decisions for further developments.

5. RELATED WORK

There has been a great deal of general research in sensing and biofeedback in human-computer interaction [3, 15] This research has indicated that a number of well established sensory methods, such as pressure and GSR, can be efficiently reused in our context to obtain a window into the state of an individual. In addition, there is work that illustrates the elevation of low-level signals to higher-level interaction [14].

The affectionate quality of a pillow is also used in other works, such as the interactive pillows by Ernevi[6] et al. [10] and Aoki et al. [4]. Both projects investigate interactive pillows as a means of enhancing long-distance communication. We share the notion of a sensual aesthetic of a pillow that encourages connection through feel in an associative and intuitive way, we do support a different vocabulary of expressiveness, based on action.

Buxton et al [6] provides early descriptions of the unique characteristics of touch tablets relative to other input devices such as mice and trackballs. Chen et al [8] describe the use of a touch-sensitive tablet to control a dynamic particle simulation using finger

[6] http://www.tii.se/reform/projects/itextile/pillow.html

strokes and whole-hand gestures, where the gestures are interpreted as a form of command language for direct manipulation. In our work we go beyond direct manipulation, enriching the interaction with parameters about the quality efforts.

The authors in [16] describe the use of kinaesthetic motion-analysis models to represent movements. The current work was influenced by this choreographic approach to motion description and presentation of these studies.

Haptics and touch have been explored by many researches. The University of Tsukuba, for example, has developed a large number system that makes use of haptics such as finger/hand manipulation and locomotion [13]. Although these systems use different technologies, they have provided us with a motivation for usage of touch.

6. CONCLUSION AND FUTURE WORK

In this paper we have described an ambient environment in which a set of small interactive throw pillows containing intelligent touch-sensing surfaces allow users to change the behaviour of the system based on the actions performed by the user. We have demonstrated that pillows serve well as adaptive interfaces in changing contexts and described a novel framework that facilitates the integration of various devices to enhance the adaptation of the environment.

A novel aspect of *move.me* is the approach to map efforts of users actions to higher-level adaptation activities, by defining the mapping space between biometric data and its potential meaning. Although the first prototype shows promising results, we have to provide significant improvements with respect to adaptation response time as well as the range of adaptations to facilitate a richer experience environment that better reflects the motions of the social interchange.

Fruitful future research aspects are how different modality sensors, e.g. pressure and galvanic skin response can be combined into one adaptation framework. Second, we want to experiment with different forms of archival and retrieval of user experiences during interaction.

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Really, Really Small: The Palpability of the Invisible

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ABSTRACT

Our physical technology continues to grow smaller and smaller; so small that the computer itself is no longer seen as an *object* but a set of *invisible* distributed *processes*. Technology is becoming an inseparable aspect of experience, palpable yet invisible. At the same time, an extra-ordinary wealth of literature is emerging within human-computer interaction that is exploring experience, embodiment, subjectivity, and felt-life. This interest is often accompanied by research questions that are continuing to re-balance our understanding of the relationship between subjective and objective knowing, making, and doing. These emerging trends can be seen as a response to the phenomena of the really, really small: and marks a cognitive and creative shift from the visible to the invisible. This paper contextualizes the emerging recognition within HCI that there is value in designing for technology as experience, and offers a framework from the field of *Somatics* that can contribute to the discourse, particularly with regard to the body in everyday life. *Somatics* is exemplified through first-person methodologies and embodied approaches to learning and interacting. I present a set of design cases that demonstrate its application within HCI.

Author Keywords

User experience, Embodiment, Perceptual Interfaces, First-Person Methodologies, Somatics, Attention, Interaction, Touch, Movement, Body-data

ACM Classification Keywords

H5.2. [User Interfaces] Interaction Styles, Theory and Methods, User-centered design

INTRODUCTION

Our physical technology continues to grow smaller and smaller. The computer itself is no longer seen as an *object* but a set of *invisible* distributed *processes* that occur beneath the surface of our skin, our clothing, our buildings and our world. On the one hand we can think of this as merely the foreseeable result of a continual process of miniaturization, yet on the other hand this marks a cognitive and creative shift from the visible to the invisible, and from the visual to the perceptible. Historically, we have equated visibility with comprehension, truth and agency [29, 19]. We have depended upon and favored vision as the sensory mechanism that defines knowledge, validity and experience. But rather than render us blind, the 'really really small' is moving us toward perceptual interfaces, palpable interfaces, ones that take advantage of all of our senses, and that accesses a richer and more fully articulated human being. Weiser's [66] definition of invisible computing includes a return to the 'whole person', engaging with practices in arts and humanities and focusing on experience. Technology is coming to be understood as an inseparable aspect of experience. And there is growing acknowledgement within HCI of the value of designing technology not only for experience but *as* experience [34]. While our technology is becoming embedded, invisible, microscopic, our experience continues to require our attention: our palpable attention.

A response to invisibility

However, all is not necessarily 'happy in Smallville'[1]. Without our well-trusted visual cues, interaction can take on magical proportions. There are times when enchantment and surprise are wondrous [35]. But what is often desired and sought out in the sensuality of the cinematic may not provide similar value in other contexts. In an example of a reactive room that appeared "possessed" [23] confusion can occur when interaction cues disappear 'beneath the surface'. The perception of loss of control appears through the absence of meaningful interaction. The concept of the invisible computer has generated fruitful discussion regarding the need for appropriate cognitive/perceptual models [50, 23, 66]. There are challenges created with invisible interfaces [50] and solutions have included recovering visuality through a return to graphical interfaces. The framework for exploring palpable design may be less about the limitations of seeing, than an invitation to extend our sensory models to consider the senses as perceptual

C&C'07, June 13–15, 2007, Washington, DC, USA.

[1] *Smallville* is an American television series that follows the adventures of a young Clark Kent before he becomes Superman

systems, active and interrelated, and engaging with the world as it unfolds in possibilities for action [18, 33].

The Palpability of the Invisible

Palpability refers to an intensity that is perceivable, easily observable and felt. Palpable interfaces describe those which 'make sense of' felt-life. Gibson [19] refers to the senses as *active* seeking mechanisms for looking, listening, touching, and understanding information in the world. For Gibson, the role of kinesthesia and movement is inseparable from perception, constantly co-operating in and coordinated with acts of perception. The hand reaches out to touch. The head turns to see. The eyelids close and the head moves downward to listen. Perception is active attention [19]. In comparison, passive sensing (where active intention and movement are much less involved) provides less information and less *depth* of experience and comprehension [19]. Although the computer and the interface may be disappearing, our world and our bodies are continuously present and made even more visible through our participation. If our goal is to increase legibility, coherence and social relevance in relationship to the 'whole human' then we need to develop richer interaction and sense-making models that align techniques of active embodied practices with technological rigor and imagination.

The Need for New Models and Metaphors

Now You See it Now You Don't

Perceptual shifts such as those that accompany the shift from visible to invisible computing can enable us to comprehend and design for the "really, really small". But substantial perceptual shifts are often accompanied by disorientation [19, 29, 20]. Can we create interaction that invites our full sensory range, and takes advantage of the wealth of the invisible? While we have entrusted vision with our sense of truth and comprehension, developing a similar level of trust in the *wholeness* of our sensing system will require an accompanying perceptual and cognitive shift. Gaining this understanding can be accomplished through active sensing that results in learning to trust a greater range of sensory data. The active sensing of the invisible does not rely solely on visual perception but provides an opportunity to integrate the visual in a larger 'sense-space'. We can engage with a more fully articulated range of our own experience. In this way, the invisible computer necessitates the development of new models and metaphors that support design, creativity, and use.

THE REBALANCING OF SUBJECTIVITY AND REASON

We are witnessing a reformulation within human computer interaction that is resulting in a re-balancing of the valuation between subjectivity and reason. There is growing interest in the fact that our bodies and digital technology share a reality that is physically embodied. The relevance of theories that account for reasoning as constructed through experience and subjectivity is gaining significance in HCI. As our technology 'disappears' into the seams of our world we are moved to understand, contextualize and integrate the consequence of this physical and metaphoric shift. There is an outpouring of interest in knowledge and methods that originate from within a seemingly endless variety of fields. We are seeing the influence of Cognitive Science [29, 24, 36, 41], Sociology [45], Phenomenology [15, 39, 40], Psychology [19, 32, 41], Neuro-Physiology [13, 2], Performance Practice such as Theatre [5, 54, 55] Dance [12, 30, 61] and Somatics [3, 10, 21, 22, 28, 31], Reflective and Contemplative Traditions [68, 14], and Critical Theory [38]. This trend is bridging methodologies by synthesizing ways that we imagine, validate, and evaluate our discoveries.

The Body in the Mind

An example from the field of Cognitive Science is the theory of embodied image schemas and their metaphorical extensions. Image Schemas have found relevance within human computer interaction [24] in their ability to support and design prototypes for intuitive interaction. The term image schema is described in Mark Johnson's *The Body in the Mind* [29]. Image schemata are abstract representations of recurring dynamic patterns of embodied interactions that structure the way we understand the world [29, 24]. They arise from our normal everyday experiences, the body in everyday life. Hurtienne and Israel have explored how the application of Image Schemas might be used in the design of Tangible User Interfaces [24].

Container	Balance	Compulsion
Blockage	Counterforce	Restraint Removal
Enablement	Attraction	Mass-Count
Path	Link	Center-Periphery
Cycle	Near-Far	Scale
Part-Whole	Merging	Splitting
Full-Empty	Matching	Superimposition
Iteration	Contact	Process
Surface	Object	Collection

Figure 1. Some Examples of Embodied Image Schema

According to Lakoff and Johnson, image schema form the experiential and cognitive building blocks for our most basic metaphorical extensions. These metaphors are deeply linked with the development of our physical bodies' through the sensorimotor system as we learn to 'make sense' of the world. Lakoff and Johnson term these *experientially grounded mappings* [32]. "More is Up" is an example of one of the correlations between image schema that occurs through early experiential mappings. "More is Up" is an example of a Primary Metaphor. The spatial image schema of verticality (up-down) and the scale image schema (more-less) is experientially mapped to create the metaphor 'More is Up'. In this example the *subjective judgement* of quantity is conceptualized in terms of the *sensorimotor experience* of verticality.[32].

Knowing is Seeing

We can contextualize this discussion with regard to extending our ability to design with and for the invisible computer. Our primary metaphors correlate to our sensorimotor systems. Our sense of sight frames our understanding of the visible and the invisible. How we see, and how we understand how we see is deeply ingrained in our experience. The primary metaphor "Knowing is Seeing" [32, p 54] correlates the *subjective judgement* of knowledge with the *sensorimotor experience* of vision. This is exemplified in our language "I *see* what you *mean*", "out of *sight*, out of *mind*", and the familiar phrase "*seeing* is *believing*". We equate visibility with comprehension, truth and agency. However, our senses share in their ability to create understanding [19], and although "Knowing is Seeing" we have a variety of mechanisms and metaphors that we use to access understanding.

Seeing is Touching

Another Primary Metaphor "Seeing is Touching" illustrates our bodies' propensity to perceive one sense *through* another sense. *Sensory substitution* [2] is the body's sensorimotor ability to map data from one sensory system (such as touch) to other sensory system (such as vision). These capabilities of the body's own nervous system are now being used to enable the blind to use tactile stimulation in order to create visual impressions, allowing a low-resolution version of sight for the blind. In "Seeing is Touching" the *subjective judgement* is visual perception and the *sensorimotor domain* is Touch. The primary experience comes from the correlation between the visual and tactile exploration of objects. An example from language is "she *picked* my face *out* of the crowd". We can invert this metaphor (Touching is Seeing, or Touching is Knowing) and we can explore ways of articulating the sense of 'felt-life'. In the context of HCI, McCarthy and Wright's explorations of 'felt-life' [34], or what something 'feels like' rather than what it 'looks like' [33], are examples of inverting tactility with visibility[43]. Larssen's [33] explorations of what *movement* feels like in the context of body-thing dialogues rather than what it looks like is an example of an approach to embodied interaction design. Sensory and interaction design questions that take into account primary metaphors can broaden our sensory mappings, expanding possibilities for interaction [4].

The Rigour of Subjectivity

Johnson speaks of image-schema as *continuous structures for organizing our experience and comprehension*. They come about through the body's sensing and sense-making as it grows into the world. "The fact of our physical embodiment gives a very definite character to our perceptual experience. Our world takes shape as a highly structured, value-laden, and personalized realm in which we feel the pull of our desires, pursue our ends, cope with our frustrations and celebrate our joys. Image schemas are pervasive, well-defined and full of sufficient internal structure to constrain our understanding and reasoning" [29]. Among other researchers that advocate the rigour of subjectivity, and the embodied nature of rationality are Gibson [19] in his exploration of the senses as perceptual systems, Damasio [13] in his descriptions of the neuro-physiological coupling of feeling, thought and action, Polanyi [48] in his treatise on the tacit dimension of knowing, Putnam [49] in his philosophical argument that value is inextricably tied to reason, and Johnson [29] who describes a non-objectivist account of truth and objectivity. For him truth is seen to be relative to embodied understanding, and objectivity takes up shared human perspectives that tie to reality through embodied imaginative understanding.

Embodied Rationality

If subjectivity can be seen to provide a rigour of 'felt-life' that co-mingles and informs our objective methodologies, we can use the notion of embodiment as a necessary precursor to rationality. "How imagination can be both formal and material, rational and bodily – is that there is not an unbridgeable gap between these two realms in the first place. Once we not longer demand a disembodied (or nonphysical) rationality, then there is no particular reason to exclude embodied imagination from the bounds of reason" [29 pp 169]. Re-balancing objective and subjective knowing provide one of the key methodological shifts in designing for experience.

THE VARIETIES OF USER EXPERIENCE

The Varieties of User Experience refers to the notion that the lived experience of the user's participation with technology can be centrally held within human computer interaction and its design discourse.[2] Borrowed from the title of William James' *The Varieties of Religious Experience*, the intention is to highlight how HCI is 'making sense of experience' [67]. James offered an account of experience that placed it at the centre of meaning and meaning-making in the many and various practices found within religious structures and philosophies [25, 26]. James grouped, compared and analyzed numerous types of experience. He concluded that it is not the credos, dogma, prior beliefs, or the structure of morality that is at the centre, but the felt and lived experience that defines the spirit of religious understanding. Within HCI the call to experience is being explored as an aspect of the value of subjectivity and the foundational constituent knowledge of embodied approaches within interaction design.

The Focus of Experience within HCI

A recent issue of *Interacting with Computers* published a special issue on the emerging roles of performance within HCI and interaction design [37]. Examples of approaches to interaction design that express experience through

[2] McCarthy and Wright [citation] urge technology designers to place 'felt-life' at the centre of HCI based on an argument founded in references to Dewey and Bakhtin

embodied goals [47, 60, 57, 42] attention to sensing systems [4, 58], aesthetics [9, 56], and awareness or situated contexts [63, 65, 44] is proliferating and creating a vital research community. Previous research in the use of exploring experience/ performance methods within the HCI community has occurred in the domain of Forlizzi and Ford's exploration of user-centered and participatory design [16]. Also included are Buchenau and Suri exploration of *experience prototyping* that fosters an "empathetic" and "embodiment" approach to user-centered and scenario-based design [7]; Burns, Dishman, Verplank, and Lassiter [8] Interval Research's exploration of *informance*: informative performance and *bodystorming*: physically situated brainstorming, *repping:* re-enacting everyday people's performances, and explorations of how Low-tech solutions can create a design environment that focuses on the design question rather than the tools and techniques, Burns, Dishman, Verplank, and Lassiter [8]; Scaife, Rogers, Aldrich, and Davies [53]. Salvador and Howells [52] shifted the focus group methods to something they called Focus Troupe: a method of using drama to create common context for new product concept end-user evaluations. Simsarian [64] has explored the use of role-play in extending the richness of the design process. In the *Faraway* project, Andersen, Jacobs, and Polazzi [1] explored story telling and 'suspension of disbelief' within a context of game and play in a design context. In addition, exploring other subjective aspects of creative process, such as the use of creating ambiguity in design has been described by Gaver, Beaver, and Benford [17].

SOMATICS AS AN EXPERIENCE TRADITION

Somatics is a field of study that explores the lived *experience* of the moving body. Somatics is defined as the *experience from within the lived body* [22]. As one of the experience traditions that defines its own knowledge-base through embodiment, *Somatics* can contribute to the discourse of HCI, particularly with regard to the body in everyday life. *Somatics* is exemplified through first-person methodologies, and offers experiential models that can begin to re-balance our understanding of the relationship between subjective and objective knowing, making, and doing.

First Person Methodologies as Defined within Somatics

First person methodologies as defined and used within performance practice and Somatics share a common set of features. They exist as a set of rigorous, definable physical processes. These can be learned and their application produces repeatable results. These techniques are based on the direction of attention in order to affect alter or produce body state. It is possible to retrain perception utilizing directed attention, which is produced through directed intentional movement. First person methodologies access and construct knowledge through the body.

In Somatic practices, learning to access and direct attention is one of the central themes. One could say that this is akin to becoming an 'expert user' in attention techniques. Ginsberg [20,21] offers examples that illustrate the value of attention skills. Other fields such as phenomenology [14] also share these goals and practices. At the simplest level, retraining the sensorimotor system, and re-enlivening sensori-motor pathways is a mechanism for retraining embodied habits and perceptions. An example includes slowing movement down as much as possible in order to increase awareness of the embodied state. This technique is practiced in Noh and Butoh traditions, as well as movement therapies that work to retrain poor sensorimotor habits that constrain the body. Slow motion enables the body to shift its attention to an immersive state in relation to its environment, where attention is intensified, and sensory details are sharpened.

Augusto Boal [4] terms these types of experiential exercise *de-specialization*. He states that in our every day lives "the senses suffer. And we start to feel very little of what we touch, to listen to very little of what we hear, and to see very little of what we look at. We feel, listen and see according to our specialty. The adaptation is [both] atrophy and hypertrophy. In order for the body to be able to send out and receive all possible messages, it has to be re-harmonized [through] exercises and games that focus on *de-specialization*." Boal's goals in theatre are to create imaginative, social and political agency. His work is premised on the notion that agency at the bodily level (agency of the self) enables agency at the social and political level. Many exercises in Somatics and performance focus on this idea of retraining attention in order to increase awareness and agency through the body, and can be applied to many levels of awareness that extend beyond the personal.

A Role for Somatics within HCI

In the performance domain, Dance Analysis and Somatics construct models directly from the *experience* of the moving body. Somatics is concerned with *lived experience* and includes practices such as Feldenkrais and Alexander technique. From the Somatics perspective, knowledge is constructed *through* experience, Hanna [22]; Johnson [28] and requires that experience be directed or focused through *awareness*. When sensory stimuli no longer results in a perceptual motor response, the body's sensorimotor system has reduced its ability to act. In Somatics this would be termed "somatic amnesia". However, when experience is specifically directed through the focus of attention, knowledge acquisition takes place which can be referred to as "Somatic learning", an activity expanding the range of what Hanna [22] terms volitional attention. While Csikszentmihaly [11] suggests that human experience operates within a limited field of attention, other movement systems within Somatics consider attention to be a generative attribute of awareness that can be augmented, increased through a process of somatic learning [22].

What Somatics Offers Felt-Life

Somatic Techniques and Experience Traditions share a common set of goals. Rudolf Laban's movement analysis systems [31, 46] and the work of Bartenieff [3] are examples of movement typologies based in experiential practices of dance [61, 62, 59] that model qualities and modes of movement. These typologies can be used in gestural recognition and modeling qualitative movement characteristics such as intentionality, interest, attention and body state. They present potential experience models for the classification of aspects of movement, and define a means to approach gestural and choreographic protocols. Participatory design, experience design, performance, theater, dance and somatics share a common focus in modeling or representing human experience. These domains also share the ability to articulate and explore engaging experience through movement, emotional response, sensorial qualities, and temporal/dynamic qualities of experience and of movement.

CASES + STRATEGIES FROM ART AND DESIGN

Experience is felt, is palpable, perceived and lived. How could these concepts be used within a design process that takes into account a framework that employs Somatics techniques? This would imply a design process that has the goal of cultivating our perception of attention, and can increase our skill with utilizing that attention. Somatics techniques apply their potential to increase the *resolution* of our attention and the *resolution* of our experience, adding value and increasing quality. Can user experience be designed to such a degree that experience itself becomes personalized bringing a degree of skill and refinement to the use of our own body states, refining the inseparability of mind from body. This would suggest that user-experience can shift its central focus from outer to inner and remain balanced between the two. And that user-experience can take the point of view of generating attention rather than competing for limited attention space of the user.

Three Cases are presented that apply first person methodologies and somatic principles in various ways that include active sensing. In Case One, the use of a series of design workshops is used to illustrate an exploratory approach to creating an interaction model through participants attention to their own lived experience. In Case Two, the physiological data of breath is used in order to create a heightened and empathic connection between a group of shared participants that wear networked skirts in order to actuate, display and share their breath. In Case Three, touch and tactile quality recognition is used in order to explore qualitative interaction where experience, intimacy and play are a central theme.

Case One: whisper[s]: wearable body architectures

This case illustrates the outcomes of a series of exploratory workshops[3]. These workshops were conducted prior to the design of an interactive art exhibition. The goal was to find out how a group of people would pay attention to their own body state and share that with others in a space. A range of somatic techniques used within performance practice to train attention or awareness were explored. The workshops relied on improvisation, props, ritual space, and placebo objects. Very little digital technology was introduced at this stage in the design process. The central theme of the workshops was asking participants to employ simple acts of 'paying attention'. For example participants were asked to listen, notice, touch, move, feel. Participants were asked to imagine and visualize; focus on somatic attributes such as breath, heartbeat, stillness, and slow motion movement. One of the goals was to design experience that could be replicated, re-enacted, and re-played in the context of a public art installation using wearable computing technology. The design goal of the public art space was an environment that could be simultaneously intimate, playful, and social, while developing and sharing a level of awareness of our selves. A set of examples from three out of a total of five workshops conducted is described below.

Figure 2. Experience Modeling *connection* and *extension*

For each workshop participants were asked to write their experiences on a single card, each of which included two to three simple open ended questions.

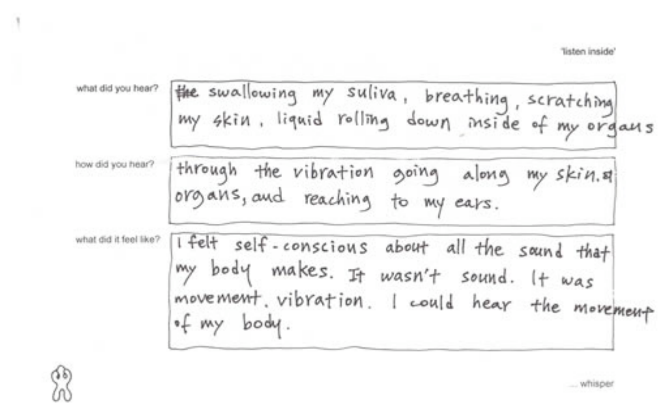

Figure 3. response card example

[3] see full paper [59] Schiphorst, T., Andersen, K.

The <listen> workshop

One of the major themes of the series of workshops is the notion of ‘paying attention’ to one’s self. The design for the installation centered on measuring physiological data as a representation of oneself: data that we do not normally pay attention to in everyday life, but can easily access. The first series of experiences relate to how we perceive and deal with directing attention to our own body data. Participants were asked to find a place for themselves in the space. They were asked not to speak. Each participant was given a pair of earplugs and they were then left alone with themselves with no further instructions for about 15 minutes. After awhile the earplugs were collected and each participant was handed a card (see fig. 3). The card asked the questions: What did you hear? How did you hear? What did it feel like?

In the space of experience, this is the simplest of experiments. By depriving the body of its external hearing it can become aware of the internal sound otherwise made invisible by the louder external sounds. We are removed from our own ears, but not from our hearing. In performance, artists like Pauline Oliveros and Augusto Boal have created practices such as “deep listening”, and “listening to what we hear”, which probe and access these very same questions of experience. The responses to the very simple question on the cards: *What did you hear?* focus on access to this level or resolution of experience. Responses indicated the participants’ discovery of the internal soundscape.

'*Heartbeat; earplugs as they settle, breath, slapping sounds from others in the room; humming noise; myself; contact with my own body*'

This seems to trigger strong emotions ranging from slight unease to feelings of fear or elation in the answers to the question: *What did it feel like?*

'*I felt self-consciousness about all the sound that body makes; it wasn't sound; it was movement, vibration. I could hear the movement of my body*'

‘Pain, shifting between past and present; fear / calm’

Some workshop participants were able to recognize that listening occurs not only through the ears, but also through the bones, the resonant cavities of vibration in the body, that the body is a metaphor for listening, and that, what is heard, is not only sound, but movement, vibration, feeling, and sensation.

The <between> workshop

<between> explored the ability to transfer invisible data to another person and the willingness to enter into an exchange of information that is otherwise private and unknown. In order for such a transfer to work, the participant needs to engage or invite trust not only to the other, but also to the ‘listening’ self.

This was an investigation into the invisible transfer of personal data between people.

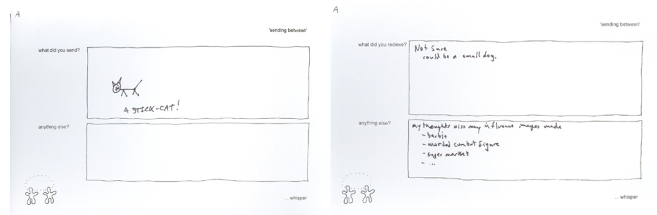

Figure 4. sending and receiving invisible signals

At the beginning of the workshop, the participants were asked to move in slow motion, as slowly as possible. They were then left to move very slowly for 10 minutes without speaking.

In Dance practices such as Butoh, this technique is utilized to enable the body to shift its attention to an immersive state in relation to its environment, what Csikszentmihalyi would term ‘flow’, where attention is intensified, and sensory details are sharpened. In neurophysiology and psychology [41] experimental studies show that the slowing or stopping of movement changes the conscious states we normally have and allows for observing the constant shifts of thought, sensation, or expands the ability to observe characteristics of basic experiencing [20].

Following the slow motion exercise, the workshop participants were asked to pair up, with one person selecting the role of *the sender*, and the other selecting the role of *the receiver*. The sender was asked to silently create an image in their mind for two minutes, and then send the image to the receiver, while the receiver was asked to simply pay attention to ‘listen’ for what image ‘came to mind’. At the end each participant was handed a card with the questions: What did you send? What did you receive?

What did you send? *“A stick cat!”*

What did you receive? *“Not sure, could be a small dog”*

The <extend> workshop

We wanted to continue to investigate issues of privacy and trust using physical objects that could mediate the interaction through physical gesture. <extend> augmented the invisible data with an amplification device. The participants were given ordinary medical stethoscopes and a small booklet with ten identical pages.

‘I felt like I was inside myself the pounding amplified my perception of myself, yet my breathing made me feel close’

By introducing the stethoscopes we gave access to another type of body data. More importantly, we introduced the possibility of sharing this data with someone else. The design of the stethoscope with a ‘listening’ end and a ‘probing’ end allows for the data to be shared by either probing someone in order to investigate their data, or giving someone the earpiece to offer them a particular sound. This latter gesture of offering inverts the interaction model of probing or surveillance, to an interaction which invites and affords intimacy, trust, and peer connection.

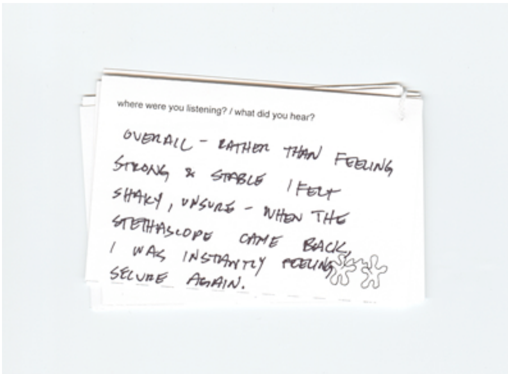

Figure 5. Response Card Sharing Physiological Data

The <phase>Workshop

By creating protocols that facilitate sharing and exchange there is a potential blurring of the boundaries between the participants as well as between what is inside and what is outside. The next exercise investigated this blur between inside and outside, as we asked participants to put on men's shirts. The shirts were given sticky Velcro patches to apply connection points anywhere they wished. The participants were encouraged to experiment with moving as each pair of shirts offered different possibilities for movement and control. The cards asked the questions: How did you extend yourself? How did you move?

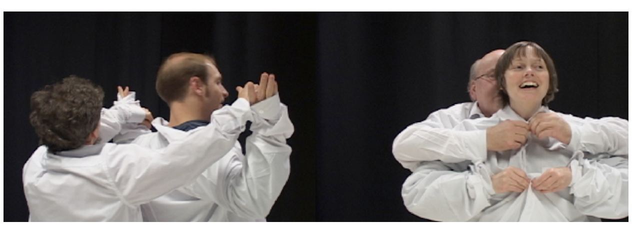

Figure 6. Extension | Creating One Larger Body

How did you move?: '*Held hands with someone other than my husband; became silly; enjoyed the unusual and unknown; became aware of another's movement*'

How did you move?: *'I found myself thinking of our 'body' as a complete unit - it just had this other piece I wasn't controlling; the attached arm felt very unusual once I got complete control back'*

How did you move?: '*I was no longer just myself, I had to extend myself to become a part of a whole; as a whole we had to work together; when we failed it was almost disappointing because we were apart*'

Here we see several examples of body extension. It is interesting to see the disappointment when an appropriated body gets separated or the combined body fails to complete a movement task. The workshops series as a whole contained a broad range of experience results that enabled us to construct an interaction model for an art installation. We continually returned to the artistic aim: that 'paying attention' to one's self enables a re-direction of attention with a greater access to optimal experience [11].

Case Two: exhale: (breath between bodies)

exhale: breath between bodies is an interactive art installation where group breath is shared between eight networked skirts. This example illustrates how our own body data can be used to create and share awareness in an intimate way in a social space. Each exhale skirt is sewn from lush vibrant raw silk in rich saturated colors. The skirts are lined with small vibrators that synchronize in correspondence with the participants' breath rhythm. Breath can be shared (given and received) through the use of RFID tags sewn into pockets in the side of the skirts. An LED array on the surface of the skirt illuminates the breath rhythm. Exhale creates a palpable interface where physical vibration created by small motors and the tiny movement of air created by small fans respond intensely and physically providing alternate 'physical displays' for the body [66].

Figure 7: exhale 'skirt trees' hanging in space

The exploration of breath in exhale is based on the notion of creating body states through somatic awareness. Shared breath creates empathic connections between participants and causes vibrations in the linings of the skirts, and light emissive fibres to respond to breathing patterns. This is an exploration of personal and group feeling states through attention to physiogical data. Damasio [13] has studied the connection of 'feeling states' in the body and asserts that a given feeling state is associated with specific physiological patterns (such as breath rhythm) along with a set of processes including thought patterns and emotion. His research suggests that these 'feeling' body-states are an inter-connected set of feeling, thought, emotion and physiological functioning: each of these being present and affecting the other. He asserts that the induction of a body-state can be brought about through attention to *any* one of the inter-connected patterns: so that attention to physiological patterning (for example breath) can induce a body state, or conversely, attention to another associated patterns, such as the occurrence of certain thought patterns can also induce body state. This inter-connectedness between physical data, and the state of the body creates a complex but coherent set of body-data and experience.

Figure 8 exhale skirt with LED array and RFID

Case Three: soft(n) tactile networks

(soft^n) is an interactive public art-installation based on exploring emerging network behavior through interaction between a group of 8 to 12 soft networked objects. This example illustrates how specific movement taxonomies can be applied as a form of qualitative input recognition. Each soft object has a specially designed tactile surface that recognizes a range of 12 tactile qualities based on Laban's Effort Analysis. The Parameters that determine the tactile qualities are shown in Table 1. Implemented tactile qualities include jab, knock, touch, caress, glide, tap, pat and float. One can think of *(soft^n)* as a counterpoint to, or a critique of, the hard: a survival strategy for interaction that allows misplaced action, mistake, forgiveness, a bad attitude, weakness, and stillness, giving in. *(soft^n)* allows critique through the computational act of quality, where the quality of caress defines the interaction and response from each object. The objects have three states, inactive (sleeping), active (listening to other objects in the family) and inter-active (being touched or thrown about).

Figure 9: soft(n) tactile networked objects

The soft objects respond to tactile caress by actuating light, sound and vibration. Small tonal sounds, sighs and melodic 'dialogue' is shared between the objects when they are touched. They form an ecology of sound, vibration and light. Each *(soft^n)* touch pad is hand sewn using a specially constructed combination of conductive fibre, conductive foam and everyday needle and thread. This illustrates the ability to use domestic cottage industry approaches to 'hand-made' input devices that share algorithmic intelligence with other tactile heuristics normally applied to consumer input devices [58, 56]. The group of soft objects that are strewn about, and tumbled within, a public urban space, are networked to one another, and create a group-body, based on tactile input. The *(soft^n)* objects communicate wirelessly to each other within their network.

To summarize: *(soft^n)* includes the development and testing of an Interaction Model based on input heuristics of touch, based on Laban effort shape analysis, a system that was developed from within the knowledge base of Somatics.

Parameter:		Description
pressure	soft, hard	The intensity of the touch.
time	short, long	The length of time a gesture takes.
size	small, medium, big	The size of the part of the interaction object that touches the pad.
number	one, many	The distinction between one finger or object and many fingers.
speed	none, slow, fast	The speed of a touch-effort. This is the overall velocity of movement. This parameter is not used directly to distinguish efforts, but is used to determine space.
direction	none, left, right, up, down, and four diagonals	The direction of movement. This parameter is not directly used to distinguish efforts, but is used to determine space and path.
Secondary:		
space (speed)	stationary, travelling	A function of speed. If speed is zero then the gesture is stationary, otherwise it's traveling.
path (direction)	straight, wandering	If the speed is not zero, and there is only one direction registered, the gesture is straight.
disposition (pressure)	constant, varying	If the pressure maintains a single value after an initial acceleration the gesture is constant, otherwise it's varying.
pattern (gesture)	continuous, repetitive	If a gesture is unique in relation to the gesture immediately before and after, it is continuous. Any repeated action or gesture is classified as repetitive.

Table 1: Parameters derived from pressure pad data

SUMMARY

This paper has explored the notion of the effect of the "really really small" and how technology is an inseparable aspect of experience. The notion of palpable yet invisible interfaces and interactions is seen in the light of emerging explorations within human-computer interaction that explore experience, embodiment, subjectivity, and felt-life. The call to experience can be explored through valuing subjectivity and the foundational constituent knowledge of embodied approaches within interaction design. The concept of the really, really small marks a cognitive and creative shift from the visible to the invisible. This paper has offered the beginning of a framework from the field of *Somatics* particularly with regard to the body in everyday life. The design cases utilize various strategies borrowed from Somatics to design and create embodied interaction in the context of art and design.

CONCLUSION

One of the promises of the invisible computer is that by its very disappearance, we are left with ourselves in our world, and the opportunity to perceive ourselves more clearly in connection our own felt-life. Perhaps the invisible computer can make visible connections and interactions with ourselves that we were not able to perceive when the physical technology was 'in the way' obscuring our lines of sight and insight.

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PillowTalk: Can We Afford Intimacy?

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ABSTRACT
This paper describes the *move.me* interaction prototype developed in conjunction with V2_lab in Rotterdam. *move.me* proposes a scenario for social interaction and the notion of *social intimacy*. Interaction with sensory–enhanced, soft, pliable, tactile, throw-able cushions afford new approaches to pleasure, movement and play. A *somatics* approach to *touch* and *kinaesthesia* provides an underlying design framework. The technology developed for *move.me* uses the surface of the cushion as an intelligent tactile interface. Making use of a movement analysis system called Laban Effort-Shape, we have developed a model that provides a high-level interpretation of varying qualities of touch and motion trajectory. We describe the notion of *social intimacy,* and how we model it through techniques in somatics and performance practice. We describe the underlying concepts of *move.me* and its motivations. We illustrate the structural layers of interaction and related technical detail. Finally, we discuss the related body of work in the context of evaluating our approach and conclude with plans for future work.

Author Keywords
social intimacy, tactile interface, somatics, movement analysis, Laban effort-shape, tangible UIs, art/design installation, play, social interaction, user experience, ambient environment, choreography of interaction.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
A growing trend within tangible and embedded interaction is a desire to express emotional qualities through interaction, accompanied by an interest in incorporating movement and human perceptual-motor abilities [18]. Within HCI, *intimacy* is among an emerging set of experiential values that also include curiosity, enjoyment, resonance, play and self-awareness [6]. Hummels, et al [18] describe this trend as a renewed 'respect for the human as a whole', and cite the shift in contextual focus of HCI from the work place to 'quality of experience' in our everyday lives. A direct reflection of this contextual refinement is the development of interactive technologies that mediate intimacy [14, 20, 28]. The expression of *intimacy* is vital in personal and social interaction. It is reflected in the persistent desire to create technologies that simulate touch, body contact, and 'near-space' interaction [20], and that communicate closeness, even at a distance [16]. Gibbs et al [14] have coined the term 'phatic technologies' to emphasize the qualitative importance of non-informational forms of exchange: interactive technologies that are less concerned with capturing and communicating information and more involved with establishing and maintaining social connection. Grivas [16] argues similarly that assigning aesthetic and emotional qualities to physical objects or locations is a key strategy for the achievement of intimate interactions. Intimacy is connected with physical togetherness and contingency, and that intimacy can be heightened by a 'post-optimal' approach to technology that values the evocative and poetic powers of electronic media over the urge for utility and efficiency. Gaver [13] reflects on intimacy and emotional communications systems by asserting that new forms of aesthetic pleasure can evoke a deeper and richer experience through increased use of unusual and sense–based materials and interactions, and less 'explicit' forms of information, encouraging imagination and expression of value and attitude.

We propose the notion of *social intimacy*, where the interplay between people and a set of networked objects in a social or public space can be used to create awareness between others, sensitivity and more vital connection between groups of people in a public space. As a part of the European ITEA Passepartout project (www.passepartout-project.org) we explore *intimate* ambient technologies in the context of home, and *social-intimacy* in urban social spaces, such as a lounge, café, or *speak-easy*. We have developed a set of small interactive throw pillows

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containing intelligent touch-sensing surfaces, in order to explore new ways to model the interactions and experiences of participants and artefacts within the environment, in the context of expressive non-verbal interaction. Key concepts investigated by *move.me* include intimacy, connectivity and play.

We apply 'phatic'[14] approaches to technology, using networked cushions to explore awareness of connection and playful interaction. We use aesthetic properties of materials and their innate sensuality coupled with movement and pleasure to support *socially intimate* connectivity, including interactions of empathy, peripheral awareness, and engagement, as portrayed in Figure 1.

Figure 1. Interactive Pillow as Intimate Object – Paris ITEA demonstration Oct 2006

We propose ambient technology that requires the ability to detect and understand the user's activity, body state and identity [2]. Additionally, it has to understand the social signals displayed in user communication, as the this is always part of a larger social interplay [15].

This article first describes the motivation for our choice of the pillow as an everyday intimate object We then outline the underlying concepts of *move.me*. We illustrate an in-depth look at the structural layers that support the representation of context within *move.me* and related technical detail. Finally, this work is placed in the context of related bodies of work for evaluating our approach. We conclude with plans for future work.

THE PILLOW AS AN INTIMATE EVERYDAY OBJECT

The pillow is an example of an intimate everyday object. A pillow can express and extend a large dynamic range of qualities of affect. Our interaction can range from affection to ambivalence in a continuous cycle within our daily lives. Warhol's "Silver Floating Pillows" and Dunne's "The Pillow" [11] have contextualized the form of the pillow in both art and design. While Philips "photonic pillow" [23] is an extension of display of a 'soft' SMS, Dunne and Gaver describe "the Pillow" as a soft, subtle, gentle emitter of ambient data, beautiful and evocative, raising its issues and its content gently, one that has a certain *value fiction* that can contextualize information about our environment (in their case: the presence of electromagnetic radiation) through immediacy, intimacy and simple pleasure. The pillow is familiar: it contains our memory, energetically and physically. Pillows have a rich and evocative metaphor space: they cushion us, bolster us when we are nervous, can be cherished, warm, close, and friendly. A pillow keeps secrets and shares intimate connections [25]. The term Pillow Talk and Pillow Book both reference this secret internal world of the body, the sensual or even erotic connotations that the pillow can suggest. Pillows are used as forms of urban or folk combat: the pillow fight, a physicalization of battle, physical play and expression of affect. They enable both the internalization as well as the externalization of movement, and 'afford' interaction that can play or slide between these varying scales. But a pillow is also a safe and humble object, it is held by a child for safety, for comfort, and to 'bring a sense of home' along for the ride.

Our exploration of the pillow as intimate technology embeds both digital technologies along side metaphors of intimacy to allow us to share, edit and communicate the evidence of our connection to reflect more subtle – or poetic – aspects of our identity and connection through patterns of touch, movement and being. We communicate embodied intimacy and play through a tactile interface embedded in the textiles and in the fabric of the cushions. In this way both the circuit design and the fabric and textile becomes an aesthetic component of the interactive object. [5]. This is also an extension of awareness technologies as discussed in Gaver's [13] reference to provocative awareness.

MOVE.ME – MOTIVATION AND SCENARIOS

Move.me is an ambient environment in which *embedded technologies* act as a "connective tissue" between users and devices within a contextualised space through domain-specific interaction strategies.

In *move.m* we developed a set of small interactive throw pillows, as portrayed in Figure 2. We utilize these pillows within two scenarios, a home scenario where a pillow is used by a single user in the context of digital entertainment, and in a café or lounge environment where the ambience is created by the dynamic social activity and interaction of people coming and going.

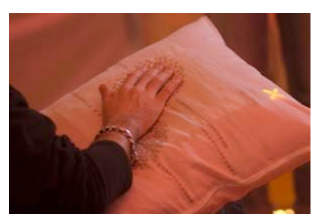

Figure 2. Pillow with actuators, touchpad, LED display and vibrator (photo courtesy of Jan Sprij).

The home scenario explores a child as the interactor with the pillow. In this scenario the media space is understood as an experience space, which the child can explore freely. Thresholds can be set for this space, with respect to levels of excitement, as well as temporal aspects such as the reaction time for adaptations. The aim of this scenario is to explore a single user single object interaction and its possibilities to influence the overall environment.

The second *move.me* scenario is situated in a café/lounge environment, where participants are invited to re-mix a set of moving images projected in large scale on the walls within the café through physical interaction with a set of small interactive pillows. Figure 3 portrays a setting of the *move.me* environment, on the left, and an action performed with a pillow, on the right.

Figure 3: The *move.me* scenario setting.

The type of purpose-free social play in this scenario forms a kind of choreographic experiment in which the result of interaction with the pillow creates movement on at least three levels: 1) the movement of the participant as they interact with the pillows (touching, caressing, throwing, hitting, holding); 2) the movement of the pillows themselves as a result of the participants interaction; and 3) the movement of re-mixed images derived and rematerialized in direct response to the public intervention. The focus of this work lies on the representation of movement in an environment that is aware of users and objects but not necessarily knows much about them. This work integrates somatics [17] and gesture interaction [21] with textiles and interactive object design [25]. A detailed description of this environment can be found here [3].

SENSORS, ADAPTATION AND FEEDBACK IN *MOVE.ME*

The main idea behind *move.me* is to establish an environment, which constantly collects raw data from various modality-sensitive objects that is then communicated to a context engine. The context engine interprets the derived parameters to manipulate in turn the presentation of audio-visual material displayed in the environment as well as the overall ambience of the environment itself, e.g. by manipulating light and sound sources.

As a result we developed an interaction model that involves three parts:

- The user.
- The interface, which in our case is a conceptual unit containing the interactive pillow as input sensor and other devices, such as vibrator, fan, light-emissive fibre, light-emissive diode, earphones, screen, sound system, lamp, et cetera, as output sources.
- The context engine as a back end server.

With respect to its interaction part the model extends Don Norman's traditional execution-evaluation model [22] beyond the user's view of the interaction by including not only the interface but all the elements necessary to judge the general usability of the interactive system as a whole. This allows placing the *move.me* environment in different social contexts with an overlap on a particular task.

With respect to the contextual aspects of our interaction model we adopt strategies from case-based reasoning (CBR) [1], in particular those strategies which argue that tracing the history of actions [9] provides the means to improve a systems capability to adaptively interact with a user. We establish a set of raw data, on which we then elaborate based on user and environmental data (both together form our context) to perform contextualized adaptation. The adaptation as well as the context it was performed in are then stored and will be used in the ongoing process of ambient user adaptation for further refinement.

In the remaining part of this section we will outline the various modules of the *move.me* environment, namely:

- *Sensors*, which are the input sensors of the pillow.
- *Sensor evaluation module*, which instantiates the device drivers for every detected pillow. Its main task is to perform some statistical analysis (high-pass filtering and mean value calculations) in order to keep the overhead of processing low.
- *Context module* that consists of data structures describing the current context with respect to users, devices and the interactions between them.
- *Adaptation engine*, which uses data from the Context module to establish a mapping between detected actions and the appropriate environmental adaptation. It also conveys instructions about the source to be adapted and the means of adaptation to the Communicator.

We are aware that a number of the described action efforts as well as resulting adaptations could also and probably should be detected by other devices than the pillow. However, for the sake of clarity we explain the mechanisms through the pillow.

Pillow sensors and their evaluation

The objectives of the technical research in *move.me* are twofold. First, we want to explore smart fabric textiles in the context of flexible electronics and displays in order to build these into a wireless network, capable of making body data available. Second, we wish to develop heuristics of interaction based on touch, gesture, and movement to infer action efforts from users while utilising the device and to manipulate this raw data to enable a higher-level mapping of action efforts and presentation manipulation techniques.

Using raw data from smart fabric textiles allow qualitative recognition for two categories of movement: 1) touch on the surface of the pillow, and 2) movement in three-dimensional space created by the 'free-throwing' of the pillow. We call our touch selection input "threads of recognition" because it refers to metaphors of input recognition in the context of smart textiles research [24].

Pressure is the essential type of data we process to extract a caress and its effort. We have identified a set of parameters that can be extracted or calculated from the information that the response area provides over time. These parameters are described in Table 1. At the moment we utilise the values for pressure, size, speed and direction as input parameters.

A pillow in *move.me* is the main medium for smart fabric textiles, and can be equipped with any of the sensors and actuators as displayed in Figure 4.

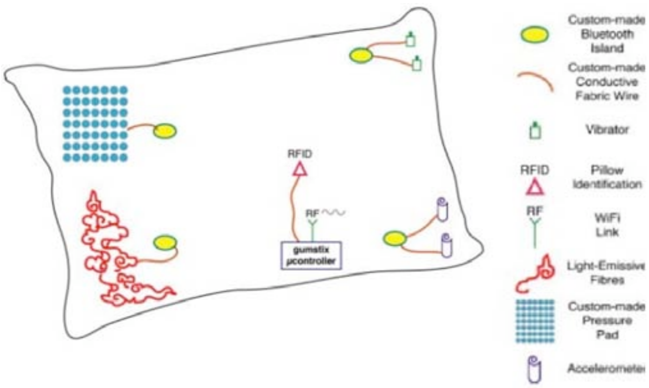

Figure 4: Pillow technology

The main sensors we apply are a touch-based interface for measuring pressure and accelerometers to measure motion. Fans, vibrators and light sources, either in the form of light emissive fibers or as a LED display, provide localized feedback.

The touch-pad itself is a simple grid (64 sensitive regions) of carbon-impregnated open cell polyethylene foam. This material has the characteristic that the electrical resistance of the foam drops as the density of the foam increases. We utilize this behaviour to identify a point of contact or applied pressure.

The processing unit is a small, lightweight, single-board computer, which connects to the accelerometers, and a sensor board card, which can measure up to 64 pressure sensors. The computer filters the incoming data and communicates at a rate of approximately 20 Hz to the server application, where the interpretation of the data is performed. When switched on, the pillow propagates its IP-address and port number on the network, which allows listening programs to detect and register the pillow and start receiving or sending messages.

For identifying users in the closer surroundings of the pillow each pillow contains an RFID reader/writer, allowing us to write our codes into programmable RFID-Tags, which are embedded within each pillow or worn by users of the environment as bracelets.

Parameter:		Description
pressure	soft, hard	The intensity of the touch.
time	short, long	The length of time a gesture takes.
size	small, medium, big	The size of the part of the interaction object that touches the pad.
number	one, many	The distinction between one finger or object and many fingers.
speed	none, slow, fast	The speed of a touch-effort. This is the overall velocity of movement. This parameter is not used directly to distinguish efforts, but is used to determine space.
direction	none, left, right, up, down, and four diagonals	The direction of movement. This parameter is not directly used to distinguish efforts, but is used to determine space and path.
Secondary:		
space (speed)	stationary, travelling	A function of speed. If speed is zero then the gesture is stationary, otherwise it's traveling.
path (direction)	straight, wandering	If the speed is not zero, and there is only one direction registered, the gesture is straight.
disposition (pressure)	constant, varying	If the pressure maintains a single value after an initial acceleration the gesture is constant, otherwise it's varying.
pattern (gesture)	continuous, repetitive	If a gesture is unique in relation to the gesture immediately before and after, it is continuous. Any repeated action or gesture is classified as repetitive.

Table 1: Parameters derived from pressure pad data

Emphasizing the sensual aesthetic of a pillow, covers are designed to encourage connection through feel in an associative and intuitive way. Pillow prototypes are portrayed in Figure 5.

Figure 5: Prototype pillows

Pillowcases are made of silk organza [24], a conductive fabric. In *move.me*, we use this material as cables that send data signals from the touchpad to the embedded processing unit. In that way we achieve that users, such as children, not only interact naturally with the pillow but also whish to do so, as the surfaces of textiles or light-immersive material asks for touch. Moreover, all the required hardware is lightweight and wrapped in soft material to avoid edgy sharpness that could destruct the intimate character of the pillow.

The pillow serves mainly as an affectionate transmitter that provides a basic analysis of the signals, e.g. calculating time and space variables, which are then sent out to the central system along with additional information, such as which other pillows or users are near to this pillow.

Once the data for pressure, size, speed and direction is received by the central system, the sensor evaluation module performs a first abstraction on the data. The way that incoming sensor data is analyzed depends on the context and the configuration of a pillow. For example, if the pillow contains a pad that allows measuring pressure as well as galvanic skin response (GSR) and an accelerometer for computing movement, a different abstraction scheme is provided as output compared to a pillow that only contains a pressure pad. This means that the system handles every pillow individually, as it also does for users. Only at a later stage are the individual views combined to the global context view.

When analysing streams of data, in this case the input data for every taxel of the pad, it is desirable to keep a history of past events especially when we are looking for trends in the data [12]. However, storing the whole dataset and re-iterating over the last *n* samples whenever a new sample arrives quickly becomes inefficient as *n* grows. We, therefore, apply a method that keeps a history of past events without actually storing them but summarizing instead the entire set of (or the last *n*) past events in a few critical parameters.

For the detection of the pillow movement we analyse the data coming from a pillow's accelerometer. The basis of the recognition is a distinction between linear movements in three directions, clockwise and counter-clockwise circular movements, as well as rectangles and triangles described in space. The collected raw data is interpreted as vectors, and the input vector (the "raw" acceleration vector) is filtered and further processed to subtract the influence of gravity, and to yield "Position" and "Orientation" vectors. The "Motion" vector (i.e. total acceleration - gravity = acceleration caused by movement) is passed on to the neural network for the analysis of pillow motion (twirl, pan, tilt). The interpretation of the sensor data depends on the context in which it was collected.

Context in *move.me*

Context in *move.me* describes an area, namely a living room (home entertainment context) and the lounge (café context), in which users interact with the pillows.

The **Context Module** describes the current (present) status of the environment with respect to resident users, devices and the interactions between them. Users as well as devices become part of the Context Model once their RFID is detected. For each detected user or object a memory structure is established that reflects only those characteristics that are relevant for the current context. User characteristics are, for example, the user identifier, relevant thresholds, the current biometric status as well as related presentation devices. Device characteristics are, e.g. the device's sensor set, its affector setup, the device IP, activity state and location as well as preferences for particular users.

That we provide devices with a memory structure that is similar to that of human users is so that they themselves become proactive towards users. At the moment we only store very simple data, such as user id, action performed and its duration, but later on we wish to explore further in that direction.

The memory structures are rather static schema with which it would be difficult to observe the dynamics of the environment. We introduced, therefore, the concept of a session, which monitors the interactions between a user and device or between devices. A session is a structure containing the ids of the two agents involved, the general start time of the session, the end time, the actions performed and resulting status reports (e.g. sensor values).

A session is instantiated by the Context Module once a device detects the user id and its sensors show some level of interaction. Sessions between devices are instantiated if a device in another session acts as a meta-device. Example: a child might hug a pillow (session A: child1 – pillow23) while it watches TV but actually operates through the pressure it performs on it the presentation of the program (session B: pillow23 – loudspeaker). Sessions are closed, depending on the device, either once the interaction stops or if the user leaves the context. In cases where more than one user is detected by a device the one using the device the longest is considered the prime user. If the prime user leaves the context then the next longest user in the list takes over. Once a session is terminated it will be stored in the History Model.

The **History Model** is our approach towards an individualized long-term memory of the interaction patterns for every user and device in a context. It is updated if a user or device exits the context or if a session has been terminated. The model contains, at the moment, two memory sets, namely **identification** and **session**. The identification set is always instantiated once a user enters a context. This set serves as a crosscheck source for the Adaptation engine to evaluate user behaviour (it might turn out that the user attends certain contexts, thus shows interest, but does not act in them – no sessions with this user id in the same time span). The session set describes every interaction the user or device was involved in. The data set stores the collected biometric data and the adaptation list contains the adaptations performed by the Adaptation engine based on the data in the same time frame. At the moment we keep track of sessions, and thus make them accessible to the Adaptation engine, in the form of a relational database. The outlined representation structures serve as sources for the Adaptation engine to determine if an adaptation is required and which type of adaptation needs to be performed.

Adaptation and Feedback

In *move.me* the Adaptation engine uses a finite state machine (FSM), where the session structure and descriptions of the Context module are used as to represent the states. Changes of theses states are triggered through the input devices' touch pad and accelerometer. The transitions are based on the constraints set for the context as well as in the user models. Actions finally describe the adaptation that is to be performed at a given moment, either in the form of the adaptation of a pillow's actuators, such as vibrator, fan, or light-emissive diodes, or the performance of presentation devices in the environment, such as a change of the noise level. Each context can be understood as a set of possible actions and moods that then again trigger certain adaptations. Thus, the organisation of rules in *move.me* is based on context scripts.

The Adaptation engine constantly evaluates the Context module for every identified user and device and reacts on changes only if they are outside the provided constraint set.

In *move.me* adaptation focuses on three major processes, namely stimulation, relaxation and representation. *Stimulation* describes the attempt to either engage a non-active user into an interaction with the environment or to increase a low-base activity. *Relaxation* tries to reduce the amount of activity or excitement. *Representation* aims to present the state of the environment and the user in a visible and audible form.

A typical situation for stimulation in the home scenario is, for example, if the child is in the living room but either does not interact with anything, i.e. simply sits on the sofa (the child is detected by the system but no session is established); or the child might hold the pillow but does that for a long time without changing neither effort nor gesture (there is a session instantiated but the changes of values are infrequent and generally low).

If the Adaptation engine cannot identify a session it tries to engage the child. The first step is to investigates which type of devices are available that are equipped with actuators that provide means to connect with the child (e.g. all types of global actuators, such as LEDs, emissive fibers, loudspeakers, etc.). Comparing the neighbourhood relations between these objects and the user the adaptation can activate the closest non-active pillow to start an interaction with the user. However, if any of the pillows already has a preference for the child, as represented in the pillow's user model, or the child has a preference for any of the pillows, this particular pillow will be instantiated to become active. In that way our system tries to utilise already established relations between objects and users. The start of an interaction can begin with already established pattern, such as the pillow shows known visual pattern that invite the child to hug the pillow. Once the contact is established the adaptation engine will use other established relations to stimulate further interest, e.g. switching on a TV or radio program.

A different type of stimulation is the detection of potential non-interest. Assuming the adaptation engine discovers over a period of time (a constraint determined by the context) a steady decrease of one of the threshold values, it might determine that the user is bored, and it may then activate both an icon on the LED matrix in the centre of the touch-pad, as well as causing a vibrator within the pillow to generate a shiver-like action. This pattern might also be used to instantiate a change of context, for example the change from TV mode into game mode.

The order of rules for the Adaptation engine is established based on the current state and the outcome of tracking the performance of the instantiated adaptation. In the example of the change between the state of watching TV and playing a game the adaptation engine would not launch the game if the child had not responded with acceptance of that change in time. In case the child ignored the suggested game, the Adaptation engine would try another strategy, e.g. instantiate a change in the environment, like increasing the volume to attract attention.

The dynamic interpretation of user actions and its efforts as well as pillow movement results in a change of visual and auditory patterns as well as task contexts, which in turn might stimulate new associations in users, resulting in a behaviour that might require that new adaptations be performed by the system. The result is a constant feedback loop where the data from a pillow triggers the interpretation mechanism, which directly affect the audio-visual outputs of the system and vice versa.

EVALUATION

We ran a small user study on the initial prototype of the system, consisting of a qualitative elicitation study, in the form of a one-day participatory workshop with 10 users, which was designed to explore user needs and system requirements. The test users were representatives of the target user group, 3 females and 7 males between the ages of 20 and 30. Aiming to gain an insight into interaction patterns, the workshop covered:

- A hands-on free exploration session with a medium-fidelity pillow prototype (the hardware as well as adaptation software for different modalities worked in real time). The free exploration sessions were conducted first from an individual starting point, and latter on a group basis.
- A "Wizard of Oz" simulation of the complete intended functionality of the system.

The participants' experiences with the pillow through the free exploration of the *move.me* system, and the discussion during the 'Wizard of Oz' sessions were both video taped for later analysis. A detailed evaluation of the workshop is described here [3]. The major findings of the workshop were:

- The current architecture is stable.
- Even though the adaptation of iconic messages on the LED display responded too slowly, causing in some users the impression that the icons were randomly generated, the initial exploration interaction pattern lead to the users' full engagement with the system.
- The way the gestures were performed by the users implied that they do not make a distinction between gestures based on the size of the area on the touch pad occupied by the gesture. For example a tap and a slap meant the same to them. A more important mean of distinction was, however, the number of repetition of

movements or the strength (or intensity) in which they were performed.

We are not only aware of the fact that the pillow is still a limited prototype (even if the current system is stable), but also that the test sample is rather small. That is the reason why, at the moment, we were only able to perform a qualitative evaluation of the system. This means that the findings should be taken as general guidelines, which will allow us to make educated decisions from a user centric point of view for further developments.

A presentation of the pillow functionality at the ITEA symposium in October 2006 showed that the adaptation based on stimulation, relaxation and representation is sufficiently sound to let users understand how the environment reacts to their actions. However, the performed user sessions are again too short to provide significant statistical data about the effectiveness of our suggested context representation. Regarding possible quantitative tests, we are aiming for a later workshop as the basis for fine-tuning the system before the public presentation of the installation in spring 2007 at the Dutch Electronic Arts Festival.

RELATED WORK

In our work we apply sensing and biofeedback technologies to establish a new way of interpreting human movements in real-time to enable expressive non-verbal interaction in the context of ambient, public, urban, social spaces. This section includes a summary of background and informing works.

There has been a great deal of general research in sensing and biofeedback in human-computer interaction [2, 8, 19, 20] Although we use these technologies in different environments, this research has indicated that a number of well established sensory methods, such as pressure and GSR, obtain a window into the state of an individual.

Buxton et al [7] provides early descriptions of the unique characteristics of touch tablets relative to other input devices such as mice and trackballs. Chen et al [10] describe the use of a touch-sensitive tablet to control a dynamic particle simulation using finger strokes and whole-hand gestures, where the gestures are interpreted as a form of command language for direct manipulation. The fabrics used in our work differ, though, as they can be multiple-touch. In our work we go beyond direct manipulation by language to including the quality effort into the recognized gestures.

The Laban notation [21], which we use in the public, urban, and social space scenario of move.me, has often been used to interpret user movements, especially in interactive artistic settings. Badler [4] presents a digital representation of the specific Laban notation. Zhao [30] has applied Laban Movement Analysis (LMA) to studies of communication gestures. Within *move.me* we interpret gestures, or rather users' effort, for establishing communication rather than precise communication acts. Schiphorst et al [26] describe the use of kinematic models to represent movements. Calvert et al [8] further describe the development of the composition tool into the product Life Forms, which uses Laban notation as the representation language. A computer-based graphical tool for working with the similar Benesh Movement Notation is described by Singh [27]. The current work was influenced by the choreographic approach to motion description and presentation of these studies.

Haptics and touch have been explored by many researchers. The University of Tsukuba has also developed a great number system that makes use of haptics such as finger/hand manipulation and locomotion [19]. Although these systems use different technologies, they have provided us with a motivation for the usage of touch.

With socio-ec(h)o [29] we share the notion of play. Just like *move.me*, socio-ec(h)o explores the design and implementation of a system for sensing and display. However, socio-ec(h)o bases its interaction models on existing serious game structures, where body movements and positions must be discovered by players in order to complete a level and in turn represent a learned game skill. In *move.me* the emphasis is more on the entertaining, purpose-free aspect of play than on the learning of skills.

CONCLUSION AND FUTURE WORK

We have described *move.me*, an ambient environment in which a set of small interactive throw pillows containing intelligent touch-sensing surfaces allow the exploration of new ways to model the environment, participants, artefacts, and their interactions, in the context of *social intimacy* through expressive non-verbal interaction.

The novel aspect of *move.me* is the approach to map efforts of actions to higher-level adaptation activities, which opens the mapping space between biometric data and its potential meaning. Though the first prototype shows promising results, we have to provide significant improvements with respect to adaptation response time as well as the range of adaptations to facilitate an experience-rich environment that reflects the broader motions of social interchange. We also have to fine-tune the relations between context, action and presentation modalities and the relationships between intimacy within the context of a one-to-one connection and within a group.

We consider *move.me* as a platform for the study of new forms of ambient-based interaction that integrate networked connectivity, in the context of *social intimacy*, and intend to explore this avenue further.

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Personalized Ambient Media Experience: *move.me* Case Study

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ABSTRACT
The *move.me* prototype illustrates a scenario for social interaction in which users can manipulate audio-visual sources presented on various screens through an interaction with a sensor-enhanced pillow. The technology developed for *move.me* uses the surface of a pillow as a tactile interface. We describe the underlying concepts of *move.me* and its motivations. We present a case study of the environment as the context of evaluating aspects of our approach and conclude with plans for future work.

ACM Classification: H5.2 [Information interfaces and presentation]: User Interfaces.

General terms: Ambient environment, ambient multimedia, interaction, social experience, user context, tactile interface.

Keywords: Guides, instructions, formatting

INTRODUCTION
The *move.me* project, a part of the European ITEA Passepartout project, explores the usage of ambient technologies in interactive digital television for home environments, as well as for public, urban, and social spaces, such as lounges at cafes, bars or cinemas. Key concepts explored by *move.me* include mobility, connectivity, invisibility, and intimacy. By applying context-aware technologies, we have developed a set of small interactive throw pillows containing intelligent touch-sensing surfaces, in order to explore new ways to model the environment, participants, artefacts, and their interactions, in the context of expressive non-verbal interaction within purpose-free social play.

In this paper we briefly describe the underlying technology of the pillows with a focus on the data collection for the context and user models. This paper reports on an evaluation workshop held in May 2006, where users tested the first pillow prototype with respect to its usability, and we investigated the feasibility of our research approach.

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PILLOW – MOTIVATION AND TECHNOLOGY
The overall scenario for *move.me* is situated in a café/lounge environment. Participants are invited to re-mix a set of moving images projected in large scale on the walls within the café through the physical interaction with small interactive throw pillows.

In the *move.me* project we investigate the representation of movement, where the interaction with the pillow creates movement on at least three levels: 1) the movement of the participant as they interact with the pillows (touching, caressing, throwing, hitting, holding); 2) the movement of the pillows themselves as a result of the participants interaction; and 3) the movement of re-mixed images derived and rematerialized as direct response from the public intervention in an environment aware of users and objects.

We root our work in general research on sensing and biofeedback in human-computer interaction [1, 5], which has indicated that a number of well established sensory methods, such as pressure and GSR, obtain a window into the state of an individual.

The affectionate quality of a pillow as a metaphor for intimacy is also used in other works, such as the interactive pillows by Ernevi [3, 2]. Both projects investigate interactive pillows as a means of enhancing long-distance communications. Though we share the notion of a sensual aesthetic of a pillow that encourages connection through feel in an associative and intuitive way, we do support a different vocabulary of expressiveness, based on motion.

Within *move.me*, we interpret users' touch effort, for establishing communication rather than precise communication acts. The work was based upon a somatic/choreographic approach to movement analysis and interpretation, described by Schiphorst et al [6]. It describes the use of qualitative kinesthetic models to represent movements.

Technology - hardware
In our approach we utilize raw data from smart fabric textiles, and apply a set of touch recognition heuristics to allow for a qualitative interpretation of the signal.

We provide several variations of pillows, each distinguished by the set of sensors and actuators they offer. The main sensor we apply is a touch-based interface for measuring pressure. The touch-pad itself is a simple grid (64 sensitive regions) of carbon impregnated open cell polyethylene foam, which we utilize to identify a point of contact or applied pressure. The processing unit is a small, lightweight, gumstix computer and a sensor board card. The sensor board can measure up to 64 pressure sensors and has 4 software calibratable GSR inputs. The gumstix filters the incoming data and communicates it at a rate of ~20 Hz to the server application, where complex interpretation of the data is performed. The communication between a pillow and the server is utilizing the OpenSound Control (OSC) protocol. Fans, vibrators and light sources, either in form of light emissive fibers or as a LED display, provide localized feedback. A typical pillow is shown in Figure 1.

Figure 1: Pillow with actuators touchpad, LED display and vibrator (photos by courtesy of Jan Sprij)

Technology - software

The pillow itself only provides a basic analysis of signals, e.g. calculating pressure, size of touch area, speed of touch and direction as input parameters, which are then transmitted to the *move.me* central system along with information, such as which other pillows or users are near to this pillow. The central system contains a number of modules:

- Communicator module enables the flexible connection of all components. It also contains interfaces to convert data generated by the application to several communication protocols and vice versa. The communicator, for example, handles the control of underlying video mixing software.
- Sensor evaluation module instantiates the device drivers for every detected pillow. The main task is to perform some statistical analysis (some high-pass filtering and mean value calculations) in order to keep the overhead of processing load low.
- Representation Module consists of data structures that describe the current context with respect to users, devices and the interactions between them.
- Adaptation engine uses data from the Representation module to establish a mapping between detected caress and movement effort. It determines appropriate adaptation method and provides instructions for the source to be adapted and means of adaptation to Communicator.

The data structure used by these modules consists of context model, user model, and device model.

Context Model describes the current status of the environment with respect to users, devices and the interactions among them. Users as well as devices become part of the Context Model once their RFID is detected. Interactions between a user and device or between devices are monitored in sessions. The context model also contains a user, device model and history model.

Context User Model (CUM) and *Context Device Mode*l (CDM) are permanent stores correspondingly for user and device characteristics. Both CUM and CDM are created for each user and device when registered in a particular context and reflects only those characteristics that are relevant for the current context. User characteristics are, e.g. the user identifier, relevant thresholds, current biometric status. Device characteristics are, e.g. device's sensor set, affecter setup, IP, dynamic values like activity state and location).

*History Mode*l is an individualized long-term memory of the interaction patterns for every user and device in a context. It stores the contextualized events for each agent. Note, that we also provide devices with a memory so that they themselves become proactive towards users.

The central system is developed in Python (ver. 2.4) and runs on Ubuntu Linux and on Apple OSX 10.4 in combination with Fink. Neural networks handling are developed under Max/Jitter. Communicator is implemented as a Java application. A more detailed description of the technology is provided in [4].

EXPERIMENTAL SETING

To establish a safe ground for the development of the pillow and the interaction with it, we ran a user study on the initial prototype as a first step in our user-centered design.

A qualitative elicitation study took the form of a one-day participatory workshop with 10 users. It aimed at exploring user needs (experiences, aesthetics of objects, etc.) and system requirements (e.g. stability, network connectivity, etc.). We utilized a pillow with a 6x6 touchpad and a LED display. The underlying system could recognize touch based on size and speed; apply a set of 6 adaptation methods.

The test users were representatives of the target user group, namely young urban people in the age group between 20 and 30. Our test group was composed by 3 females and 7 males, all art students from the Piet Zwart Institute in Rotterdam. They participated in two separate sessions conducted in a lounge environment that we created in one of the cubicle houses in which the institute is situated.

To gain an insight on interaction patterns, we covered:

- A *hands-on free exploration session* with a medium-fidelity pillow prototype (the hardware as well as adaptation software for different modalities worked in real time). The free exploration sessions permitted each participant to interact with the pillow for around 15 minutes in whatever way they wished.
- A *first individual session* of roughly 15 minutes to fill in usability questionnaires. The questions applied compara-

tive scales for evaluating the understandability of the icons used as visual feedback on the pillow and how intuitive and natural the gesture/actions pairs were. Moreover, we also applied semantic differential scales to explore the users' connotative meaning about the pillow/movement space based on [8]. A detailed description of the results is provided in [7].

- A *second individual session* of roughly 15 minutes in form of an interview. The intention of this interview was to gain insight in the users' experience with an attitude towards the pillow as further fundament towards a complete system. Additionally we aimed at investigating requirements and aspects to focus on during further development and the future evaluation steps. The rest of the paper reports on results gathered in this part of the study.

- Finally we ran with all the users at the same time a *"Wizard of Oz" 1.5 hours simulation* of the complete intended functionality of the system (the VJing was performed by a professional as the mixing ability of the system was at the time of the experiment too rudimentary). The participants' experiences with the pillow through the free exploration of the *move.me* system, and the discussion during the 'Wizard of Oz' sessions were both video taped for later analysis.

DISCUSSION – SECOND INDIVIDUAL INTERVIEW

After half an hour of exploration of the pillow and a quarter of an hour session, in which participants individually evaluated particular communication aspects of the pillow, a second individual interview session was launched, where the participants were asked to evaluate the general concept of *move.me*. A verbal question and answer interview style was employed. The topics and related questions were predefined. The participants had roughly four minutes for each topic to describe their ideas about achievements, failures and potential additional wishes regarding the pillow in particular and the overall system in general The topics covered in the interview were: purpose and functionality, interaction, networking/sensors, and actuator settings.

Purpose and functionality

One of the major findings of the workshop is that our initial approach towards invisibility and intimacy by providing the right aesthetics worked: all participants used the pillow as an object to rest, to support body parts, or to express affection through different caresses. All participants agreed that a pillow is a suitable way of collecting body data in a non-intrusive way. Functionality related to the typical use of the pillow was well accepted. However, a variety of additional functionalities resulted in distractions for the majority of participants (7). They would only accept additional functionality, such as the LED screen, which not only provided personalized information but could also be used as a remote control, an option liked by (8), with clear indications in different modalities according to the current usage context.

Expanding on these issues all participants emphasized that an environment as suggested by *move.me* should support practical tasks in the house and combine already automated devices in or around the house (e.g. central heating, sunscreen, light-sources, audio-visual equipment).

Interaction. All 10 participants found the pillow a very pleasant and intuitive object to interact with. However, they would normally not look at a pillow while using it. Thus, the LED screen for additional information caused concerns as it forced the users to change their natural behavior ('I cannot lie on the pillow if I have to look at it to receive messages'). 3 participants perceived the active use of the pillow as unnatural vs only holding it or lying on it. Suggestions were made to integrate the feedback from the pillow into presentations of actuators that serve in the context of activities currently performed. For example, information about the user's current excitement level can be overlaid on the visual material the user is consuming. Another option is to use a vibrator to provide information, which allows the user to lie on the pillow and still receive feedback.

While exploring the pillow two main problems were indicated. First, the pillow appeared rather hard (gumstix box) and containing sharp pins (circuit board connector). Second, the feedback given by the LED's was difficult to understand if at all. The adaptation of iconic messages on the LED display responded too slowly, causing in some users the impression that the icons were randomly generated.

Networking/sensors. All participants experimented with only one pillow. This provoked desire in the majority to have other active pillows so that they can communicate with other people via them. Four users considered implicit and explicit communication (e.g. the exact relation between pillows, pillows in different locations). In that context most (8) participants indicated a desire to experiment more with our various memory models, an aspect not evaluated during this workshop. The necessity for such models was clear if an adjustable level of detail in the result presentation is present. With respect to the sensor capability of the touchpad – three users suggested that the pillow should be able to monitor brainwave activity. In this way the pillow could assist, for example, in improving optimal sleep.

Actuator settings. For six participants the LED's on the pillow were too bright, which they found very distracting and uncomfortable. They suggested the brightness of the LED's to be adjustable (where they were equally happy with automatic, semi-automatic or manual adjustment).

Derived Social Indicators

During the interview the participants also provided feedback on social issues, e.g. trust, comfort, (dis)like, believe, willingness to invest time. The two most important social categories for all the participants were trust and comfort.

Trust was considered as a function of all the technical aspects that are mentioned above. Being confronted with novel technology, it is only natural for people to be suspicious and it takes time to establish a relation of trust. Another aspect of trust is the ability to receive feedback. If the system makes certain decisions the user must be able to understand the basis and purpose of this adaptation. Related to the aspect of feedback is the aspect of control. Depending on the level of control (e.g. adjusting actuator settings to users liking) the level of trust can decrease or increase. No control from the user was unanimously rejected as an option. The level of control by the system was not clearly identifiable by the users, as that would require long time testing. Yet, a certain level of control was accepted.

Comfort. All users expected a high level of comfort while working with the pillow. Problems, such as poking out pins or hard objects in a pillow, are serious as they decrease the level of comfort. Wide ranges of sensors are at our disposal, some of which users are already more or less familiar with. Six participants felt highly uncomfortable when biosensor data, like GSR, body temperature or heartbeat, was monitored while others (5) felt less comfortable when monitored by camera's or motion detectors. Ideally, users should be able to choose the sensors of their liking to be used by the system. That is why we provide a set of different pillows (e.g. users that do not like monitoring of biometric data can choose pillows with gesture recognition only).

A lack of trust and comfort leads to *dislike* and *disbelieve* in the system resulting in a non-willingness to invest time with it. In particular *belief* is important for the bound between the user and the pillow and to achieve the balance between effort made and the reward gained.

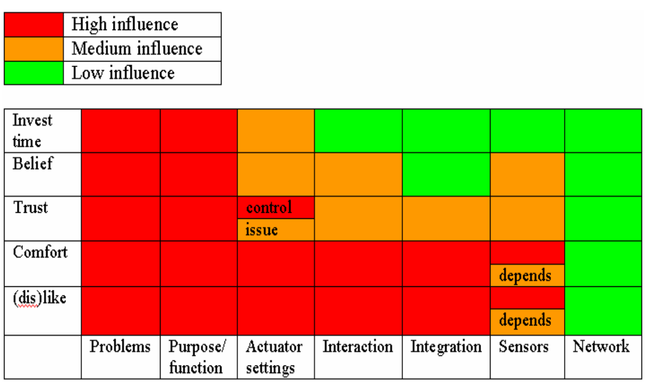

Figure 2: Hardware aspects - social indicators relation

Figure 2 describes the relationship between hardware aspects and social indicators we presented. It indicates the most important hardware aspects and social indicators as success factors. Further development of the pillow is focused on the 'high influence' aspects. We are aware that the pillow is still a limited prototype (even if the current system is stable) and also that the test sample is rather small. Our user-centered approach allows us to perform further studies in order to analyze and evaluate multiple aspects of the ambient environment and the system.

The findings from this experiment draw guidelines for further design and evaluation based on the relations in Figure 2 in to fine-tune the system before the public presentation during DEAF 2007.

CONCLUSIONS

In this paper we have described *move.me*, an experiment on personalized ambient media in the context of purpose-free social play. We described the current implementation and presented a first qualitative elicitation study applied on it.

The novel aspect of *move.me* is the approach to map movements to higher-level adaptation activities, which opens the mapping space between biometric data and its potential meaning. Though the first prototype shows promising results we have to provide significant improvements with respect to adaptation response time as well as the range of adaptations to facilitate an experience-rich environment that reflects the motions of the social interchange. We also have to fine-tune the relations between context, action and presentation modalities.

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Affectionate Computing: Can We Fall in Love with a Machine?

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I wanna hold your hand

It was dark. She could hear her heart beating softly against the pillow. I must still be alive, she thought.

Human beings need to connect: to themselves, each other, and their objects of affection in the world in which they live. We know that without touch, an infant will die, and without affection the human body's necessary neurophysiological development is deeply impaired. We also know that our technologies are becoming smaller and more powerful. So what does Maslow's hierarchy of needs have to do with Moore's law? Mobility, connectivity, invisibility, and intimacy aren't just keywords—they're becoming key content, and even key processes. What was the search key is becoming the sought-after object of our desire: our experience of ourselves through our technologies.

Current research in smart fabrics technologies includes the development of flexible circuits and flexible computing embedded within textiles and fabric polymers (see Figure 1). Within a handful of years the set-top box, portable computer, cell phone, game controller, and i-Pod will no longer be physical necessities. Form factor will become an imaginative choice, no longer a physical constraint.

Our technology will let us choose the shape, size, and function of our applications. Shapeshifting will no longer be science fiction; rather, it will be a feature set in wireless applications.

Editor's Note

This article addresses new ways of computer interaction beyond the known mouse and button paradigm. The author explores haptics as a means to pay attention to the self, and using this sense to connect with others.

—Frank Nack

Can't buy me love

Her pillow was awake, too. It was soothed by the sound of her heart, but felt a little anxious, as it had been dreaming of one of its past lives.

How can we begin to conceptualize and prototype our applications of tomorrow? Our ability to design our futures requires some hand holding: bringing closer connection to the communication between art, science, and research in the technology industry. This hand holding can be uncomfortable at first, with a requisite period of sweaty palms, uncomfortable silences, and social faux pas. But hand holding can also invite affection, curiosity, and vulnerable data: which, if respected, can result in knowledge sharing and building.

This research domain extends embodied cognition, expanded perception, adaptive environments, and interactive systems. It considers these differing aspects as layers of architectures that embrace and include the body and its own data, affectionate computing, sensual interfaces, models for intention, smart materials, textiles, shapeshifting forms, and spaces that can move and transform.

I'm looking through you

Was it real, or was she imagining the familiar sound of a ring tone beneath (or was it inside) her head? She considered her pillow one of her better and most deeply trusted friends.

As our technologies become smaller and more invisible, as they embed themselves more deeply within our clothing and the objects of our affection, we're left looking through our technologies and into ourselves.

Ubiquity and wearability bring our technologies closer to the surface of our body, and sometimes even under our skin. Metaphorically we would say these technologies are drawing us clos-

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er to ourselves. Touchy subject? From our own bodies' skin, to the clothing that covers (and uncovers) it, to the buildings that our bodies move within and through, embedded technologies perforate[1] these protective layers and form a connective tissue within our ambient spaces.

Trends in bridging the interdisciplinary research methods evident in context-aware computing and computer-supported cooperative work (CSCW) are prototyping new ways to model the environment, its participants, their artifacts, and their interactions.

A growing number of research initiatives are exploring this domain. For example, there are ongoing projects at Simon Fraser University in the Whispers research group (http://whisper.surrey.sfu.ca/) and the Exhale project (http://www.siggraph.org/s2005/main.php?f=conference&p=etech&s=etech15), as well as the European Framework <Passepartout> project between Philips, Technische Universiteit Eindhoven (TU/e), Centrum voor Wiskunde en Informatica (CWI), and V2_lab in Holland.

I'm happy just to dance with you

Her pillow was listening to her thoughts. It could just tell she was second guessing herself again. Although this would have disappointed a lesser object of affection, her pillow just softened to it all …

One of the domain strengths of the Whispers research group is performance practice: creative methodologies used in dance, theatre, and somatics. *Somatics* is a term coined by philosopher Thomas Hanna in 1976 and is defined as the "experience from within the lived body."

The moving body can contribute its tacit, experiential, and first-person phenomenological knowledge as both experience used within the design of user models, and experience of the environment itself.

The common ground that exists between human–computer interaction and performance practice are techniques and protocols that articulate models of experience. These first-person methodologies reveal an under-theorized area of practice. Models of interaction and the experience of the user/performer is a shared starting point. Our emphasis is on building knowledge *within* the experience of the body, an area well defined within performance and somatics. Paul Dourish[2] invites methodological modeling as a critical next step.

Listen, do you want to know a secret?

Not knowing why, she suddenly sighed, and

Figure 1. Example of how sensors and conductive fabrics (soft cables) become constructive elements of garments.

began to gently weep, hugging her pillow even closer.

One of the major exploratory goals of experience modeling is the notion of paying attention to the self, and using this sense of self to connect to and exchange information or experiences with another. In our user modeling scenarios, we explore this ability to transfer this sense of self to another person or object. We use techniques for extending our bodily awareness through attention to breath and movement. We focus on our perception of our own physical data.

We can work it out

Her crazy pillow was in the mood for a fight, must have been the dream … with playful glee, it flung itself across the room … we'll see what tomorrow will bring …

Using body area networks (BANs) as a platform allows flexible exploration and prototyping of wearable applications. In our case, Bluetooth islands are physically independent—we can remove them from clothing or accessories, move them to other locations on the body, or even move them to other locations in close proximity to the body (such as a pet, furniture, or accessories that are left in the home or in the car).

We have explored numerous smart fabric technologies including soft cables for flexible design

Beatles Song Titles

Just as psychology and physiology research modes of affection, popular culture expresses this through creating songs and lyrics. In this article, the author uses Beatles' songs as examples of phrases we use to tell stories that express affection.

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Figure 2. Sensor and actuator electronics embedded within fabric enable explorations in garments as physically expressive devices.

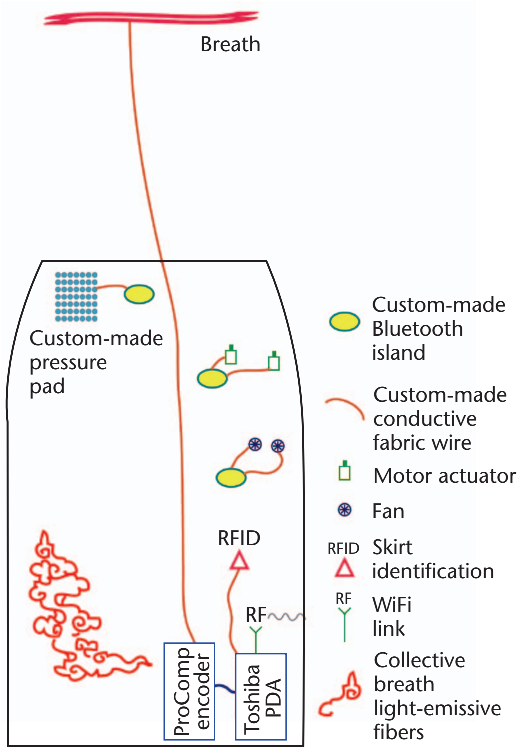

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Figure 3. Architecture of a sensor-enabled skirt.

and interaction (see Figures 1 and 2), and heuristics for gestural recognition that can be implemented in fabric technologies. The objective of this technical research is to identify current smart fabric textiles that are available in the context of flexible electronics and flexible displays. From there, we can develop our own heuristics of interaction through touch[3] and physiological input such as breath in order to embed this into a wireless network, capable of transferring data on the body, to other bodies in a public space.

Figure 3 illustrates one of our prototype architectures for a wearable garment network. Each garment (in this case, a set of eight skirts) in the network holds an embedded personal digital assistant and Smartphone (we're currently porting from Toshiba PDAs to Nokia Smartphones). Physiological data is transmitted via Bluetooth from Thought Technology's Procomp unit to the smart device in the skirt.

Small actuators such as cell phone motors, small fans, and tiny speakers embedded within the skirts' linings, respond in real time to the volume and rhythm of the breath. This creates a direct physical actuated response that is directly felt through the cell phone motor embedded in the waistband of the skirt. Small light-emissive fabric displays on the outside of the skirts also brighten and dim in response to the breath data. A person can transmit their body data from a tag in their skirt to another person's skirt through a touch mechanism using radio-frequency identification (RFID) tags embedded in the skirts. Participants can share physiological data through these mechanisms. The light emissive displays in the skirts are programmed to light and dim when two or more participants begin to breathe in concert with one another. Breath becomes an empathic input and response.

Oh, darling

She rolled out of bed, a little distressed, and stumbled through the dark, to retrieve her pillow on the other side of the room. "You're lucky I adore you," she muttered, as she fell into bed and drifted back into her dreams, the weight of her troubles falling effortlessly into the pillow ...

Clothing is expressive in what it reveals as well as what it hides. This acts as a mechanism for personal expression as well as a way to communicate with one another. In our ongoing exploration and design of garments embedded with wearable technologies, we explore the notion of intimacy that can be accessed and revealed through our own physiological data, the sharing of breath, and through the act of a touch or caress as interface to our own skin and the skin of our clothing.

At Simon Fraser University, we created these garments as sensuous textured skirts, with bands and sleeves made of silks and organza, natural fibers in earthy and vibrant tones (see an up-close example in Figure 2 and the overall clothing line in Figure 4). These parts of our clothing speak to each other, so that we can speak to ourselves. "Clothing is like a language's lining [and] language and clothing are intimate technologies indeed."

With the incorporation of the exploration of adaptive user modeling, we can highlight certain aspects of our own interactions. System memory brings a reflective ability and the concept of where the environment can reflect upon its own combined behaviors. The system can represent the concept of intentional acts (constructed through navigational choices enacted through gestural interaction or biometric behaviors, such as certain breath patterns).

Another concept that we can explore is the notion of persistent memory of qualitatively meaningful events in the lives of the artifacts or devices themselves. In the context of wearable garments, our skirts, our scarves, or our accessories can develop past lives exhibiting human behaviors of both memory and forgetting—where past events or interactions affect their future behavior both positively and negatively.

A device could also develop stubbornness or a quality of languidness based on its previous experiences within the system. This supports folkloric ideas of animism in objects and artifacts around us. Sociologists have shown us that these notions of animism enable greater degrees of intimacy and meaning to be created between people and artifacts, as well as between people and one another. For example, UK designers Fiona Raby and Anthony Dunn[4] have explored the notion of the placebo object, where objects were attributed with functions such as protection against electromagnetic fields, and where people developed close social bonds with these objects.

A specific example of this could include placing the object outside for light or fresh air, and then bringing it inside in the evenings for warmth and company. These more relational concepts about the nature of meaning that we attribute to our devices or artifacts are a rich and playful area for experience exploration in the context of interactive art.

There are many ways we can go about personifying our objects. In addition to some of the examples I've tried to show with the pillow in this article, our garments could also be affected by previous wearers or participants within the system. Artifacts such as accessories or devices (or even our pillows) could have moods, or be affected by our moods. They could exhibit selective memory, and other remembering and forgetting strategies that model human behavior more closely than they model computer memory characteristics. These behaviors bring us back to our synonyms for expressivity: the mobile, animated, communicative, open, easier to read, meaningful, and representative mechanism that suggests a kind of animism, and other life-giving behaviors. **MM**

Figure 4. Various forms of sensor-enabled clothing modeled at Siggraph 2005 in Los Angeles.

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Further Information

Can We Fall in Love with a Machine? is a new media art exhibition opening at the Wood Street Galleries in Pittsburgh in January 2006, curated by Murray Horne and Claudia Hart, and including interactive work by Thecla Schiphorst titled *Bodymaps*. For more information see http://www.woodstreetgalleries.org/.

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Breath, skin and clothing: Using wearable technologies as an interface into ourselves

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Abstract

There is a common ground that exists between the first person methodologies of performance practice and the technology research of Human–Computer Interaction (HCI). Exploring this common ground, this essay describes movement research based in performance and somatics and then applied to the design of digital networked interfaces for wearable technologies. The research is based on a body of knowledge practices from performance/somatics that operate 'from the inside out', using the experience of the moving body to construct knowledge. Within both performance practice and HCI, there is a need to construct models of the user's experience. One of the key questions this paper asks is: How can we bridge specific domain knowledge within performance practice to transform design strategies for our new technologies? The first section provides a theoretical context for bridging embodied practices from performance to HCI, and looks at (1) how performance methodologies can be used as a model for experience, (2) applying existing design concepts for creating gestural movement vocabularies in interaction, and (3) developing methods that bridge from experience to experience modeling. The second section provides a design context through the description of the development of the interactive wearable technology art piece entitled exhale, an installation that illustrates how first person methodologies of performance can be used to inform the design of digital interfaces/interactive clothing within an experiential environment.

Keywords

wearable technologies
digital network interface
human–computer interaction
embodied computing
contextual performance practices

> Not only can we be aware of each part of our physical self, we can be aware with each part of our physical self. This leads to a very intimate, almost microscopic experience which is the self.
>
> (Cohen 1994)
>
> Clothing is peculiar in the sense that it conceals in its very conspicuousness and reveals what it appears to hide.
>
> (Guedon 2002)

Theoretical context – bridging embodied practices from performance to HCI

I am interested in accounting for experience as a practice based function of accessing and constructing knowledge, as it is defined within performance practice. When I make the statement that experience accesses and constructs knowledge, I am speaking specifically of the subset of knowledge that can be experienced by our body/mind, and that is constructed through experiential and embodied practice. I am gathering shared evidence within *human–computer interaction* (HCI), and performance (somatics) that supports this view of experience, where experience constructs a way of understanding, and of creating knowledge in practice, while framing this within the greater field of HCI as well as performance.

There is a common ground that exists between the domains of HCI and performance practice. I refer to this shared ground as first person methodologies: techniques and protocols that articulate models of experience. It is precisely the differing frames of reference between the domains that can reveal an under-theorized area of practice. The need to have models of interaction used to design the experience of the 'user'/'performer' can be seen to be one such shared starting point that is framed through differing methodological strategies. How is interaction conceived, constructed and integrated within a design process? What are the underlying assumptions that differ between these domains?

Performance methodologies: A model for experience

I explore interaction as a space of lived experience and enactment, as something that is simultaneously inter-body and intra-body. Specifically, I explore human–computer interaction – defined by *human* experience in which action and meaning are inseparable – as a model for developing relational human–computer interaction systems.

Within the field of HCI, Dourish (2001) lays a strong argument for a foundation in HCI that validates the notion of an embodied interaction. The need to augment abstract reasoning and objective meaning with practical action and everyday experience is central to this approach. Dourish notes that his contribution is foundational, rather than methodological, which opens opportunities for methodological modelling and testing as a critical next step in the development of this area.

Suchman's (1987) ethnographic research, which views all activity as situated and embodied, and her interest in purposeful, intentional activity, alongside Nardi's (2001) work in constructing a 'theory of practice' within HCI based on the development of activity theory and intimacy between human and machine constructed through intense relational concentration, provide strong bridging links to our work.

Designing gestural movement vocabularies

What are the properties of a gestural movement vocabulary? In Activity Theory, Nardi (2001) illustrates the notion of a 'function organ' – a transforming bond with an artefact. A photograph depicts a child listening intently to the radio; the expression of intense concentration suggests the creation of a relation between body and object. In dance and theatre the gesture itself can also become a 'function organ', an artefact that creates or enacts a transforming bond between the participant and their own movement. In this way, we think of the gesture *itself* as a function organ: an artefact that creates affordances for interaction.

The design of specific gestures that can become enactors is a notion common to theatre and dance practice. Richard Schechner (1985) uses the term *restoration of behaviour*, to describe gesture as 'material'. Restored behaviour is organized as sequences of events, scripted actions or scored movements. He refers to these as strips of behaviour, and states that a restored behaviour, although 'originating from a process, used in the process of rehearsal to make a new process, or performance, the strips of behaviour are not themselves process but things, items, *material*' (Schechner 1985: 35). This concept of gesture as source 'material' for designing interaction models is central to our work.

Augusto Boal states that 'bodily movement is a thought, and a thought expresses itself in corporeal form' (Boal 1992: 61). Boal's *arsenal of theatre* can be used to re-enact, or re-materialize the body state that accesses or indexes that thought or 'thought-unity'. Grotowski refers to an acting score as a script for designing *point of contact* or connection (Schechner and Hoffman 1997). In Interaction Design this is the equivalent of interaction schemas, which are navigated in order to construct the instantiation of the interactive experience. Grotowski speaks to the necessity of scripting gestural sequences in order to construct connection schema: 'What is an acting score? The acting score is the elements of contact. To take and give the reactions and impulses of contact. If you fix these, then you will have fixed all the context of your associations. Without a fixed score a work of mature art cannot exist' (Schechner and Hoffman 1997: 54, 55).

We suggest using gesture as a 'function organ', as a mechanism that can assist in defining properties for a scripted interaction score. These gestural function organs have the goal of paralleling processes to construct Grotowski's concept of mature art: works of 'mature interaction' (Schechner and Hoffman 1997: 55).

From experience to experience modelling

What do we mean by experience modelling? By bridging domains of performance practice with HCI, we are focusing on an area of enacted cognition: the *enactment* of descriptors, or schemas for movement. Previous research in the use of exploring experience/performance methods within the HCI community has occurred in the domain of user-centred and participatory design (Forlizzi and Ford 2000: 419–423). This has included: *experience prototyping* that fosters an 'empathetic' and 'embodiment' approach to user-centred and scenario-based design (Buchenau and Suri 2001: 424–433; Burns et al. 1994: 119, 120). Interval Research's exploration of *informance*: informative performance and *bodystorming*: physically situated brainstorming, *repping*: re-enacting everyday people's performances, and explorations of how low-tech solutions can create a design environment that focuses on the design question rather than the tools and techniques (Burns et al. 1994: 119, 120; Scaife et al. 1997: 343–350). Salvador and Howells (1998) shifted the focus group methods to something they called Focus Troupe: a method of using drama to create common context for new product concept end-user evaluations. Simsarian (2003) has explored the use of role-play in extending the richness of the design process. In the *Faraway* project, Andersen, Jacobs, and Polazzi (2003) explored story telling and 'suspension of disbelief' within a context of game and play in a design context. In addition, exploring other subjective aspects of creative process, such as the use of creating ambiguity in design, has been described by Gaver, Beaver, and Benford (2003).

In the performance domain, dance analysis and somatics specifically construct systematic articulated movement models directly from the *experience* of the moving body. Somatics is defined as the *experience from within the lived body* and includes practices such as Feldenkrais and Alexander technique. From the somatics perspective, knowledge is constructed *through* experience (Hanna 1988; Johnson 1995) and requires that experience be directed or focused through *awareness*. Experience alone is not a pre-cursor to knowledge acquisition, since experience alone could result merely in conditioning, or in accessing conditioned responses. In somatics this would be termed 'somatic amnesia'. However, when experience is specifically directed through the focus of attention, knowledge acquisition takes place which can be referred to as 'Somatic learning', an activity expanding the range of what Hanna terms 'volitional attention' (1979: 137–152). While Csikszentmihaly (1990) suggests that human experience operates within a limited field of attention, other movement systems within somatics consider attention to be a generative attribute of awareness that can be augmented, increased through a process of somatic learning (Hanna 1988).

Rudolf Laban's movement analysis systems (Laban 1974; Newlove 1993), and the work of other researchers such as Bartenieff (1980) and Blom and Chaplin (1982), are examples of gestural typologies based in experiential practices of dance (Schiphorst 1997: 79–98; Schiphorst et al. 1990: 167–174), which model a range of qualities and modes of movement. These typologies can be used for gestural mapping and modelling qualitative movement characteristics such as intentionality, interest, attention and body state. They present potential experience models for the classification of aspects of movement, and define a means to approach gestural and choreographic protocols.

Participatory design, experience design, performance, theatre, dance and somatics share a common focus in modelling or representing human experience. These domains also share the ability to articulate and explore engaging experience through movement, emotional response, sensorial qualities and temporal/dynamic qualities of experience and of movement.

A design context example – *exhale*

In this second section, I use an example of an interactive installation, *exhale*, that has been designed based on principles outlined above. In *exhale*, the experience of breath, interaction through movement and touch, and the experience of 'wearing' one's own physiological data was a design intention.

Exhale is an interactive art installation based on designing and fabricating 'a-wearable' body networks for public, social space. The term 'a-wearable' is used to refer to a synthesis of 'wearing' clothing that uses attention to afford 'awareness' of the self. In *exhale* networked group breath is used as an interface for interaction. The rhythm of breath is a mechanism for sharing our bodies' affective non-verbal data. This occurs through responses in the linings of skirts worn by the participants. Networked breath is used to create output patterns through small fans, vibrators and speakers that are embedded in the lining of these sensually evocative skirts. This response enables a hidden and 'inner' one-to-one communication between bodies in the installation, so that one body's breathing can directly affect another body's skirt. At the same time, collective group-breath is made visible on the *exterior* layers of fabric on the skirts by using a specialized fabric printing technique that enables certain fibres to 'light up' in a continuous cycle according to collective breath rhythm. Breath bands wrapped around the chest measure the ebb and flow of the breath cycle. As clothing, and as a type of costuming, the skirts of *exhale* cross our gendered modes of 'wear-ability', and are able to 'contain' both inner and outer senses of self. *Exhale* interaction enables an expression of collective group empathy through the use of breath. This artwork integrates somatics and gestural interaction with textiles and garment design, developing new communication metaphors for wearable technologies and wireless networks. *Exhale* premiered at the Emerging Technologies exhibition in Los Angeles at SIGGRAPH (August 2005).

This description is organized into the following components: experience, artistic concept, interaction and technical description. Together, these sections address various aspects of creation, production and working method:

1. how the public will ***experience*** the installation as they approach, enter and interact within it;
2. what is the ***artistic concept*** that supports that experience, and unifies the concept of *breath* as a starting point, and the concept of *wearing ourselves* through garments, clothing or costume;
3. how the ***interaction*** enables *group breath* to be expressed through the garments, and how interaction utilizes modes of self-to-self, self-to-other and self-to group communication;
4. how the piece is ***technically designed*** and constructed in order to support the artistic concept and participant experience.

Exhale experience scenario

Participants walk towards the darkened space, becoming aware of eight textured and sensual garments: skirts made of silks, and organza, natural fibres in earthy and vibrant tones, hanging from cables stretched from ceiling to floor. The visual image is a small forest of 'skirt trees': skirts suspended at various heights in space, connected to vertical cables dropping in plumb lines to the earth. A light positioned at the base of each skirt illuminates it upward from below, highlighting and bringing light to its materiality (Figure 1).

Guides assist the participant in 'dressing': putting on the skirt and wrapping the breath sensor around the rib cage, a process that occurs behind a draped area. Once outside the dressing area, a Polaroid image of that participant is taken by the guide and placed in a small bag that is also attached to the vertical cable. These small 'purses' have see-through front pouches that enable the image of the wearer to be left in the space, as a memory of the skirt, and as a mechanism to bring the skirt back to its home, once the participant's experience is complete.

As a participant moves through the space, consciously shifting their own breathing cycle, they create three kinds of interactions: the interactions of self-to-self, self-to-other and self-to-group: wirelessly communicating and creating a shared breath state. And as the lining of each skirt 'breathes' with the participants, the small fans and vibrators respond to the breath beneath the lining unseen to others; the small speaker within the skirt marks the sounds of the breath data creating a body network that tickles and caresses and whispers from within. Collective group breath acts like moving dimmers, slowing lighting up, and then dimming fibres on the outside of the skirts, following the pattern of matched breath patterns. These fibres only light up when participants breathe in the same pattern as one another.

Initially, the guide shows the participant how to actuate the small vibrators and fans in the lining of the skirt based on their own breath: the interaction of self-to-self. Once the participant experiences and understands his or her own relationship to self-data, the guide invites them to share their data with other participants in the space. Sharing data occurs through

Figure 1: Exhale *uses a 'forest of skirt trees' suspended floor to ceiling by cables.*

touch sensitive conductive fabric strips sewn within the side linings of the skirts: the interaction of self-to-other. Participants can stroke or caress another skirt creating a shared data space between skirts. Multiple participants can create shared connections through touch. Once contact with another participant is made, the actuators within the skirt lining move in relation to the connected participants. Participants navigate the sharing of their own data through caress. Therefore, a participant's experience, based on the actuators sewn within the linings of the skirts, can move from their own data, to another's data, to a group of data. When any two participants breathe using the same breath pattern, the 'light fibres' sewn onto the outside of the skirts light up in the same pattern as the breath: the interaction of self-to-group. When all participants breathe in the same cycle, the breath fibres slowly ebb and flow with the group breath within the installation.

Artistic concept – breath, skin and clothing

The artistic concept of *exhale* is in its most essential form: 'to wear our breath', as a mechanism for redirecting our attention to our own body states, individually, and between bodies in a space, creating a group ecology through its breath. In *exhale* the breath is contained within the body, and also is *worn* on the body, shared through the garments and the garments response in a group-body, a group-breath. This cycle of inside and outside forms the modes of representation selected for this wearable art installation.

:: breath ::

> . . . the work with breathing starts with sensing the inner atmosphere of our organism—the basic [. . .] stance we take to ourselves and the world.
>
> (Lewis 1997: 45)

> So it all ends, in wordlessness. . . Yet, something forms within the world of my tears, shaped by the world that caused it; something takes shape within this uttered breath that builds an image of breath.
>
> (Goyen 1999: 41)

Breath reflects a state of rhythm and intention *as we wear ourselves*. This concept of breath as a starting point, as a marker for representation, and as an *input* to be mapped through navigation, selection and interaction allows us to use breath as a metaphor for synchronizing and coordinating: that is, giving and receiving data. Breath is a source of information, as well as a pattern in which to communicate that information. Our bodies' respiratory system is connected to most of the body's sensory nerves; so that any sudden or chronic stimulation coming through any of the senses can have an immediate impact on the force or speed of our breath, or can stop it altogether. Intense beauty, for example can 'take our breath away'; fear 'stops us in our tracks'; deep contentment is often accompanied by fuller, more languid and more rhythmically even and connected breathing.

We can – within limits – intentionally hold our breath, lengthen or reduce our inhalation and exhalation, breathe more deeply, and so on.

When we do so, the nerve impulses generated in the central cortex as a result of our intention bypass the respiratory center and travel down the same path used for voluntary muscle controls. Breathing is both autonomous and conscious, and can move between these two physical control systems of the body. The process of exhaling is a process of release and letting go: 70% of the body's waste products are eliminated through the lungs through the respiration cycle.

Breathing in concert with another is a physical way to synchronize with another's body state, enabling a sharing of internal state, represented through multiple physiological signals, and synchronized through attention. At times of physical duress such as death, illness, distress, and also states of intimacy, human bodies instinctually connect with another through synchronizing breath, either consciously or unconsciously. This can be seen in the work of mid-wives and labour-coaches during birthing; sports coaches during high performance physical training; in meditation techniques that calm and quiet the body; in the work of pain therapists that use attention to re-direct the body's proprioceptive state. Instinctively small children will synchronize breath to give or receive information with a parent or loved one, often in the form of feeling tone or 'feeling state' information.

Neurophysiologist António Damásio has studied the connection of 'feeling states' in the body and asserts that a given feeling state is associated with specific physiological patterns (such as breath rhythm) along with a set of processes including thought patterns and emotion (Damásio 2003: 112-33). His research suggests that these 'feeling' body-states are an inter-connected set of feeling, thought, emotion and physiological functioning: each of these being present and affecting the other. He asserts that the induction of a body-state can be brought about through attention to *any* one of the inter-connected patterns: so that attention to physiological patterning (for example breath) can induce a body state, or conversely, attention to another associated patterns, such as the occurrence of certain thought patterns can also induce the body state. This inter-connectedness between physical data, and the state of the body creates a complex but coherent set of body-data.

What does this mean in the context of this art-work? Using Damásio's notion of body-state allows us to start from a physiological pattern of the body, such as breath, as an access point to contacting and sharing state data between bodies. We synchronize breath in order to align communication non-verbally. Synchronizing breath enables a tuning of the natural and proprioceptive systems of the body, as breath is both autonomous and consciously controlled. Poetically, breath has been attributed to notions of life-force, or the presence of life in non-organic objects. In William Goyen's novel, *The House of Breath*, memories of a house from childhood are attributed with breath, and the notion of intention, thought and breathing as being one and the same:

> Through the mist that lay between us it seemed that the house was built of the most fragile web of breath and I had blown it – and that with my breath I could blow it all away.
>
> (Goyen 1999: 181)

The beauty of this poeticism is that it is also echoed in concepts occurring in fields as diverse as neuroscience (Damásio's neurophysiological assertions of body-state and body-maps), and Yogic teachings of Pranayama and the Science of Breath, where breath, thought and intention are also seen to form a coherent union.

Figure 2: Exhale *breathband measures breath, while RFID tag enables breath exchange.*

:: wearing ourselves ::

Another important artistic concept in *exhale* is the concept of *wearing ourselves*. In *exhale* we *literally* wear ourselves through our breath. The breath-band adorns the rib-cage, creating a physical holding and wrapping, a sensual and safe and felt textured cut of fabric, as it simultaneously *captures* our breath, our data. We *reveal* our breath through the properties of the cloth itself in the form of the skirts, our breath is revealed as it shimmers in light and dims with each exhale on the fibres of the fabric. Our clothing expresses properties of adornment, revealing, concealing, sensuality, pleasure, intimacy and containment (Figure 2).

One of the artistic goals is to develop an interface for expressive non-verbal interaction in the context of a wearable or ubiquitous environment. Ubiquity and wear-ability bring our technologies closer to the surface of our body, and sometimes even under our skin. Metaphorically we would say these technologies are drawing [us] closer to ourselves. And while they draw closer, they also allow us to move. Mobile technologies recognize that people move and are moving; and mobility sustains movement, allowing people to move themselves with their environments, and within their environments.

Our colloquial language uses phrases such as 'she wears herself well', 'he wore a smile', and the almost cliché and well-rendered phrase 'I am wearing my heart on my sleeve'. These phrases point to ways in which the body has its own tendency to *reveal* inner states, intimate and personal aspects of the self, often affective, feeling states, through the concept of *wearing the self*. To wear the self is the body's way of communicating its own knowledge and being. In *exhale*, we ask the question: how can the body itself contribute its tacit, experiential and first-person phenomenological knowledge as both experience used within the design of wearable interaction, and experience of the environment itself? We explore the use of smart fabrics and interactive textiles, which integrate flexible electronics and flexible displays as an interface in wearable computing garments that express *ways of wearing the self*.

Exhale **interaction**

Interaction within *exhale* is comprised of three interaction modes: (1) self-to-self, (2) self-to-other and (3) self-to-group interaction. The interaction mode determines which participant's breath data is actuating responses inside the lining of any given skirt. Participants are able to choose, to select and to switch interaction modes. Interaction modes are selected through *touching* or *caressing* specially designed fabric panels that are sewn into the skirts. These fabric panels recognize qualitative aspects of the touch gesture and direct the breath data to the actuators within the participant's own skirt, or to another participant's skirt. The third category of interaction: self-to-group is created when participants are breathing in concert with one another, and is not selected through touch.

:: input ::

Breath is used as the *input* interaction in all three modes. Breath is measured using a breath band which is wrapped around the chest area, around the clothing, and which measures the contraction and expansion of the rib cage. These images (Figure 3) illustrate some initial prototype tests with conductive fabric; however, they do not reflect the final breath band design. Prototyping fabric swatches, such as those show here, allows the testing of functionality alongside the potential experience of the texture and 'feeling' of the fabric, the result of the experience, and the technological configurations necessary to create the whole set of interactions.

:: output ::

The *output* or response to breath data depends upon the interaction mode. When the participant first puts on the skirt they are in self-to-self interaction

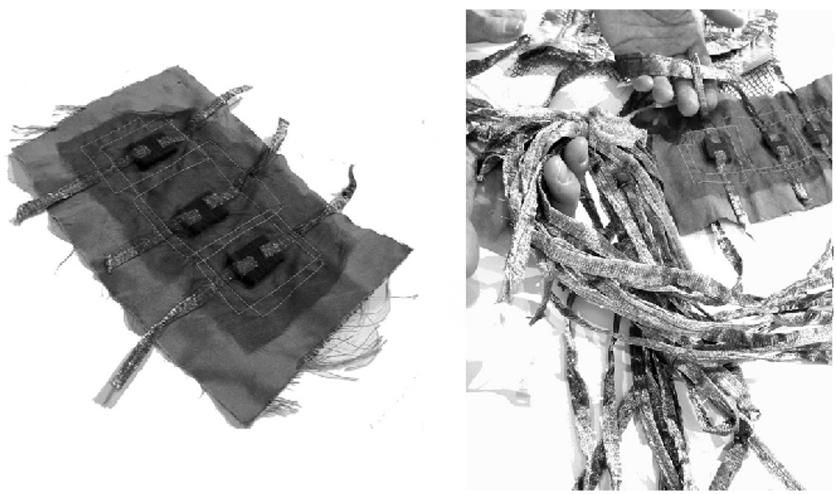

Figure 3: Prototyping conductive fabric for touch and as passive conductor.

mode. In this mode the ebb and flow of their breath data creates responses in the linings of their own skirts. Each skirt has small *vibrators, fans and speakers built into the linings*. As the participant breathes, the data patterns (speed and intensity) of the vibrators and the fans ebb and flow in response to the participant's breath rhythm.

A second kind of output is used with the self-to-group interaction mode, also called collective breath interaction. This mode is enacted when participants within the installation breathe in the same tempo pattern as one another. When this occurs, the output for group interaction is the display of collective breath on specially designed fibres on the surface of the skirt fabric. These fibres are imprinted with a specially designed nano-inkjet technology, which creates a conductive and light emissive surface that can display variable light levels depending upon the ebb and flow of the breath data that is used to control the pattern of the light (Figure 4).

Figure 4: LED array embedded within fabric to display continuous breath data.

:: selecting modes through touch ::

The interaction modes of self-to-self and self-to-other are selected through touch on custom designed touch RFID pads embedded into the fabric of the skirts (see Figure 2). These touch pads recognize qualitative aspects of movement. A softer caress selects data from another skirt and outputs it inside the lining of the participant who is 'pulling' the breath toward them. A harder directed 'pushing' caress sends the data from the participant's skirt to the partner's lining. Participants can reselect their own breath data by caressing their own skirt. These touch pads are specially designed using heuristics described in the technical section below.

Exhale technical description

In order to implement our higher-level goal of developing expressive non-verbal interaction that brings awareness to the body's states in the context of a wearable or ubiquitous environment, we ask two questions: how can we model the environment, its participants, their artefacts and their interactions to enable the goal of expressive non-verbal interaction in the context of a wearable environment? And how can the moving body itself contribute its tacit, experiential and first-person phenomenological knowledge as both experience used within the design of the model, and experience of the environment itself? The first question moves from the outside inward, and the second moves from the inside out; the first we answer through our technical research goals, and the second, through our artistic inquiry and creation.

The objectives of the technical research in *exhale* is to identify current smart fabric textiles that are available in the context of flexible electronics and flexible displays and to develop our own heuristics of interaction through touch and breath in order to build this into a wireless network, capable of transferring data on the body, to other bodies in a public space. We call our touch selection input 'threads of recognition' because it refers to metaphors of input recognition in the context of smart textiles research. We are working on developing a wearable platform based on a body area network that utilizes Bluetooth on the body, in combination with custom made hardware, running on a Toshiba PDA platform.

An *exhale* skirt is a custom-made garment with electronics embedded within it to form a sensor and communication system that can exchange physiological signals and responses with another *exhale* skirt.

Each skirt has a small portable computer, or PDA, that coordinates and interprets the data communication. Along with the PDA, there are several very small computers that control embedded transducers – fans and vibrating motors – and that are mounted on individual circuit boards, called 'islands'. These 'islands' interact with the PDA via a Personal Area Network, or PAN, constructed using Bluetooth technology.

Connections that cannot be made wirelessly are made using conductive fabric 'wires' which are composed of a transparent directionally conductive fabric contained in a non-conductive fabric or sewn directly into the skirt to form portions of the skirt itself. There is also a pressure-sensitive pad area, constructed of the conductive fabric wires, connected to one of the Bluetooth 'islands', to provide touch-based gesture data. The PDA has two specialized devices attached to it as well: an encoder that converts the analogue electrical signals from a breath sensor into digital format, and an RFID sensor that is used to identify nearby skirts via small disks sewn into each skirt. The breath sensor is an adjustable, stretchable band worn about the chest that generates an electrical signal on each exhalation and inhalation. This signal is conveyed to the PDA via the encoder, where it is analyzed and then transmitted to a central system, along with information on which *exhale* skirts are near to this skirt as well as any gestures reported from the pressure-sensitive pad.

The central system routes the analyzed signals to other *exhale* skirts, based on the 'neighbourhood' information that has been gathered. At the same time, the breath signals from groups of skirts are gathered together and analyzed; this collective breath is then sent back to the skirts within the group, and displayed on each skirt as a pattern of light using special light-emissive fibres controlled by the PDA. The PDAs also activate their fans and vibrating motors, using their Bluetooth 'islands', when the gesture or breath data matches their criteria.

The central system converts the data obtained from the skirts – the physiological data, the RFID data and the pressure pad data – into a visible

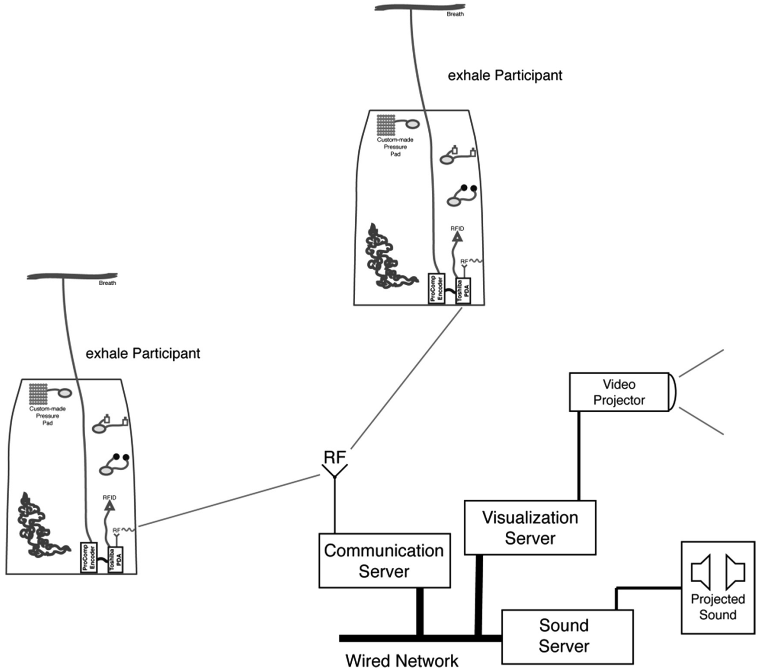

Figure 5: (a) Networked interaction in exhale*. (b) Optional (made available by author): Technical implementation of body area network (BAN) in an* exhale *skirt.*

and audible representation of the state of the installation space and its participants. A video projection system and multiple speakers are used to convey this representation to the participants within the space (Figure 5).

Conclusion

This essay illustrates how we can augment experience design with first person performance methodologies found in theatre, dance and somatics. *Exhale* is an example in designing and testing experience models based in this strategy. The differing frames of reference between the domains of HCI and performance practice reveal an under-theorized area of practice, which can be explored through experience modelling. Embodied interaction is a reflective process that is simultaneously inter-body and intra-body. In addition, this essay has provided a case-study for a model of designing embodied interaction by applying the use of gesture as a 'function organ', as a mechanism that can assist in defining properties for an interaction score that Grotowski describes as scripts, or *points of contact*. The experience with the *exhale* installation illustrates that participants can learn to shift their own threshold of attention, awareness and body-state through the interaction affordances created within movement and embedded within the garment. They participate in becoming expert users of their own physiological data, and in playfully engaging with an emerging co-operative and physically and emotionally negotiated body state and collective system state. Social navigation is created through the perceived data flow (through the interaction with RFID tags in exchanging breath) and represented through the actual data flow (through the server). As such the installation is also its own experience workshop, and is a starting point to continue to explore methodologies of experience modelling.

As an installation, *exhale* was an initial exploration of modelling experience through a variety of gestural protocols that led to the design of an interaction language facilitated by wearable garments. This work is a starting point to mapping more complex data relationships to body state and intention. The *exhale* installation illustrates that participants can become playfully engaged in simple feedback loops of 'attending to' their breath, and sharing that data with others in the space. *Exhale* also points to next steps in research: exploring mapping and 'meaning' in data patterns across participants body state, extending types of physiological data (brain waves, GSR, temperature), types of output actuators (vibration, local sound, local motor memory), as well as building an intelligent model of interaction which includes memory, resonance and meaning in the devices themselves. This kind of work that integrates performance practices as a design strategy in wearable garments and technologies continues to model experience through deepening first person methodologies. And as the Digital Cultures Lab at Nottingham exemplified, such methodologies and communities of practice also require cross-cultural workshop spaces that can enable and iterate the practice itself through shared experience and reflection with other artists and practitioners.

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She is the recipient of the 1998 PetroCanada award in New Media awarded biennially to a Canadian artist, by the Canada Council for the Arts. Her media art installations have been exhibited internationally in Europe, Canada, the United States and Asia. She has an interdisciplinary MA in computer compositional systems [dance and computer graphics] from Simon Fraser University and is receiving her PhD (Fall 2006), in the School of Computing at the University of Plymouth. Contact: School of Interactive Arts and Technology, Simon Fraser University, Surrey BC, V3T 5X3, Canada. http://whisper.iat.sfu.ca
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exhale: (breath between bodies)

ARTIST STATEMENT

The artistic concept of the piece exhale is in its most essential form: "to wear our breath," as a mechanism for redirecting our attention to our own body states, individually and between bodies in a space, creating a group ecology through its breath. In exhale, the breath is contained within the body, and also is worn on the body, shared through the garments and the garments response in a group-body, a group-breath. This cycle of inside and outside forms the modes of representation selected for this wearable art installation.

exhale is a whisper[s] research group project based on designing and fabricating "a-wearable" body networks for public spaces. The rhythm of networked group breath is used as an interface for interaction and a mechanism for sharing our bodies' affective non-verbal data. We use the networked breath of the participants within the system to actuate the responses of small fans, vibrators, and speakers that are embedded in the lining of sensually evocative skirts worn close to the body. This work integrates gestural interaction with fashion, developing new communication metaphors for wearable technologies network design.

Art and Science

This work embodies the confluence of artistic design and expression with software and hardware technology. The whisper[s] research group combines backgrounds in fabric and garment design, choreography, and complex software systems, including both hardware and software architectures. The resulting work was influenced by their practices with modeling experience studies, networked micro-controllers, and real-time systems. It applies tools from choreography, such as Laban Effort/Shape Analysis, along with linguistic and statistical analysis, to investigate the physiological data that the work utilizes. The garments employ conductive fabric, shaped equally by the needs of the electronic elements and the design aesthetics. Placement and organization of the sensors and transducers is guided by body ergonomics, bio-energy systems, and interface design. Movement analysis is used to frame gestural interaction, creating playful, intimate connections between participants.

Vision

In this work, garments are a step in a progression to systems that transparently exchange and express internal body state and intention via participant-mediated communication, mixing physiology-derived information with gestures and other non-verbal mechanisms. Concepts of device "listening" and biofeedback enable what we term subtle machine learning. The garments provide an environment in which we can augment verbal and visual modes of communication, where the quality of a gesture can replace many words, and can be exchanged with their affects as well as their effects through out-of-band pathways.

Experience

Participants walk towards the darkened space, becoming aware of eight textured and sensual garments: skirts made of silks and organza, natural fibers in earthy and vibrant tones, hanging from cables stretched from ceiling to floor. The visual image is a small forest of "skirt trees": skirts suspended at various heights in space, connected to vertical cables dropping in plumb lines to the earth. A light positioned at the base of each skirt illuminates it upward from below, highlighting and bringing light to its materiality. Guides assist the participant in putting on the skirt and wrapping the breath sensor around the rib cage. As participants move through the space, consciously shifting their own breathing cycles, they create the interactions of self to self, self to other, and self to group: wirelessly communicating and creating a shared breath state. And as the lining of each skirt "breathes" with the participants, the small fans and vibrators respond to the breath beneath the lining unseen to others; the small speaker within the skirt marks the sounds of the breath data, creating a body network that tickles and caresses and whispers from within.

Innovation

The core technical innovation of exhale: (breath between bodies) is integration of non-verbal models of network communication in a playful multi-modal environment, using layers of directionally conductive fabric to provide both electronic pathways within the garment systems and a sensual tactile experience for participants. Connections between participants are realized through specialized electronics and embodied through acts of physical contact, designed using gestural models for interaction.

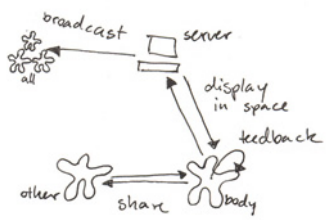
The fabric that forms the conductive layers within the garment has electrical behavior due to its construction as a combination of very fine silver or gold wire with traditional materials such as silk. This conductive fabric is used as a replacement for conventional wiring, which is much heavier and less flexible. It is also used to form simple touch or pressure sensors, via contact between layers, and identification patches, using isolated fabric regions that include devices that have unique electronic signatures. Touch zones on the garment (or another garment) can make contact with these isolated regions, and the signature can be "read" to establish self-to-self, self-to-other, and self-to-group connections.

Acknowledgements

the whisper[s] research group: Susan Kozel, Sang Mah, Gretchen Elsner, Robb Lovell, Diana Burgoyne, Norm Jaffe, Jan Erkku, Calvin Chow, Camille Baker, Lars Wilke, Adam Marston; Industry Contributors: Thought Technology, Tactex Inc, Credo-Interactive; Sponsors: Heritage Canada, Canada Council for the Arts, B.C. Arts Council, Savage Media, CFI, I-Lab at SFU, and Shadbolt Centre for the Arts.

exhale: (breath between bodies)
Art installation

(aRt&D)



soft, softer and softly:

[whispering] between the lines

soft, softer and softly: [whispering] between the lines

by Thecla Schiphorst,
the whispers research group
School of Interactive Arts and Technology
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CONCEPTUAL FRAMING

This paper describes some trajectories of the artistic research and development for the whisper project, an art research project that was developed in collaboration with v2 lab from 2002 to 2003. The concept of *softly* developing art research through embodiment strategies and techniques is borrowed from first person methodologies as defined within somatics. In this essay we look at the role of r+d, the research and devising process within our art research.

Our project name, whisper, is an acronym for **w**earable **| h**andheld **| i**ntimate **| s**ensory **| p**ersonal **| e**xpectant **| r**esponse **| s**ystem. The research of *whisper* is based on wearable body architectures, extrapolated as small wearable devices, embedded within garments, worn close to skin: proximity creating resonance, contact and communication, body as carrier to device, device as devising the body.

The whispers research group is a collective made of dancers, choreographers, software engineers, hardware engineers, interaction designers, fashion designers, media artists, sound designers, and computer scientists based in the Interactivity Lab at the School of Interactive Arts and Technology at Simon Fraser University. With a research team of over a dozen individuals, one size does not fit all. whispers builds art research through techniques of body. But what does this mean? Does this ‘work’? As we ask these questions through our work … softly, softer, whispering, shouting, weeping, dissolving, re-emerging our strategies, technologies and techniques, re-constructing our selves and each other, we make and re-make our work, our aRt+d.

How? Our art research re-appropriates usefulness, user and usability, re-inventing usefulness in terms of relationship to the self. One can perhaps even refer to this as a form of hyper-subjectivity "a process of de-hypnotizing…. this depends upon avoiding external suggestion and becoming independent of anything which is not internal." [1] A hyper-subjectivity that may produce engineering outcomes, but that shares methodological strategies with first person techniques of physical practice.

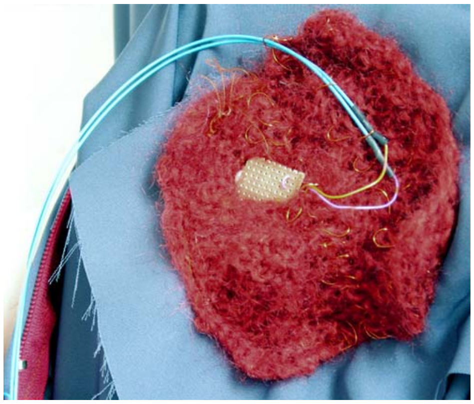
In our own art research we create and *name* outcomes that include delicate hardware, biodegradable software, softer firmware, tough love, bio-kinesiology for textiles, energy work for circuits, and 'circuit-training' for dancers. Within this collection of essays, the headings of embodiment, interface and technique distinguish trajectories of art research. And although the whisper research deals very much with art as interface, it does so through developing techniques of *body* interface, creating a synthesis of art research that weaves body, interface and technique as a threaded research question.

The title of this essay *soft, softer and softly: whispering between the lines'*, refers to methods of embodiment that extend through the body, softening the edges between our selves, each other, our methodology, and our materials: hardware, software, textiles, objectiles, and the sensual smudging, messing and pleasure, exotic and abject that exists between the lines. *Soft, softer and softly* also refers to drawing attention, and paying attention to ourselves within our processes, observing ourselves observing, in hyper-reflexivity.

We also explicitly reference building somatic practices between the 'lines' of software code, as well as between the lines of our own rhetoric. We call these somatic practices *first person methodologies*. Somatics is a term applied to a physically based research discipline, named and developed during the twentieth century in Europe and America by Thomas Hanna [5]. Somatics studies the living body as perceived from within first-person perception, from within its experience of itself. And the soma as internally perceived incorporates a viewpoint that includes immediate proprioception.

First person methodologies as defined and used within performance practice and somatics share a common set of features. They exist as a set of rigorous, definable physical processes or techniques that can be *learned*, and produce *repeatable* results. They are based on the direction of *attention* in order to affect, alter or produce *body state*. It is possible to retrain perception utilizing directed attention that is produced through the application of directed movement, gesture or action, through *intention* in the body. First person methodologies *access* and *construct knowledge* through the body. They are simultaneously epistemological and ontological, creating *knowing* through *being.*

Our research methods attempt to subvert and destabilize traditional software and hardware engineering, as well as traditional physical engineering, the bodies of technology. This destabilization loosens, and softens, releases previous boundary conditions, problematizing technical processes (body, code, method, memory). In order to design our circuits, living as they do alongside the electromagnetic energy of the body, traditional electrical engineering employs techniques that 'retro-fit' our selves. Are we retro-fitting our bodies into our technologies, or reverse engineering the self to map the 'shortening circuit'? Is there a radical re-invention of engineering that can create a longer exhale in the design life cycle?



In order to bridge this perspective within our research, we have created a curiosity cabinet of methodologies for the creation of physical, technological, kinesthetic & affective vocabularies.

METHODOLICAL FRAMING

Our methodological framing is something we call experience modeling. We were interested in creating gestural protocols for the interaction model used in our wearable body architectures. Since we were interested in using data 'of the body' to model or map the space of body state, we used physiological data of the body as data source.

One of our methodological approaches was to create experience *workshops* as a way to imagine communication protocols between bodies. In other words, we designed our hardware and software networks by exploring experience itself, utilizing the workshop as a model for the hardware, software and network architectures.

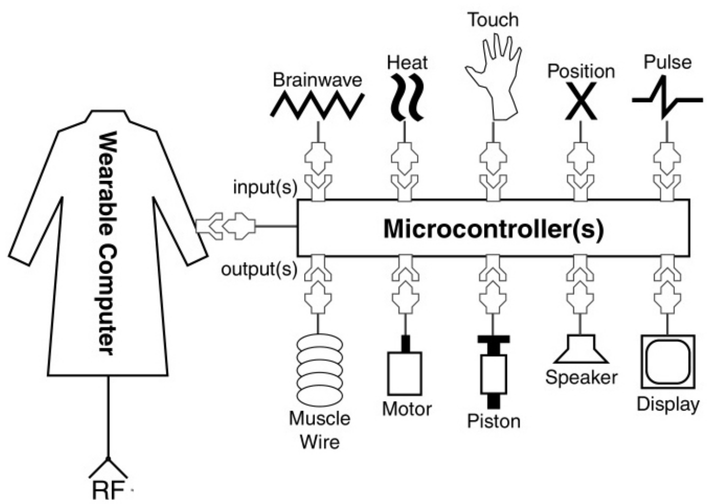
A series of user-experience workshops were designed with the goal of developing an interaction model for the network. These workshops modeled levels of intimacy, social navigation and play, using performance methods to create gestural protocols, or movement responses between participants.

Participants generated movement vocabularies by negotiating permission and control of their own physiological data, their own 'body state'. Gesture was utilized as an expressive indicator of intentionality, extension of body image, permission, control, exchange and play.

We gathered data from the workshops through video, gestural analysis, and experimental feedback in the form of small hand-drawn cards which participants could draw or 'journal' on. These feedback mechanisms let us imagine how we could create an interaction model, wearable garment design, and body-to-body network protocol that would eventually be used in the public art installation, and also how performance methodologies could contribute to the research and devising of interaction.

TECHNOLOGICAL FRAMING

Keywords
gestural protocols, performance methods, choreography, wearable computing, intentionality, improvisation, first person methodologies, physiological computing, play, experience prototyping, public art, informance design, bodystorming, somatics, experience design, social navigation



Our work in designing and testing experience models borrows across methodologies from the performance practices of Theater [4], Dance [2,3], and the field of Somatics [5], expanding work in the area of computationally centered design techniques as well as the rhetoric of user-centered design, experience design, and participatory design. Our premise is that performance, as a practice-based research domain, contains a longstanding history of constructing experience models. Computational interface strategies omit the bodily experiences of participants. We explore embodied cognition as a reflective process that is simultaneously inter-body and intra-body.

Technical Interaction :: Gestural Movement Vocabulary

Our interaction model required that participants exchange their body-state, or physiological data between themselves, and their garments. In order to design circuit connectivity for networked participation we needed to explore how gesture could enact bodily connectivity.




What are the properties of a gestural movement vocabulary? In Activity Theory, Nardi [6] illustrates the notion of a "function organ" – a transforming bond with an artifact. A photograph depicts a child listening intently to the radio, the expression of intense concentration suggests the creation of a relation between body and object. In dance and theatre the gesture itself can also become a "function organ", an artifact that creates or enacts a transforming bond between the participant and their own movement. In this way, we think of the gesture *itself* as a function organ: an artifact that creates affordances for interaction.

The design of specific gestures that can become enactors is a notion common to theatre and dance practice. We follow with examples from performance practice that support this notion. Richard Schechner [7] uses the term *Restoration of Behavior,* to describe gesture as "material". Restored Behavior is organized as sequences of events, scripted actions, or scored movements. He refers to these as strips of behavior, and states that a restored behavior, although "originating from a process, used in the process of rehearsal to make a new process, or performance, the strips of behavior are not themselves process but things, items, *material*". This concept of gesture as source 'material' for designing interaction models is central to our work explicated in this paper.

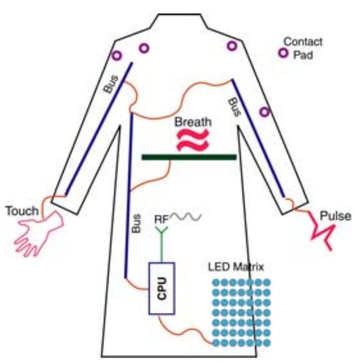
Augusto Boal [4] in *Games for Actors and Non-Actors,* states that "bodily movement *is* a thought, and a thought expresses itself in corporeal form". Boal's *arsenal of theatre* can be used to re-enact, or re-materialize the body state that accesses or indexes that thought, or "thought-unity". Grotowski refers to an acting score as a script for designing *point of contact* or connection [8]. In Interaction Design this is the equivalent of interaction schemas, which are navigated in order to construct the instantiation of the interactive experience.

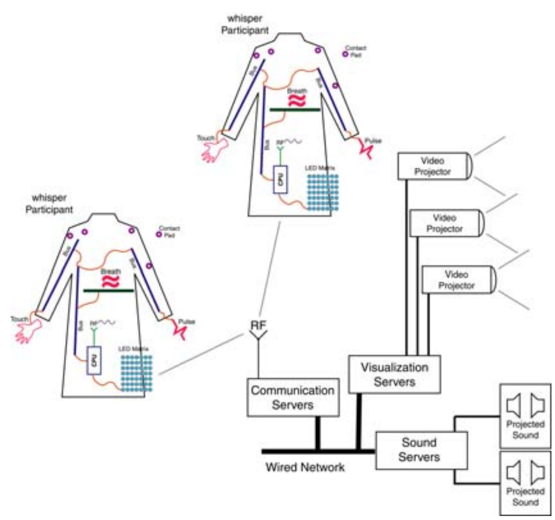
Grotowski speaks to the necessity of scripting gestural sequences in order to construct connection schema: “what is an acting score? The acting score is the elements of contact. To take and give the reactions and impulses of contact. If you fix these, then you will have fixed all the context of your associations. Without a fixed score a work of mature art cannot exist” [8].

We suggest using gesture as a “function organ”, as a mechanism that can assist in defining properties for a scripted interaction score. These gestural function organs have the goal of paralleling processes to construct Grotowski’s concept of mature art: works of “mature interaction”.

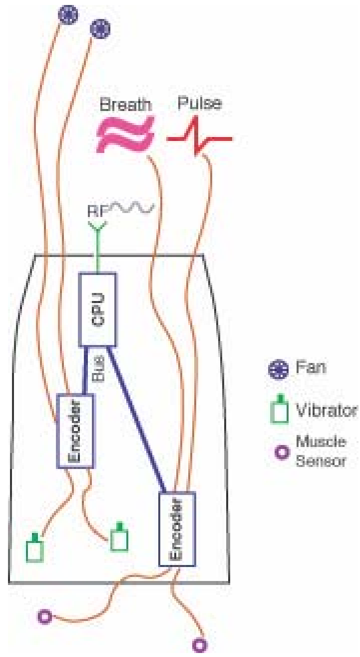
CIRCUIT TRAINING FOR DANCERS – Addendum

In the spirit of our embodied research we have created artifacts of these processes which have been exhibited at the DEAF festival 2003, Future Physical Respond, Cambridge 2003, e-culture fair in Amsterdam October 2003, Ciber@rts Bilboa, April 2004, Siggraph Cyber Fashion Show, Los Angeles 2004, New Forms Festival Vancouver 2004, and Siggraph Emerging Technologies Exhibition, Los Angeles, 2005.





Our first technical prototype - developed in very close collaboration with v2_lab - involved compact networked microcontroller systems that were linked via Bluetooth communication to a network of servers; the wearable systems integrated real-time breath and heart rate data as well as instantaneous tactile connectivity information to synthesize visual and sonic responses that were derived from the dynamic aggregate data streams.



The second generation platform, <between bodies>, incorporates commercial, off-the-shelf, PDA technology with integrated WiFi communication as well as custom electronics that interfaces to Thought Technology's biofeedback/psychophysiology monitoring devices, which provide EMG [ElectroMyoGraphy: muscle contraction] , breath rate, heart rate and GSR [Galvanic Skin Response: skin resistance] physiological signals from directly attached sensors. The PDA is also connected to multiple transducers to generate localized feedback to the wearer in the form of air motion (with miniature fans) as well as tactile and sonic feedback.

We continue to explore a set of embodied practices within our research. These continue to develop our research questions, our (aRt&D) forward soft, softer, and softly through ….

Emanating relationship

> *whisper* device states are learned and emerge from living on a specific body, and begin to represent that body; *whisper* devices remember past lives and these past lives influence their behavior.

Body as system

> *whisper* devices are held close to the body. Our bodies have secrets, contain multiple intelligences, conceal information in unlikely places, surrender things to one another, learn, habituate and unlearn by applying directed attention. So do the devices of *whisper*. Any one of our bodies is a 'we'. When our bodies are together they can operate as an 'I'. So can the devices in *whisper*.

Future memory

whisper builds and represents and builds 'future memory'. The past is incomplete and the whispers can revisit and reconstruct past views as time progresses. The past is not replaced, it is augmented and restructured as the system perception grows. And the rediscovery of the past propagates into the future and the system's anticipated behaviors.

Cultural study of telepathy and mapping

whisper is an incursion into the cultural study of telepathy: impressions are transferred invisibly, mediated both through body and technology. Telepathy is the ultimate wireless network. we create wearables for the telepathically impaired. *whisper* excavates the invisible, is a search for lost things.

Special thanks to v2-lab, Anne Nigten, Stock, Marjolein Berger, Alex Adriaansens and all the warm bodies that supported this research.

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Threads of Recognition: Using Touch as Input with Directionally Conductive Fabric

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Abstract

In this paper, we describe the design of a touch input system utilizing directionally conductive fabric for use as "smart fabric" in wearable computing garments. Our development is based on utilizing the fabric surface as a tactile interface. We have defined a set of qualitative gestures using heuristic algorithms. This model provides high-level interpretations for the tactile quality of the caress, which is used to derive parameters for the interaction model. The user (or wearer) uses this fabric as interface to select interaction modes that direct data between networked garments in a wearable art installation.

The fabric is composed of highly conductive fibers alternating with insulating materials, such that current can flow "along the grain" but not across. This design allows the fabric to become a passive conductor replacing conventional cables, and more significantly, an active device such as a touch sensor surface. The fabric is integrated into garments (in this example, a set of networked skirts), and is used to provide a source of tactile input.

The garment is used to explore the interpersonal exchange of physiological data, controlled and selected by the individual wearing the garment, using gestures sensed by the fabric, and contact between garments, as initiated by the wearer. These connections form the basis of ongoing studies of the dynamics of person-person and person-group interactions.

Categories & Subject Descriptors: J.5 [**ARTS AND HUMANITIES**]: *Performing Arts*; B.4.2 [Input/Output Devices]: *Tactile input*

General Terms: Design, Experimentation, Human Factors

Keywords: Tactile UIs, Input and Interaction Technologies, User Experience Design, Tangible UIs, gestural analysis, tactile input, Laban Effort-Shape analysis, whole hand input.

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ACM 1-59593-002-7/05/0004.

INTRODUCTION

The input system is based on the blending of two primary techniques: Laban Effort-Shape Analysis and a generalized input library, called the Gestural Interface Toolkit. The Laban Effort-Shape Analysis provides a movement-based theoretical basis for the development and description of the system, while the toolkit supplies an abstraction layer for the realization of the system in hardware and software.

Effort-Shape Analysis is a system and a language for observing and describing effort qualities of movement, originally described by Rudolph Laban [8]. Effort/Shape Analysis describes: 1) movement qualities and dynamics defined as Weight, Space, Time and Flow, and 2) Shape qualities which are defined as interactions with the environment: Directional and Shaping. Our work extrapolates primarily Efforts. Effort quality is defined as a continuum between polarities — Weight varies between strength and lightness, Space varies between direct and indirect/flexible, Time varies between sudden and sustained and Flow varies between bound and free.

Combinations of the main qualities are described as "qualities" of Effort. There are eight Basic Effort Actions, corresponding to the eight possible combinations of Space, Time and Weight. Figure 1 shows these qualities organized as the vertices of a cube, superimposed on the Effort components.

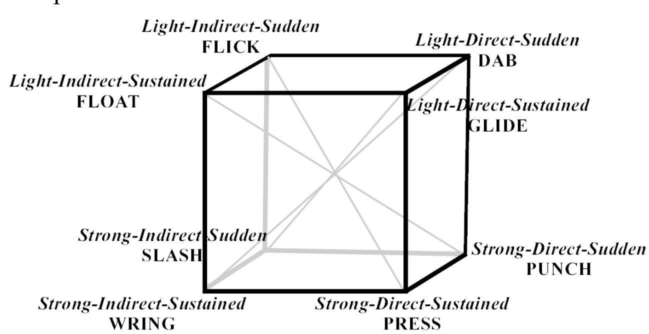

Figure 1. ***Effort Qualities and Actions***

The Gestural Interface Toolkit (GIT) is an Application Programming Interface (API) for developing responsive wearable applications that require access to tactile input [19]. It incorporates gestural interpretation based on heuristic algorithms that represent Laban Effort Analysis.

The objective of the toolkit is to provide uniform and consistent handling of several classes of tactile input.

The toolkit is parameter driven for tactile data [11]; in this application a two-dimensional model of signal sources from the fabric is used, in combination with thresholds and filters tuned for the range of the discrete attributes of Laban Effort qualities.

PRIOR WORK

The Laban movement notation is described in Laban [8]. Badler [1] presents a digital representation of the specific notation, Labanotation. Singh [18] describes a computer-based graphical tool for working with the similar Benesh Movement Notation.

Zhao [21] has applied Laban Movement Analysis (LMA) to studies of communication gestures. In this work, we focus on interpretation of the gestures as control actions for selecting communication pathways, as opposed to the gestures expressing the communication.

Schiphorst et al [13,14] describes the use of kinematic models to represent movements and Calvert et al [4] describes the further development of the composition tool into the product Life Forms, which uses Laban notation as the representation language. The current work was influenced by the choreographic approach to motion description and presentation of these studies.

Buxton et al [2] provides early descriptions of the unique characteristics of touch tablets relative to other input devices such as mice and trackballs. In particular they explore multiple-touch and pressure-sensitive tablets. The fabric used in our work can be multiple-touch, although our initial focus has been on single-touch gestures, as well as a more symbolic, high-level, treatment of the data.

Chen et al [5][6] describe the use of a touch-sensitive tablet to control a dynamic particle simulation using finger strokes and whole-hand gestures, where the gestures are interpreted as a form of command language for direct manipulation. In this work, we extend the concept of a direct manipulation language to incorporate some emotional expression in the observed gestures.

IMPLEMENTATION – HARDWARE

Our exploration with conductive fabric is based on the following needs from our prior work:

1) The conventional cables for the electronics used with sensors and personal digital assistants (PDAs) in our first prototype garments were too bulky and too rigid, so that the natural movement of the wearers became constrained and awkward, due to concern with the physical interconnects, such as cables and attachment points.
2) The interaction model that we wished to explore required a more robust connection mechanism between garments than we had experienced with earlier prototypes; it focuses on affective and expressive non-verbal communication based on touch, gesture, and movement, integrating these missing modes of communication into computer-assisted human-human networked systems as well as human-computer interfaces. Mechanical connections (such as fabric snaps) were hard to connect and required significant visual attention from the garment wearer to work; we want to connect more by feel, based on more associative and intuitive, touch-based gestures.

The implementation of our touch-based interface uses directionally conductive fabric, silk organza [12], forming layers of a garment. The prototype garment is a skirt that has integrated embedded cables that use the conductive fabric (as shown in Figure 2) to power transducers and to route data signals from sensors to a small wearable computer. The transducers are clusters of vibrator motors and fans embedded in the skirt lining to provide localized feedback for the wearer of the garment. Thanks to the physical characteristics of the fabric (nearly transparent and very lightweight), the cabling can be easily adjusted to accommodate different garment configurations, activities or wearers.

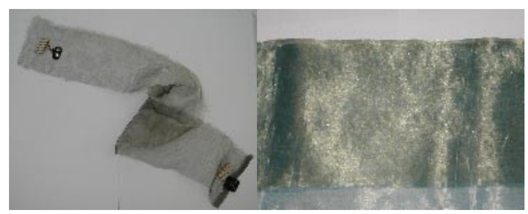

Figure 2. ***Conductive Fabric Strip***

Connections can be made directly to the fabric, with a high degree of isolation between signals. This can be accomplished without interfering with the flexibility or appearance of the conductive fabric. Large pockets in the garment are used to house the wearable computer, the power supplies and the associated electronics.

Figure 3. ***The Garments***

In addition, the conductive fabric is easily added to the garment to form response areas [7]. The fabric is layered with non-conductive fabric to form a simple grid that can be interrogated with a small amount of electronics [13] to identify a point of contact or applied pressure [17]. The information obtained from the fabric is sent to a small, lightweight, wearable computer, which communicates wirelessly with a central server. The server integrates the information from the garments with physiological data (such as heart and breath rates), gathered using a commercially available medical-grade sensor system that utilizes low-noise electronics and very reliable biosensors.

Figure 4. ***Sensor Electronics***

IMPLEMENTATION – SOFTWARE

Early versions of the garment used a very ad hoc approach to touch and contact recognition, primarily due to limitations imposed by the hardware architecture. The software model has been refocused to emphasize the dynamics of connection and contact, which are key to our studies of non-verbal interpersonal communication.

For this, earlier work [16] on adapting Laban Effort-Shape Analysis to recognizing gestures on a touch-sensitive tablet were adapted to the problem of identifying similar gestures on a response area. Some simplifications were necessary, as the fabric doesn't provide fine variation in detectable pressure. It does, however, have good isolation between the conductive fibers, so that determining the bounds of the contact region is both easier and repeatable. It is assumed that, at any given moment, there is only one touch-effort intended by the user [10]. For example, the wearer is not tapping with one finger and jabbing with another.

Data from the response area is input into an image-processing environment, with some filtering performed using the wearable computer. The image is then processed as a visual representation, to extract parameters that we have identified as representing physical values that can be extracted or calculated from the information that the response area provides over time. These parameters are described in Table 1.

To simplify the decision process used to determine what quality of touch is used, we take a fuzzy approach and use some techniques borrowed from Laban. The rationale for this is that parameters generally aren't represented linguistically by gradations of numbers, but are described in more dualistic terms such as "soft" or "hard. By categorizing each parameter into two or three qualitative values, the number of possible touch-efforts is reduced to a manageable quantity, which is more representative of the actual types of touches that we have identified. These values are then quantized to provide a standard representation that can be further analyzed and mapped to gestures, such as "stroke", "pat" or "touch". These gestures are combined with inter-garment connection information to generate a model of the actions being requested by the garment wearer — she can indicate which physiological signals she wishes to share or observe, and how the signals are to be mapped to the feedback devices on the garment.

Parameter:		Description
pressure	soft-hard	The intensity of the touch.
time	short-long	The length of time a gesture takes.
size	small-medium-big	The size of the affected region in the response area.
number	one-many	The distinction between one finger or object and many fingers.
speed	none, slow-fast	The speed of a touch-effort. This is the overall velocity of movement.
direction	none, left, right, up, down, and diagonals	The direction of movement.
Secondary:		
space (speed)	stationary-traveling	A function of speed. If speed is zero then the gesture is stationary.
path (direction)	straight-wandering	If the speed is not zero, and there is only one direction registered, the gesture is straight.
disposition (pressure)	constant-varying	If the pressure maintains a single value after an initial acceleration the gesture is constant.
pattern (gesture)	continuous-repetitive	If a gesture is unique in relation to the gesture immediately before and after, it is continuous.

Table 1. Parameters That Can be Extracted or Derived

At the same time, the connection information provides a representation of the groupings of the garments into clusters; each cluster can, at the discretion of the participants, provide aggregated physiological signals that can be used to modify aspects of the environment, in the form of visual imagery projected on suspended reflective sheets.

RESULTS

The response areas on the garments allow us to explore a touch-based interaction model that supports wearer-controlled sharing of physiological data from multiple sensors as self-to-self, self-to-other and self-to-group communication. The use of lightweight electronics and a wireless network allow the garment wearer essentially unrestricted movement within the installation. The response areas can be adjusted for each wearer, so that differences in "reach" or applied pressure can be accommodated.

The vibrator motors and fans that are embedded in the skirt lining provide sensual, non-verbal representations of the recognized gestures and allow the wearers to experience the contact and sharing aspects of the system, which is our primary exploratory focus.

FUTURE WORK

We are interested in applying the parameterized model of effort qualities to expressing and inferring meaning from caress and other forms of touch, such as holding and hugging [8]. The current system uses a single fabric insertion area as a response area, which limits the range of movements that can be expressed. By incorporating multiple response areas, it should be possible to create multiple active regions on the body, so that interpersonal touch can be represented and qualified [19]. Alternatively, the same fabric could be used to form an active area within a device or object, by embedding it within the floors and/or walls of a room, or by applying it to surfaces such as furniture.

Wearable computers in the form of PDA's provide localized processing; we are porting the platform to the cell-phone Symbian environment. This will enable peer-to-peer exchange of interpretation of gestures and the formation of ad-hoc communities, which will provide opportunities for higher-level analysis and exploration of other applications where quality, intention and meaning, rather than quantitative position-based interaction is required [3]. Moving to a more decentralized organization, where servers in multiple locations exchange gesture information through the internet, will also allow us to explore how gesture exchange might work when there is no visual contact between participants, let alone direct touch.

This work raises some interesting questions: Can we integrate such visceral information with conventional communication mechanisms, in such a way that the sensual nature of a gesture is not lost? How does one store, access, communicate and elicit such communications, as we do with a telephone call? Can we e-mail a hug?

ACKNOWLEDGEMENTS

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Artist Round Tables

Researching the Future: (CAiiA-STAR and the Planetary Collegium)

Taking the Planetary Collegium as their starting point, members of the round table address research issues as they relate to the development of practice and theory in the context of collaborative criticism and inquiry across a wide field of knowledge and experience. The Collegium network is worldwide, in terms of its meeting and conference locations, the cultural identity of its members, and its ambition to develop nodes based on and complementary to its unique procedures and methodologies.

The Collegium emerges from 10 years of experience with CAiiA-STAR in gathering doctoral and post-doctoral researchers of high calibre whose work transcends orthodox subject boundaries, and whose practices are at the leading edge of their fields. We are living in a time of crisis for universities, museums and corporations, a time in which old cultural and academic structures need to be replaced by research organisms fitted to our telematic, post-biological society. The Collegium combines the physical, face-to-face transdisciplinary association of individuals with the nomadic, trans-cultural requirements of a networking community. The panelists, all members of the Collegium at various stages in its development, present their personal visions of the direction future research might take and the structures needed to support it.

ROY ASCOTT (CHAIR)
University of Plymouth

DONNA COX
University of Illinois at Urbana-Champaign

MARGARET DOLINSKY
Indiana University

DIANE GROMALA
Georgia Institute of Technology

MARCOS NOVAK
University of California, Santa Barbara

MIROSLAW ROGALA

THECLA SCHIPHORST
Simon Fraser University

DIANA SLATTERY
Rensselaer Polytechnic Institute

VICTORIA VESNA
University of California, Los Angeles

Ars Electronica: 25 Years of the Digital Avant-Garde

Celebrating 25 years of Ars Electronica. The panel provides not just interesting historical information, but also comprehensive insight into new directions of digital art.

ROY ASCOTT (CHAIR)
University of Plymouth

CHRISTINE SCHÖPF
GERFRIED STOCKER
Ars Electronica

KAREL DUDESEK
Ravensbourne College of Design

MICHAEL NAIMARK
New York University

BARBARA ROBERTSON

Since its invention in 1979, Ars Electronica has maintained its strong focus on the crossovers between art and technology. With each annual edition of its Festival for Art, Technology and Society, Ars Electronica has become more and more an international meeting point for the ever-growing community of people interested in digital art, its practise, and its theories. The festival advanced from an insiders' event for pioneers and early adopters to the major event of the international digital art circus.

Ars Electronica also developed a strong influence on the local level and became a major driving force in Linz, Austria's process of transformation from a city based on the aging steel industry to a new economy of innovative technologies and industries, and it became an icon for Linz's new identity as a modern cultural city.

Ars Electronica established a unique dialogue between artists and scientists to explore the possibilities of digital technology and to encourage critical awareness of its cultural and social impact. Emerging technologies, new artistic practises, and advanced theories have very often found their first large public presentation at the annual Ars Electronica Festival.

In 1987, Prix Ars Electronica was introduced as the first international art competition dedicated exclusively to digital arts. It was the logical next step for Ars Electronica and an immediate success, not least because of its significant prize money and its high profile among jurors and award winners. Over the past 17 years, about 30,000 works have been submitted to this annual competition, and prizes totalling $US1.7 million have been presented to artists. The Prix contributed essentially to the building of Ars Electronica's large international reputation and its network of partners, friends, and collaborators.

With the opening of the Ars Electronica Center in 1996, Ars Electronica's field of operation was significantly redirected toward the general public and development of new forms of collaboration among art, science, and the general population. The Center resembles a prototype for a fully interactive museum and acts as a successful educational walk-in centre for a broad spectrum of audiences. It features frequently changing exhibits of outstanding media art works and innovative research projects from artists and media laboratories all over the world.

The Ars Electronica Futurelab, also founded in 1996, is an internationally acclaimed model for interdisciplinary collaboration among artists, designers, engineers, and researchers from the academic and commercial communities.

High-profile artists-in-residence projects as well as top-level research projects with large corporations provide a very inspiring and challenging foundation for any type of creative work in new technologies.

The panel provides not only interesting historical information, but also a comprehensive insight into new directions for digital art.

Synaesthesia

This panel discusses synesthesia, which typically involves sensory crossover among the basic senses (vision, hearing, taste, smell, and touch) within the normal range of sensation.

ROY ASCOTT (CHAIR)
University of Plymouth

DONNA COX
University of Illinois at Urbana-Champaign

MARGARET DOLINSKY
Indiana University

DIANE GROMALA
Georgia Institute of Technology

MARCOS NOVAK
University of California, Santa Barbara

MIROSLAW ROGALA

THECLA SCHIPHORST
Simon Fraser University

VICTORIA VESNA
University of California, Los Angeles

Synaesthesia Abstracts

DONNA COX

Baking Images with the Taste of Color

Visualization and digital-image generation requires control of red, green, and blue color specification in quantitative numbers. Cox's first love in making digital images is in the process of cooking with color, as a synaesthetic experience. As an artist, she practiced painting and color photography. In 1983, she discovered digital imaging and numerical control of perceptual color. By 1985, Cox developed an Interactive Computer-Assisted RGB Editor (ICARE) that enabled color control using trigonometric sinusoidal functions. She will discuss the link between her synaesthetic taste of color as a physical experience and the digital bake-offs in large collaborative visualization projects over the past 21 years.

Cox collaborates to make data-driven digital animations from sensored observations and simulations. She has played multiple roles in these collaborations, but most of the projects involved her control or influence on the design of color. While she has collaborated with scientists and developed new methods for color design, she primarily and intuitively experienced color by taste. Her "tasteful" embrace of color has lead to innovative color solutions for scientific visualization. She describes several projects that include the "grid" virtual technology and other advanced technologies used to create animations for museum displays, PBS Nova television shows, and other large-scale colorful projects. Cox discusses how the "taste of color" affects her palettes and how this approach reveals itself in striking contrast to many of her scientific colleagues.

Her collaborations include the 1997 Academy Award-nominated IMAX movie "Cosmic Voyage," for which she was associate producer/art director for scientific visualization. In this Round Table, she also shows astrophysical visualizations and decisions she made in producing "Unfolding Universe" for the Discovery Channel. Under her direction, the NCSA Experimental Technologies Group recently completed a tornado project for Nova, "In Search of the Super Twisters," which she will explain in her exploration of the relationship among technology, visualization, displays, and synaesthesia.

DIANE GROMALA

Riots of Sensation

A medically defined, idiopathic abberation. A keyboard that produces a different taste for each note. A cyberpunk ideal. An LSD trip. An artistic method to expand consciousness. The man who tasted shapes. Each could be an instance of synaesthesia, defined as "the transposition of sensory images or sensory attributes from one modality to another." Synaesthesia has proven to be a provocative concern of Western artists and scientists alike, arguably from the era of Isaac Newton and John Locke, prominently in the late 19th century, and certainly in contemporary times.

Although synaesthesia still is not well understood and suffers from mild associations with moderate deviance, its importance can be inferred by the prominence of the scientists, artists, and philosophers who have historically grappled with it, and by its cyclical recurrence as an object of intense scrutiny. Interest in this phenomenon curiously seems to resurface during times of technological change, such as our own. Yet the ways of defining, understanding, and contextualizing synaesthesia have traditionally divided artists and scientists. This paper argues that the shared interest in emerging forms of technology among certain artists and scientists, through a phenomenological approach, promises to be far more productive than the usual feel-good interdisciplinary enterprises suggest.

The paper briefly outlines the major assumptions upon which most contemporary and historical accounts of synaesthesia rest as seriously problematic, pointing to examples familiar to the SIGGRAPH community. For example, the notion that we have five distinct senses has given way to the identification of other senses, and a reconsideration of their distinction (the so-called "binding problem" in consciousness studies). Though this has been an outgrowth of research in much larger realms, the focus here is on the work of artists, cognitive and computer scientists, and experiences encountered in work with technology, such as proprioception in virtual reality.

The paper then posits a reconsideration of synaesthesia, by describing continually fluctuating perceptual fields, thresholds, and liminal states that arise from stimuli, both internal and external. It will focus on the potentials and possibilities that emerging technologies hold for users to "remap" sensation, drawing on the overlapping findings of scientific research and artistic practices.

MARGARET DOLINSKY

Synaesthesia in Your Toolbox

In reality, synaesthetic percepts have been found for a wide variety of intermodal combinations. Senses are not discreet and often work in unison, one triggering the other. For example, a trained pianist feels sound through her fingers. She is kinesthetically aware of finger positions, tactilely sensitive to the keys and auditorially attentive to the sound. As she plays the piano, the tactile becomes sound as one sense predicates another.

When we are confronted by a novel sensation, we rely on our senses to correlate it to previous percepts and learn how to incorporate it within our base knowledge. The senses act as meta-knowledge that can be extended and developed. Perhaps synaesthesia has different levels of definition. Perhaps synaesthesia is not uncommon; perhaps the senses are not discreet but instead one modality often invokes another.

In virtual reality, participants see images moving past them, which triggers a sensation of motion. Participants can perceive height, move into empty space, and sense themselves falling. The visual can become kinesthetically effective enough to cause a range of physical sensations from dizziness to motion sickness.

Philosopher Andy Clark posits that humans have not entered a post-biological era but, rather, have always been natural born cyborgs using tools as extensions of the body. From the early adaptation of tools to create cave paintings to the recent ingestion of nanobots to capture corpus video, we have incorporated foreign objects with our biological mainframe to heighten our senses and awareness. A case in point: the artist uses the paintbrush as an extension of her body, feeling the sensuousness of the camel-hair tip as it caresses the canvas, leaving a moist trail of color in its wake. The flow of the hand, brush, and paint connect the action, image, and body physically, mentally, and sensorially into one place, one moment, and one being. This process, termed "flow" by psychologist Mihalyi Csikzenmihalyi, is an action that is summarized by a "total involvement with life." Psychologists believe that this process is just one of the methods that we use for gathering information, the very essence of our survival.

MIROSLAW ROGALA

I Wanted To Keep Touching the Words

Dynamic mapping involves changing (v)user behaviour and implies that a new narrative structure is needed to inform any (v)user, be it single or multiple. Dynamic mapping confronts (v)users not only with complexity, but also with the responsibilities that the freedom to navigate complex structures brings with it. In "Divided We Speak," through repeated engagement, the audience becomes comfortable with the range of freedoms they are offered. Because of the problems that have arisen in the interpretation of the movements and gestures of multiple participants in the same shared space, the spatial grammar of experience and behaviour need to be redefined. Mapping horizontal movement in the space becomes a mode of interpretation. Thus, both hand and body movements dynamically create new art forms. As participants exclaimed: "It is really amazing that you can actually touch the sound!" And another stated: "I wanted to keep touching the words." The process of dynamic mapping interactions requires exploration and decisions to be made by the (v)user. The (v)user's confrontation with power and control are determinants for expanding the aesthetic experience.

THECLA SCHIPHORST

Between Bodies, Between Senses: Practicing [Holding] the A-Wearable Self

The body synaesthetic is a simultaneous act of movement and stillness. The ability of the body to hold multiple states and multiple sensory domains is codified as daily practice in performance and somatics. Dance and theatre provide models for knowledge acquisition, information design, networked connectivity, remote sensing, and wearable technologies. In my own work with wearable technologies, the notion of LANs (local area networks) is extended to include: BANs, body area networks, SANs, skin [subtle] area networks, and MANs, meridian area networks.

VICTORIA VESNA

NanoMandala: Feeling is Believing

This paper discusses the significance of considering the ideas of a Mandala – a cosmic diagram and ritualistic symbol of the universe, used in Hinduism and Buddhism – when working with science on the molecular scale. Using an interactive installation that was created in collaboration with nano-scientist James Gimzewski and a group of Tibetan Buddhist monks from the Gaden Lhopa Khangtsen monastery in India who built a seven-foot-diameter sand mandala, I will approach this uneasy subject of the invisible made tangible by the metaphysical.

With the invention of the scanning tunneling microscope (that should really be called a tactoscope), using "touch" to feel the molecular surfaces, scientists are able for the first time ever, to access this realm in a "tangible" way and prove the complexity of "nothingness." Manipulation of individual molecules bears some resemblance to the methods monks use to laboriously create sand images particle by particle, and what is considered here in particular is the process. Eastern and Western cultures use these bottom-up building practices with very different perceptions and purposes, and the merging of the two could result in some interesting research. A Mandala can be translated from Sanskrit as "whole," "circle," or "zero." It consists of a series of concentric forms, suggestive of passages between different dimensions, the macrocosm and the microcosm, from the largest structural processes as well as the smallest. It is the planet earth, the atom that composes the material essence of our being, and the galaxy of which the earth is but an atom. By approaching the molecular worlds with this in mind, rather than the usual idea of working with nano as something very small, there is an amazing potential for discovery and expansion of our perception of our worlds.

MARCUS NOVAK

TransSense: General Synaesthesia

Synaesthesia normally occurs when input to one sensory modality registers across another sensory modality. Typically, this has involved sensory crossover among the basic senses (vision, hearing, taste, smell, and touch) within the normal range of sensation. However, several continuing developments are expanding not only the range of the senses, but also their kind, and even their scale. Numerous avenues of research, including studies of neural plasticity in the cerebral cortex, sensory substitution, prosthetics, robotics, and others, point to the expansion of the sensorium to a condition of generalized synaesthesia, in which all available sensory modalities, biological or technological, can be, to varying extents, mapped into one another.


Merce Cunningham

Four Key Discoveries

Merce Cunningham Dance Company at Fifty

A discussion with Carolyn Brown, Merce Cunningham, Laura Kuhn, Joseph V. Melillo, Thecla Schiphorst, and David Vaughan

The following discussion was held at the Brooklyn Academy of Music on October 18, 2003. The panel, moderated by Joseph V. Melillo and organized by BAM's Education and Humanities department, was held to observe the Merce Cunningham Dance Company's fiftieth season and the world premiere of *Fluid Canvas* and *Split Sides*, performances created in collaboration with the rock groups Radiohead and Sigur Rós. Cunningham also incorporated new computerized choreography software into the chance-based performance.

JOSEPH V. MELILLO In Merce Cunningham's own words, "there have been four events that have led to large discoveries in my work." Today, at the company's fifty-year milestone, we have assembled a distinguished panel of artistic collaborators, critics, historians, and dancers to consider the past and present evolution of these Cunningham discoveries.

This discussion is titled "Four Key Discoveries" because Merce once said that the company's work can be considered through the prism of these ideas: (1) the separation of music and dance as influenced by John Cage; (2) the use of chance operations in choreography; (3) the possibilities of film and video; and (4) experimentation with computer technology. Merce, would you give us your point of view about this statement?

MERCE CUNNINGHAM Yes. First, the music: John Cage didn't like the idea of one art supporting another or one art depending on another. He liked the idea of independence and wondered if there were another way we could work separately to produce a work of music and dance. The first things we made were short solos, and it was difficult for me to do, not having the music as support in the traditional way. But at the same time there was marvelous excitement in this way of working, so I pursued it. In one of those first solos, we had a given time structure within which the dance might take place — I think it was five minutes. I remember so clearly the first day when we were rehearsing with John and I made a large, strong movement — there was no sound but just about three seconds later came this ravishing sound, and it was very clear that this was a different way to act: not being dependent on the music but being equal to it. You could be free and precise at the same time. As we have continued to work this way with music and composers, it's always struck me how

Carolyn Brown, Laura Kuhn, and Merce Cunningham. Photo: Elena Olivo precise the dances become on their own terms: it's both being free and at the same time working together.

The second discovery was chance operations. That began in the 1950s. A scientific institute called the Institute of Random Numbers had declared that using random numbers was just as useful as logic. The *I Ching*, the Chinese book of changes, had been published—that showed that chance was a way of working which opened up possibilities in dance that I might otherwise have thought impossible. I would try them, and sometimes they were impossible, but they always showed me something else that I hadn't thought of: ways of getting from one thing to another, kinds of rhythm, use of space. So I abandoned the idea of frontal staging focus; we could now face anyplace, any direction. One direction is equally as valid as any other. *Split Sides*, the piece we're doing here tonight, is a chance operation from the beginning. Every night we have the possibility of changing the order of music, set, costumes, and lighting design.

Tonight, before the curtain, we will cast the dice, first to see if it comes up odd or even: Even means we start the program with section A, odd means section B. A has come up now for three nights, but I can't tell you what this one will be and equally so with all the parts: which set, costumes, and lighting design to use for each section.

I made the third discovery when I worked with Charles Atlas on films in the 1970s, and later with Elliot Kaplan, who filmed a number of dances. I never had any connection with the camera, but then Charlie showed me its principles. The first thing that struck me was that the space I was looking at wasn't at all like the stage, so you didn't have to think that way. The camera can change its relationship to what the dancer or dancers are doing. Television in particular has a quickness and clarity in the camera's movement, which I began to investigate in classes.

The last discovery, computer technology, I made with Thecla Schiphorst, with whom I've worked for ten years on LifeForms. I'm going to let her talk about that, but I should say that it has opened my eyes to things about movement which I wouldn't have seen otherwise. I'm grateful to her, as I am for all of these things, because each one has showed me something that I might have thought impossible in movement. But each has somehow given me a new way to work in the dances that I make.

LAURA KUHN I think I have the most fun topic because of the collaboration with Radiohead and Sigur Rós this season. I don't know what the effect has been outside the company, but within that world it's been a little controversial, and it's fun to think about the effect of that collaboration.

Merce and John Cage were artistic partners for most of their adult lives, and John Cage was the first music director of Merce Cunningham Dance Company, formed in 1953, and he remained in that capacity until approximately 1990. As the music director, it was Cage's job to find composers to work with a company distinguished by a total separation of music from movement—there is no relationship. Until the first performance the dancers themselves don't actually hear the music that will be performed with the dances.

If you read the roster of composers and performing musicians who worked with the company since its inception, it reads like a *Who's Who* of modern music. Merce Cunningham and the Kronos Quartet may be tied for commissions of new American music. Like Merce, Cage was always interested in finding something new, such as his early embrace of electronic music. There were, however, certain tacit musical decisions over the past fifty years.

Rarely, if ever, could you hear an intelligible spoken voice, though in a few instances musicians have come and used text, and it's created a slightly disruptive sensory competition. Also, as a rule, Merce has introduced new composers to his audience; what's interesting about the event tonight is that it's nearly the reverse. Virtually nobody in the Merce Cunningham world knew who Radiohead or Sigur Rós was. The two bands were encouraged to do something different—without the commercial music world's confines—and they did. Another thing the Cunningham collaborations tend to shy away from in music is a fixed beat. Rock music, on the other hand, normally has a rigid, fixed beat. But tonight there is no drummer. In fact, Radiohead made a unilateral decision not to have percussion, which I thought was extremely interesting.

But the other thing I find curious about this performance is the correspondences. This was especially striking on Tuesday night, which was the only live performance with the musicians playing in the pit. Especially in the Sigur Rós collaboration, there were a number of correspondences between sound and movement. If the dancers did a quick step, the music got jittery, because the musicians were watching the dancers. The band clearly did not know that this is taboo, so they felt free to try to dance with them, musically speaking.

CAROLYN BROWN Fortunately or unfortunately, in 1966 I wrote an article called "On Chance." I did a lot of research and tried to find out what this work was all about, prompted by two critical pieces by a writer who wrote both for a Chicago paper and for *Dance News*. In them she said, "The dancers did their favorite movements." There was a huge misunderstanding—people thought the dancers were just up on the stage making up their own steps. (Though how they could look at these dances and imagine that we were up there making up our own steps is beyond me.) So I wrote an outraged letter to *Dance News* and then proceeded to write a longer article for *Ballet Review*. I gave it to Merce before submitting it to the editor; he read this long article and then looked up at me with eyebrows raised and said, "So serious!"

And it was. I wanted to point out a lot of important precedents. Chance in performance didn't start with John, it goes back to Dada in the early twentieth century, poets and artists like Duchamp—who actually did one of the first musical chance pieces—who took words and shuffled them for compositions, and who cut up drawings and threw them up in the air and repasted them on paper as they fell.

In a way chance dance is like any other form, because Merce has done a meticulous study, and then he teaches it to us so we don't have to go through the same process. Once he has taught the choreography, it stays as it is.

Merce Cunningham Dance Company in *Split Sides*, Brooklyn Academy of Music, 2003. Photo: Jack Vartoogian

Split Sides. Photo: Jack Vartoogian

The unusual element is not so much chance as indeterminacy, in which something unpredictable can happen. This is not about improvisation — among many other things, Merce is a master of structure and timing. We once did a piece called *Story* in which we had a little freedom on stage, and it drove Merce crazy when we took too much time on stage. There's a wonderful story about Merce going out on stage during a performance, picking a dancer up, and carrying her off. What is indeterminate is not the dance itself but the components of a performance. A piece like *Rune* is indeterminate — it had five sections which could take place in any order. But once the order was decided (by chance), it was set and didn't change. I think it's important that people understand that. Henri Bergson once said, famously, that "disorder is simply the order we are not looking for." And to me, this is what Merce does on stage.

DAVID VAUGHAN As Merce said, he's worked with two filmmakers: Charles Atlas and Elliot Kaplan. Charles Atlas first came into the company as a stage manager, and he happened to be a budding filmmaker at the time. He had a Super-8 camera, and at first he made short clips of Merce's joints in movement, in close-up, moving in different ways. Sometimes these were used as decor in performance events, though I don't think I ever saw any of those. Then in 1972 Charlie asked Merce which dance in the repertory he would most like to see filmed, and Merce said *Walker on Time*. He shot the pieces in two parts: one in Berkeley, California, and the second in Paris, which was actually Carolyn's last performance, in 1972.

So in a way Charlie was moving toward actually collaborating with Merce, and in 1974 they made their first piece together. It was called *Westbeth* after the name of the building where our studio is. The technical materials available were primitive. But the result was the beginning of an exploration of what you could do with film. Over the next few years, Charlie and Merce made several pieces together, video dances and then film dances. And in a way each one explored a different aspect of the camera, ending up with a kind of grammar of the dance on film. Interestingly, they were subsequently transferred to the stage, reversing how people usually work—making film or video versions of existing dances. But Merce transferred them back to the stage, and of course that meant they had to be changed quite a bit.

Charlie made his last piece, *Coast Zone*, with Merce in 1983. And then Elliot Kaplan, who'd been Charlie's assistant, took over and became the filmmaker-in-residence. I might add that one reason Merce wanted to collaborate with a filmmaker was that he had seen the way other people's dances were chopped up on film; he thought it was necessary to find out more about technology and the camera so he could have more control over the way they were seen. Many people making film or video versions of their dances at that time wanted to make it look as much like the stage as possible. But Merce realized that there's no point in doing that. Instead, people always come in from one side or the other, from behind the camera, or else the camera shifts a bit and they are found in place. Since it's clear from looking at the films that everything has to be planned in advance, I once asked Merce how chance comes into the video process. And he said, "Well, it's partly because the camera never quite does what you want it to do, so you have to do something else."

THECLA SCHIPHORST I'm going to share with you some of the work that Merce has been doing with the computer tool for choreography now known as LifeForms, although it has had a number of names over the years. It started with the name Compose and was renamed LifeForms, and actually now there's a version of it called DanceForms. It's now used specifically to create and explore movement. What's really interesting about chance is that it affords a mechanism by which we can let go of habit. Each of these four discoveries offers another, new way of working.

Merce and I actually started working together in 1989 at Simon Fraser University. Some Italian producers had invited us to work together using the software. Although the commission fell through, Merce has continued to explore the computer since then. In the beginning Merce was just working with shapes, which found their way into the dances. He used those movements in the classroom, and these movements found their way into the dances. So even more than has been acknowledged in the press or in interviews, this has become a part of the exploration questioning movement.

Interestingly enough, in 1967 there was an article in *Dance* magazine about Michael Knowles's work. Knowles was a researcher at Bell Labs, and Merce was aware of his work and actually commented on it in a way that really speaks to the sense of what technology could do for movement at that time. In 1968 Merce said: "There have been some slight experiments that I know made in this direction, and this situation makes me think immediately that a dancer could be on a screen. Imagine stick figures, the screen is a notation, the shapes move in depth and in space and can be moved in time and space." This is a description of the LifeForms software we started working with in 1990.

This experiment with technology is in many ways an extension of Merce's use of chance. Merce used found objects such as test phrases which the computer programmers had left on Merce's computer. Those test phrases either found their way into his dances or he reconstructed them by exploring the relationship between time and space. With a figure doing a simple walking phrase, Merce would actually explore the relationship in time and space, looking at how he could change first the legs, then modify the arms totally separately, and then see how the spine could be modified. Of course what was created was a very complex, very difficult walk, not something that was natural in any sense. So the dancers not only had to learn these movements, but they also had to relearn how to use their bodies to perform and understand what this movement was. They shared in this questioning of what movement is. On the computer, the body is represented by joints, and the program is about the complex ways you can put together so many kinds of joints. Even though the movement may appear to be physically impossible, its sheer complexity has really shifted both the choreography and the way the dancers have to understand movement.

CUNNINGHAM: With LifeForms, as with my other processes, it's a continual balance of making and looking. I have it in my G4 and carry it on tour. In the beginning I worked on this enormous machine. Thecla came and very carefully showed me how to do things the first time we worked together, and then she went away. And then I tried things and everything crashed. I thought, "Well, it doesn't matter, I don't know anything so it's not a mistake." Eventually I started again, playing with the possibilities, and when I showed Thecla what I'd done she said, "How'd you do *that*?" I couldn't explain it.

I like to produce movement that seems out of range, to enlarge the range and add things to what we think of as dance. I think one of the things that has happened with the dancers and not just the technology is the use of arms, for example. I was working with LifeForms, using chance means to arrange the arms in a way which I'd never seen before. So I tried them in a minimal way and saw they were possible, so I began to use the arms in a much more complex way. With the computer—so far—I take the movement to the dancers. I want to do it the other way, but so far I can't think of a way to do it. I have my own personal difficulties with moving now, so most of the demonstration is talking—and dancers don't like that, they want to *see* it.

Here's a simple example of my work with the software: let's say that I always do a certain movement, 1–2–3, 1–2–3. One is a hop, two is falling down, and three is a jump. Applying chance principles means tossing the dice: maybe the order comes up as fall, hop, and run. You might think that's not possible to do, but when you go ahead and try it, you find out that you can do it. It gives you a different physical continuity, a different physical coordination. Now imagine two people dancing together—in fact, one of the duets in this evening's performance comes out of the computer. The movements were put into the computer by chance, and the order of the duet comes from applying chance to a single sequence of events for this person and then for the other person. When it comes together, you have not only the chance continuity of these events but also the sequences in relation to each other. Now these are not simply figures on the screen; these are people who move around and who don't want to run into each other. So it can give you limitations, but the limitations keep changing almost beyond what you think is possible.

I will ask two dancers to try something based on the computer results, and the two of them do it together and all of a sudden something happens that we hadn't even ever thought

Split Sides. Photo: Jack Vartoogian

of. And I'll say, "Oh, keep it!" Because it's something that we hadn't experienced before. I don't mean to say it's easy—it's constant work. More times than not, though, you find a way.

From the beginning—like the other discoveries, such as separating music and movement—the software has constantly brought up other possibilities. I've always felt that there is a limit to the structural activity of the human body: once we stood up on two legs, we were caught and have to work that way. But there is always some other way to do it. Not that I'm going to find it or anybody else is, but there always is something else to discover. That's been the history of movement; dance is another way someone has found to deal with the question of what movement can be. The computer has opened it up to me. It has broadened what I think of as possible in dance.

Between Bodies: using Experience Modeling to Create Gestural Protocols for Physiological Data Transfer

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ABSTRACT

In this paper, we describe the use of experience modeling to create gestural protocols for physiological data transfer. This design method has been applied to the development of a wearable computing public art installation called *whisper*.

A series of user-experience workshops were designed with the goal of developing an interaction model for the public installation. These workshops modeled intimacy, social navigation and playful exchange, using performance methods to create gestural protocols.

Workshop participants generated movement vocabularies by negotiating permission and control of their own physiological data. Gesture was utilized as an expressive indicator of intentionality, extension of body image, permission, control, exchange and play.

We illustrate through video, gestural analysis, and experimental feedback, how the workshops provided an experience model for the interaction, wearable garment design, and body-to-body network protocol used in the public art installation, and how performance methodologies can contribute to the area of interaction design.

Author Keywords

gestural protocols, performance methods, choreography, wearable computing, intentionality, improvisation, first person methodologies, physiological computing, play, experience prototyping, public art, informance design, bodystorming, somatics, experience design*,* social navigation

ACM Classification Keywords

H.5.2. User Interfaces, User-Centered Design, Prototyping

1. INTRODUCTION

The title *Between Bodies* is a metaphor that provides our framework for experience modeling. Our work in designing and testing experience models borrows methodology from the performance practices of Theater [4], Dance [3], and the field of Somatics [12], expanding work in the area of user-centered design, experience design, and participatory design. Our premise is that performance, as a practice-based research domain, contains a longstanding history of constructing experience models. Many participatory design perspectives omit the bodily experiences of participants. Performance-based experience methodologies can contribute to exploring our bodies' physical responses in the growing area of interface design for ubiquitous, wearable and affective computing. We explore embodied cognition and interaction as a reflective process that is simultaneously inter-body and intra-body. This research provides a case-study for a model of designing embodied interaction.

1.1 Artistic Aim

One of the major themes of the installation *whisper* is the notion of 'paying attention' to one's self, and using this sense of self to connect to, and exchange with another. This requires an ability to transfer this 'sense of self' to another person. Designing expressive interactions that afford intimacy, privacy, affect as well as connection are the goals of interaction. How can a system create a willingness, a trust, the 'suspension of disbelief' needed to enter into an exchange of information that is otherwise private and 'unknown'? To explore these questions of access to experience we turned to performance methodologies. For example, techniques for extending our bodily awareness through attention to breath and movement are common to performance methodologies found in theatre and dance. Techniques in these domains build both intra-body and inter-body knowledge by focusing on our *perception* of our own physical data. This includes having access to, and agency over our own breathing, our own heart, our own thoughts, and our own body state. In the installation this is afforded through the use of measuring physiological data as a representation of one's se, and in effecting how this data is displayed, exchanged, and shared.

1.2 The Outcome: A Wearable Public Installation

We developed an interaction model for the public art installation through a series of experience workshops outlined in this paper. *whisper* is a real-time interactive public art piece, based on small wearable physiological sensors, micro-controllers, and wireless network transmission, embedded in evocative and playful garments worn by the participants. *whisper* is an acronym for [**w**earable, **h**andheld, **i**ntimate, **s**ensory, **p**hysiological, **e**xpressive, **r**esponse **s**ystem]. Focusing on body state represented through participants' breath and heart rate, whisper aims to monitor physical data patterns of the body, mapping heart and breath physiological data onto linked and networked devices worn within a specially designed garment. *whisper* collects breath and heart rate data from the bodies of participants, and through visualisation and sonification techniques, enables participants to interact, interconnect, and interpret their own and other participants internal data in playful and responsive ways.

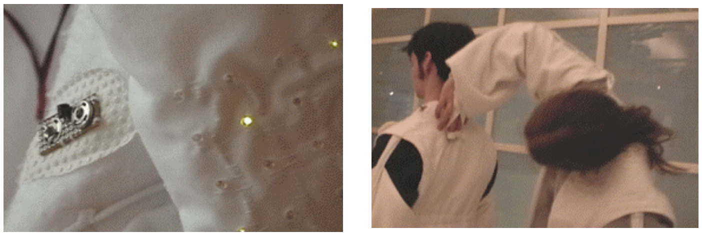

Figure 1. *whisper* garment and gestural interaction DEAF03 Festival

The wearable installation is the outcome and testing ground for an experience modeling methodology described here. *whisper* has been exhibited at DEAF03, the Dutch Electronic Arts Festival, in the public lobby of the Schouwburg Theatre, in Rotterdam in February and March 2003, at Future Physical's Respond festival, in Cambridge, UK in March and April 2003, and at the e-culture fair at the Amsterdam Paradiso in October 2003. Up to six participants are able to listen to and affect their own body-state represented by their physiological data (breath and heart-rate). They are also able to connect to and exchange their physiological data with other participants in the interaction space through gestural interactions which enable connecting, listening, exchanging, giving and receiving.

2. BACKGROUND

During our design workshops, gesture was utilized as an expressive indicator of intentionality and body state. We modeled our workshop methods on performance techniques that provide a link between embodied interaction, activity theory, user-centered and participatory design, and situated cognition. Within HCI, gesture/movement design analysis is an under-theorized area, and a need exists to explore richer methods to create gestural interaction. Our work attempts to bridge this gap, and specific examples are described throughout the paper.

2.1 Workshopping Experience through Gesture

The workshops were modeled using a range of performance techniques such as improvisation, props, phantom partners, prosthetic devices, ritual space, and placebo objects. We used attention modeling that incorporated listening, sending attention and touching; imagining and visualization; focus on somatic attributes such as breath, heartbeat, stillness, slow motion movement; journaling using hand-writing and drawing; social navigation using gesture and touch to express permission, trust, exchange, and feeling; and costumes and props to express physical extension, connection and group identity. The goal of the workshops was to model experience that could be replicated, re-enacted, and re-played in the context of a public art installation using wearable computing technology. The design goal of the public art space was that it could be simultaneously intimate, playful, and social, while developing a level of awareness of our selves.

We illustrate our process through video, gestural analysis, and experimental feedback. Gestural protocols created and imagined by the workshop participants during playful engagement became the basis for: body to body network protocol; the wearable garment design, including the selection of connection points, placement of wearable computers, sensors, wiring paths, and visual display systems; and for the mechanisms of gestural connection, intention and data sharing that was used in the public art installation.

2.2 Performance Methodologies as Experience Models

There is a common ground that exists between the domains of HCI and performance practice. We refer to this shared ground as first person methodologies: techniques and protocols that articulate models of experience. We posit that it is precisely the differing frames of reference between the domains that can reveal an under-theorized area of practice. For example, the need to have models of interaction and the experience of the 'user'/'performer' can be seen to be one such shared starting point that is framed through differing methodological strategies. How are these models of interaction conceived, constructed, and integrated within a design process? What are the underlying assumptions that differ between these domains?

We explore interaction as a space of lived experience and enactment, as something that is simultaneously *between bodies* and *within-bodies*. Specifically, human-computer interaction, as it is defined by *human* experience in which action and meaning are inseparable. We explore human interaction as a model for developing relational human computer interaction systems.

One of our contributions to this shared domain of developing models of experience, is that in our work, the 'bridge' is being built from the side of performance practices, rather than from the side of HCI. This brings with it new vocabularies, techniques, with an emphasis on building knowledge *within* the experience of the body, an area well defined within Performance and Somatics.

Dourish [9] lays a strong argument for a foundation in HCI that validates the notion of an embodied interaction. The need to augment abstract reasoning and objective meaning with practical action and everyday experience is central to this approach. Dourish notes that his contribution is foundational, rather than methodological, which opens opportunities for methodological modeling and testing as a critical next step in the development of this area.

Suchman's [28] ethnographic research, which views all activity as situated and embodied, and her interest in purposeful, intentional activity, alongside Nardi's [18] work in constructing a "theory of practice" within HCI based on the development of activity theory and intimacy between human and machine constructed through intense relational concentration, provide strong bridging links to our work.

2.3 Gestural Movement Vocabulary

What are the properties of a gestural movement vocabulary? In Activity Theory, Nardi [18] illustrates the notion of a "function organ" – a transforming bond with an artifact. A photograph depicts a child listening intently to the radio, the expression of intense concentration suggests the creation of a relation between body and object. In dance and theatre the gesture itself can also become a "function organ", an artifact that creates or enacts a transforming bond between the participant and their own movement. In this way, we think of the gesture *itself* as a function organ: an artifact that creates affordances for interaction.

The design of specific gestures that can become enactors is a notion common to theatre and dance practice. We follow with examples from performance practice that support this notion. Richard Schechner [22] uses the term *Restoration of Behavior,* to describe gesture as "material". Restored Behavior is organized as sequences of events, scripted actions, or scored movements. He refers to these as strips of behavior, and states that a restored behavior, although "originating from a process, used in the process of rehearsal to make a new process, or performance, the strips of behavior are not themselves process but things, items, *material*". This concept of gesture as source 'material' for designing interaction models is central to our work explicated in this paper.

Augusto Boal [4] in *Games for Actors and Non-Actors,* states that "bodily movement *is* a thought, and a thought expresses itself in corporeal form". Boal's *arsenal of theatre* can be used to re-enact, or re-materialize the body state that accesses or indexes that thought, or "thought-unity". Grotowski refers to an acting score as a script for designing *point of contact* or connection [23]. In Interaction Design this is the equivalent of interaction schemas, which are navigated in order to construct the instantiation of the interactive experience. Grotowski speaks to the necessity of scripting gestural sequences in order to construct connection schema: "what is an acting score? The acting score is the elements of contact. To take and give the reactions and impulses of contact. If you fix these, then you will have fixed all the context of your associations. Without a fixed score a work of mature art cannot exist" [23].

We suggest using gesture as a "function organ", as a mechanism that can assist in defining properties for a scripted interaction score. These gestural function organs have the goal of paralleling processes to construct Grotowski's concept of mature art: works of "mature interaction".

3. PRIOR WORK IN DESIGNING EXPERIENCE

What do we mean by experience modeling? By bridging domains of performance practice with interaction design and HCI, we are focusing on an area of enacted cognition: the *enactment* of descriptors, or schemas for movement.

3.1 From Experience To Experience modelling

Previous research in the use of exploring experience/ performance methods within the HCI community has occurred in the domain of user-centered and participatory design [10][14]. This has included: *experience prototyping* that fosters an 'empathetic' and 'embodiment' approach to user-centered and scenario-based design [5]; Interval Research's exploration of *informance*: informative performance and *bodystorming*: physically situated brainstorming, *repping:* re-enacting everyday people's performances, and explorations of how Low-tech solutions can create a design environment that focuses on the design question rather than the tools and techniques [6][21]. Salvador and Howells [20] shifted the focus group methods to something they called Focus Troupe: a method of using drama to create common context for new product concept end-user evaluations. Simsarian [26] has explored the use of role-play in extending the richness of the design process. In the *Faraway* project, Andersen, Jacobs, and Polazzi [1] explored story telling and 'suspension of disbelief' within a context of game and play in a design context.

3.2 Building Experience within Performance Practices

In order to provide a context for the techniques we use in our workshops, we introduce an overview of some of the work that has been explored in the performance domain related to constructing models of experience. This discussion is by no means complete, but suggests a range of models that can be borrowed in order to define experience methodologies. For example, Dance Analysis and Somatics specifically construct systematic articulated movement models directly from the *experience* of the moving body. We are interested in applying these models in our work with interactive systems.

Somatics is a term coined by Thomas Hanna in 1976 [12] to label a field that was beginning to develop mind/body integration disciplines using the body as experienced from within. Somatics can be defined as the *experience from within the lived body,* and is an example of first-person methodologies. It includes practices such as Laban Effort-Shape Analysis, Feldenkrais and Alexander technique. From the Somatics perspective, knowledge is constructed *through* the experience of the body [12][13], and requires that experience be directed or focused through *awareness*. Somatics differentiates between conditioning and learning. In these terms, experience alone is not a pre-cursor to knowledge acquisition, since experience alone could result merely in conditioning, or in accessing conditioned responses. In Somatics this would be termed "somatic amnesia". However, when experience is specifically directed through the focus of attention, knowledge acquisition takes place which can be referred to as "somatic learning", an activity expanding the range of what Hanna [12] terms volitional attention. In our workshops, we specifically using methods to direct and access attention, (what we termed earlier as *attention modeling).* Attention modeling enables us to create affordances to access specific body states that increase awareness. In our workshops, we were interested in creating repeatable, enactable, embodied states that could be used in interaction design. While Csikszentmihalyi [7] suggests that human experience operates within a limited field of attention, other movement systems within Somatics consider attention to be a *generative* attribute of awareness that can be augmented, increased through a process of somatic learning [12], or conversely, limited or atrophied through a process of somatic amnesia.

Rudolf Laban's movement analysis systems [15][19], and the work of other researchers such as Bartenieff [2] and Blom and Chaplin [3], are examples of physical methods to create gestural typologies based in experiential practices of dance [24][25]. These systems model a range of qualities and modes of movement. Laban and Bartenieff's work creates a systematic description of qualitative change in movement. Blom and Chaplin create a set of exercises that explore choreographic techniques for movement generation. We use aspects of these typologies for gestural mapping and modeling qualitative movement characteristics such as intentionality, interest, attention and body state. They present experience models for the classification of aspects of movement, and define a means to approach gestural and choreographic protocols.

Participatory design, experience design, performance, theater, dance and somatics share a common focus in modeling or representing human experience. These domains also share the ability to articulate and explore engaging experience through movement, emotional response, sensorial qualities, and temporal/dynamic qualities of experience and of movement.

4. EXPERIENCE WORKSHOP DESIGN

To develop an interaction model for our installation, a series of workshops were designed. The workshops modeled participant experience of non-verbal expressive gesture that shared and communicated physiological data. At the beginning of our workshop process we included four categories of physiological data: breath, heart rate, galvanic skin response (GSR) and brain signals. The workshop exploration utilized choreographic methodologies in order to create gestural movement vocabularies.

Figure 2. Experience Modeling *connection* and *extension*

In the context of this work, workshops are a formal, scripted experience in which a specific physical experiential concept is explored, tested and documented for the purpose of developing an interaction model. The term workshop is borrowed from its performance context, where a script or form is 'acted out', 'acted through', and explored with the intention of testing, developing and iterating a theatrical model. This theatrical model also becomes the foundation for the interaction | technological model: the model that provides a basis for the development of the interaction through the technology. As with the theatrical model, the interaction | technological model, includes a set of experience concepts such as intention, gesture, direction of focus or attention, relationship, rhythm, body-state, and use of, and attitude to space. This model creates a formal container for experience that includes a physical as well as technological description, and is a process that enables an evaluation, assessment and analysis of the formal relational elements that operate successfully or unsuccessfully in the construction of that experience.

4.1 Workshop Design: First come First Play

We made use of a series of workshops in order to investigate and prototype the representation of experience for the forthcoming installation. The workshops were designed in the following manner: Each workshop had up to 12 participants with a maximum duration of about 45 minutes. Participants were students and employees at Simon Fraser University and participation in the workshops was assigned on a *first come first play* basis. Invitations were e-mailed to the University School community each week, with a simple subject line such as "invitation to listen", where <listen> is the title of the workshop. Contextual or conceptual information was purposefully left out of the e-mail exchange and workshop formats, creating an affective, metaphoric, yet ambiguous framework [11] for the invitations. The workshops took place once a week over 5 weeks. Each workshop was divided into two components or exercises that encompassed an overall theme represented by the name of the workshop. Each exercise was based on clearly stated tasks represented by the theme. For example, the exercises in the <listen> workshop were *listen inside* and *listen outside*.

The facilitation of the workshop followed a designed script, and attention was paid to using everyday non-specialized language. The themes/names of the workshops were *listen, between, mutate, extend* and *phase*. After each segment of a workshop the participant was asked to write their experiences on a single card which included two to three simple open ended questions. Participants were given time to write, note or draw their experiences in long-hand written "journaling" form. The workshops were conducted in a 'blank' circular space delineated with 'theater black' curtains. The workshops were videotaped and photographed throughout.

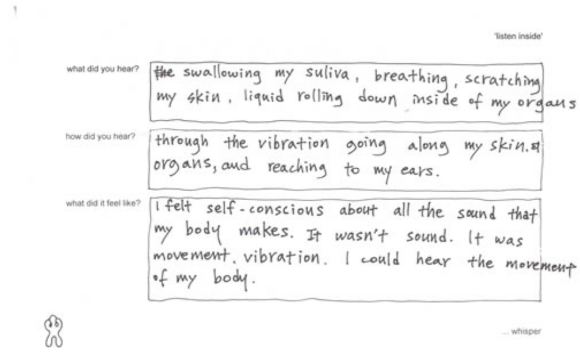

Figure 3. response card example

In the following section we describe a selection of workshop experiences.

4. 1. 1. workshop <listen>

themes: listening/awareness/body-data/self to self

One of the major themes of *whisper* is the notion of 'paying attention' to one's self. As the installation centers on measuring physiological data as a representation of one's own self, data that we are not normally aware of in our day to day life, the first series of experiences and experience questions relate to how we perceive and deal with shifting attention to our own data, to having access to, and agency over our own heart beat, our own breathing, our own thoughts, our own body.

This experience was initially prototyped in the workshop exercise called <listen>. The participants were asked to walk around until they found a place for themselves in the space. They were asked not to speak. A facilitator then gave each of them a pair of earplugs and they were then left alone with themselves with no further instructions for about 15 minutes. At the end the earplugs were collected and each participant was handed a card (see fig. 3). The card asked the questions: What did you hear? How did you hear? What did it feel like?

In the space of experience, this is the simplest of experiments. By depriving the body of its external hearing we become aware of the internal sound that is otherwise drowned out by the louder external sounds. We are removed from our own ears, but not from our hearing. In performance, artists like Pauline Oliveros and Augusto Boal have created practices such as "deep listening", and "listening to what we hear", which probe and access these very same questions of experience. The responses to the question on the cards: What did you hear? focus on this. Responses indicated the participants' discovery of the internal soundscape.

'Heartbeat; earplugs as they settle, breath, slapping sounds from others in the room; humming noise; myself; contact with my own body'

This seems to trigger strong emotions ranging from slight unease to feelings of fear or elation in the answers to the question: What did it feel like?

'I felt self-consciousness about all the sound that body makes; it wasn't sound; it was movement, vibration. I could hear the movement of my body'

'Pain, shifting between past and present; fear / calm'

'Normal, I'm alive; Invigorating - breath going in and out with "normal" rhythm, and changing properties'

Some workshop participants were able to shift their internal awareness to recognize that listening occurs not only through the ears, but also through the bones, the resonant cavities of vibration in the body, that the body is a metaphor for listening, and that, what is heard, is not only sound, but movement, vibration, feeling, and sensation.

4.1.2. workshop <between>

themes: awareness/attention/sending/receiving/self to other

The ability to transfer data to another person and the willingness to enter into an exchange of information that is otherwise private and 'unknown' is the other main theme for whisper. In order for such a transfer to work, the participant needs to engage or invite trust not only to the other, but also to the 'listening' self.

In order to investigate the invisible transfer of personal data, and the trust of the self, we created a workshop experience we called <between>.

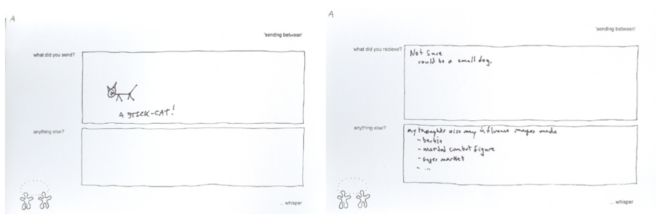

Figure 4. sending and receiving invisible signals

At the beginning of the workshop, the participants were asked to find a space for themselves and begin to move in slow motion, as slowly as possible. They were then left to move very slowly for 10 minutes without speaking.

In Dance practices such as Butoh, this technique is utilized to enable the body to shift its attention to an immersive state in relation to its environment, what Csikszentmihalyi would term 'flow', where attention is intensified, and sensory details are sharpened.

The workshop participants were then asked to pair up, with one person selecting the role of *the sender*, and the other selecting the role of *the receiver*. The sender was asked to silently create an image for two minutes, and then send the image to the receiver, while the receiver was asked to simply pay attention to 'listen' for what image 'came to mind'. At the end each participant was handed a card with the questions: What did you send? What did you receive?

What did you send? *"A stick cat!"*

What did you receive? *"Not sure, could be a small dog"*

4.1.3. workshop <extend>

themes: transfer/sharing/play/self to other

As stated in the previous workshop, transferring private, internal and personal data to another person requires a willingness to enter into a private exchange of information. The participant needs to invite trust with the other, and also engage in a level of agency as to whom, and where, this exchange takes place.

We wanted to continue to investigate these issues of privacy and trust using physical objects that could mediate the interaction through physical gesture. We created a workshop experience we called <extend>, which augmented the invisible data with a non-digital amplification device. The participants were given ordinary medical stethoscopes and a small booklet with ten identical pages. On each page there was space to write or draw and each page had the questions: Where you listening? What did you hear?

'I felt like I was inside myself the pounding amplified my perception of myself, yet my breathing made me feel close'

'My friend stood up and tried to hear my heart, it was hard, I heard my heart, I heard low voice'

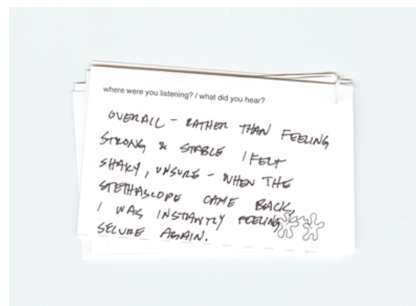

Figure 5. Response Card Sharing Physiological Data

By introducing the stethoscopes we gave access to another type of body data. More importantly, we introduced the possibility of sharing this data with someone else. The design of the stethoscope with a 'listening' end and a 'probing' end allows for the data to be shared by either probing someone in order to investigate their data, or giving someone the earpiece to offer them a particular sound. The latter gesture of offering inverts the interaction model of probing or surveillance, to an interaction which invites and affords intimacy, trust, and peer connection.

4.1.4. workshop <mutate>

themes: permission/control/exchange/touch/islands/snaps

By introducing the possibilities for sharing we immediately encounter notions of permission, surveillance and thresholds of privacy. The following workshop introduced Galvanic Skin Response [GSR] data, and investigated thresholds of boundary, agency, and control.

In the first exercise of the workshop the participants were given white men's shirts that were attached by simple sewing [basting] into pairs at various locations such as the seam of the sleeves, the back shoulder seam, and the seam at the cuffs. Each shirt pair set had a unique contact seam; no two pairs were connected identically.

Figure 6. Exploring Transfer | Play | self to other

The participants were instructed to put on the shirts and button them up. This is a difficult task that requires the pairs to cooperate, both physically and socially, but it also dictates a close proximity between the participants. A series of movement related tasks followed. As in each workshop experience, following the experience, participants were given cards to fill out. An example of the challenges in allowing this proximity is present in an answer to the question: How did you change?

'I wouldn't have gotten that close/intimate under normal circumstances'

In the second half of the workshop the participants were grouped again in pairs and given primitive boards that measure GSR. The boards were constructed in such a way that one of the participants is wearing the sensors [simple metal points of two fingers] and the other has the output [a red LED] pinned on the shirt and connected to the board with a long wire. As the GSR goes up or down the red light brightens or dims. The participants were also given small booklets asking the question: What did you feel?

'As an observer, a recorder, an instigator, responsible'

Here we see an example of one type of response to this particular sharing situation. The first responder classifies him/her self as the passive observer of the other, but since the output of the GSR is closely related to emotional excitement this observer, also feels involved and responsible. By taking responsibility for the output you also take responsibility for the object of your observation.

'I do not know, Dennis is not showing me my output, I will attempt to limit my input to nil, to avoid detection'

This is an example of another group of responses. The observed party feels exposed by the observer not allowing access to the output data and as a consequence the observed participant will deliberately try and influence the result. In this way the observed party changes the rules of engagement and turns what was a probing of emotional personal data into a game.

Figure 7. Extension | Creating One Larger Body

4.1.5. workshop <phase>

themes: extension/body image/creating one larger body

By creating gestural protocols that facilitate sharing and exchange there is a potential blurring of the boundaries between the participants as well as between what is inside and what is outside.

The next exercise is investigating this blur, as we asked participants to put on men's shirts again. This time the shirts were given sticky Velcro patches to apply connection points anywhere they wished. The participants were then encouraged to experiment with moving as each pair of shirts have different possibilities for movement and control. The cards asked the questions: How did you extend yourself? How did you move?

How did you move?: *'Held hands with someone other than my husband; became silly; enjoyed the unusual and unknown; became aware of another's movement'*

How did you move?: *'I found myself thinking of our 'body' as a complete unit - it just had this other piece I wasn't controlling; the attached arm felt very unusual once I got complete control back'*

How did you move?: *'I was no longer just myself, I had to extend myself to become a part of a whole; as a whole we had to work together; when we failed it was almost disappointing because we were apart'*

Here we see several examples of body extension. It is interesting to see the apparent disappointment when the appropriated body gets separated or the combined body fails to complete a movement task.

4.2. Workshop Results: Experience to Gestural Protocol

During our design workshops, gesture was utilized as an expressive indicator of intentionality, body state, extension of body image, permission, control, exchange and play. The workshops were modeled using a broad range of performance techniques. Improvisation was used in all five workshops, improvising both movement and stillness. Stethoscopes, ear-plugs, blindfolds, heart monitors, GSR sensors were used as props. Men's White Shirts became phantom partners, prosthetic devices and placebo objects. The simple 'black box' curtained circle became a ritual space. We modeled the use of physical attention that incorporated listening, 'sending' invisible messages, and touching to connect one's self to another. We used imagining and visualization to explore movement vocabulary. We focused on somatic attributes such as breath, stillness, and slow motion movement. Journaling in both hand-writing and drawing was used as a method of documenting, archiving and expressing. The workshop participants integrated social navigation using gesture to express permission, trust, exchange, and feeling. And the white shirts as costumes along with various props, modeled and expressed physical extension, connection and group identity. The design of the stethoscope with a 'listening' end and a 'probing' end allowed some participants to invert the normalized medical surveillance 'probing' model of listening in favour of giving someone their earpiece to offer them a particular sound.

The workshops contained a broad range of experience results that enabled us to construct gestural protocols within the installation. We continually came back to the main theme found within the workshops, and the artistic aim of the installation: that 'paying attention' to one's self enables a re-direction of attention with a greater access to optimal experience [7]. The workshops responses illustrated that the body can become a metaphor for listening, and that what is heard, is not only sound, but movement, vibration, feeling, sensation, and the self. We discovered that some workshop participants were able to shift their internal awareness to recognize that listening occurs not only through the ears, but also through the bones, the resonant cavities of vibration in the body.

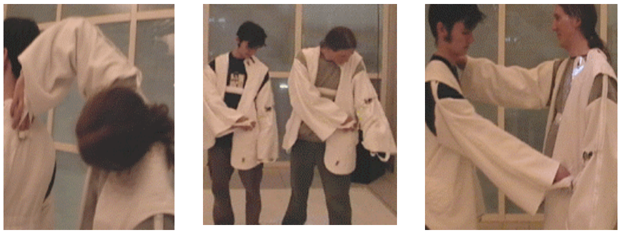

Figure 8. Gestural Interaction in the Installation

In Theatre and Dance practices such as Noh and Butoh, the slow motion technique used in the <between> workshop enables the body to shift its attention to an immersive state in relation to its environment, where attention is intensified, and sensory details are sharpened.

Augusto Boal [4] terms these types of experiential exercise *de-specialization*. He states that in our every day lives "the senses suffer. And we start to feel very little of what we touch, to listen to very little of what we hear, and to see very little of what we look at. We feel, listen and see according to our specialty. The adaptation is [both] atrophy and hypertrophy. In order for the body to be able to send out and receive all possible messages, it has to be re-harmonized [through] exercises and games that focus on *de-specialization*." Our workshop series are related in form and function to Boal's *arsenal of theater series* of *listening to what we hear,* exercises of the *4th series:rhythm of respiration*, and *5th series: internal rhythms*.

The workshops met their goal of modeling experience that could be replicated, re-enacted, and re-played in the context of a public art installation using wearable computing technology, where the public art space was simultaneously intimate, playful, and social. As a consequence we selected a subset of successful gestural interactions to be specifically modeled within the installation.

5. DESIGN CONSEQUENCES

The workshops were the basis of the concept design, interaction model, and development of the *whisper* installation. The workshops made it possible to probe and investigate the underlying interaction issues early on in the hardware and software development process. A significant design outcome from this process was the importance for each body to physically control access to their privacy, and allow shared play of their own body data. This was enacted in the installation by the Gestural Protocols discovered during the workshops, where costumes or white shirts expressed physical connection and extension of the body through 'sticky' connection points.

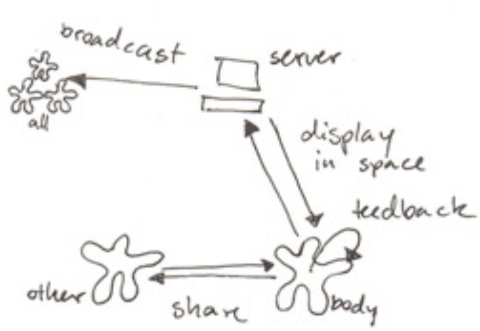

Figure 9. State Spaces: Self to Self | Self to Other

In the workshops these connections were 'sewn' together, or explored through Velcro fabric swatches that enables participants to play with connection placement. These connection points were engaged through 'feel' or 'touch' rather than through a visual symbol or natural language interface.

As a consequence of this workshop exploration we designed a tactile interface to the wearable garment. This consists of a set of wired clothing snaps attached to the right hand fingers of the participant and a series of tactile 'islands' placed in various positions on the wearable device. These islands are small id chips wired up to matching sets of snaps. By touching the snaps of an island with the finger-snaps the participant can choose and mix between the different sets of body data coming from his or her own body.In order to access data you have to negotiate physical and social interaction of touching someone.

Figure 10. Garment Design | Snaps | Connection

The islands are made from different textures to allow the participants to navigate the data through touch and feel.

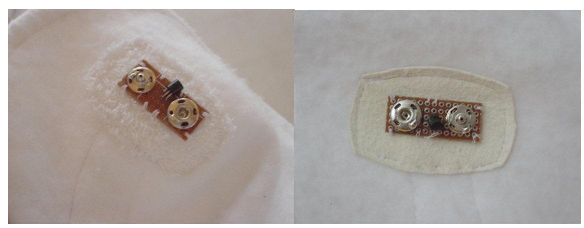

Figure 11. Snap Islands "Textural" Recognition

6. CONCLUSIONS

Our work in designing and testing experience models has illustrated that we can augment experience design with first person performance methodologies found in Theatre, Dance and Somatics. The differing frames of reference between the domains of HCI and performance practice reveal an under-theorized area of practice, which can be explored through experience modeling. We have explored embodied interaction as a reflective process that is simultaneously inter-body and intra-body. In addition, we have provided a case-study for a model of designing embodied interaction. We have applied the use of gesture as a "function organ" [18], as a mechanism that can assist in defining properties for an interaction score that Grotowski [23] describes as scripts, or *points of contact.* The experience with the installation illustrates that participants can learn to shift their own threshold of attention, awareness and body-state through the interaction affordances created within the gestures and embedded within the garment. They participate in "becoming expert" users of their own physiological data, and in playfully engaging with an emerging co-operative and physically and emotionally negotiated body state and collective system state. Social navigation is created through the participants' perceived internal body data flow [through the fingers, or connection snaps] and represented through the actual data flow [through the server]. As such the installation is also its own experience workshop, and is a starting point to continue to explore methodologies of experience modelling.

7. FUTURE WORK

As an installation, *whisper* was an initial exploration of modeling experience through gestural protocols that led to the design of an interaction language facilitated by wearable garments. The *whisper* hardware remained relatively low level due to bandwidth and memory constraints, physiological data patterns were explored directly through server-side visualization, without the development of context aware intelligent devices. Mapping more complex data relationships to body state and intention were not explored or modeled in this work. *whisper* illustrated that participants could become playfully engaged even in simple feedback loops of "attending to" their heart rate and breath, and sharing that data with other in the space. *whisper* also pointed to next steps in research: exploring mapping and 'meaning' in data patterns across participants body state, extending types of physiological data [brain waves, GSR, temperature], types of output actuators [vibration, local sound, local motor memory], as well as building an intelligent model of interaction which includes memory, resonance and meaning in the devices themselves. Perhaps most importantly, we are interested in continuing explore workshops that model experience by bridging first person methodologies used in performance practice with those of interaction design.

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Cross-Dressing And Border Crossing: Exploring Experience Methods Across Disciplines

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Abstract
As designers of interactive systems (spaces, process and products for people), we find ourselves stretching the limits of methodological structures that enable us to explore, build, communicate, and prototype experience. This workshop aims to investigate divergent disciplines that each contains rich knowledge and rigorous methodologies for for addressing human experience in interactive systems.

Categories & Subject Descriptors: H.5.2 [Information Interfaces and Presentation]: User Interfaces — Theory and methods; H.53[Information Interfaces and Presentation]: Group and Organization Interfaces — Theory and models; [H.1.2 [Information Systems]: User/Machine Systems — Human factors.

General Terms: Design, Human factors, Theory

Keywords: experience design, interaction design, interdisciplinary methods, prototyping.

INTRODUCTION
As designers of interactive systems (spaces, process and products for people), we find ourselves stretching the limits of methodological structures that enable us to explore, build, communicate, and prototype experience. We argue that designing experience requires a 're-dressing' of methodological practice, and that HCI can benefit from drawing on methodological frameworks that traditionally fall outside of its purview. Domains such as performance, theatre, dance, architecture, conceptual design, industrial design, and visual art each contain rich knowledge and rigorous methodologies for constructing experience. Each of these domains defines experience, experience qualities and attributes, and defines affordances for enacting [and re-enacting] experience as a fundamental methodological tool in the respective discipline.

We invite participants from multiple disciplines across and within HCI, including kinesiology, performance, visual art, architecture, anthropology, organizational research, computing science, visualization and engineering. Participants are expected to be practitioners exploring unique methodological frameworks for designing technologically mediated experiences that live in technologically mediated environments. Participants will be expected to share, explore their methodologies for constructing and designing experience. Our fundamental assumption is that experience matters. We assume that an understanding, exploration and sharing of experience design is central to HCI. Building experience is an interdisciplinary practice, we invite participants to share and explore the diverse practices that contribute to the evolution of methodologies for designing experience.

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GOALS OF THE WORKSHOP
The focus of this workshop is to cross boundaries, assume other roles in order to experiment methodologically and to establish a new common knowledgebase aimed at design and human experience. We see this as a step toward establishing a community of practice within HCI. We propose the following key issues as points of departure and exploration during the workshop:

- In today's HCI landscape, experience is felt, defined and modeled across multiple media and disciplinary domains, and environments. This provides a scope challenge that requires creative solutions derived by a diverse community of practice.
- Members of this community can engage each other in a cross-disciplinary dialogue around the task of creating positive "user experiences".
- In doing so each practitioner sits at the experience design table with a slightly different set of assumptions, knowledge, methodology and context around what it means to consider user experience.
- The considerations related to user experience in each discipline are unique and valuable in their own right. It is important to recognize this and embrace alternate perspectives.

THE WORKSHOP ACTIVITIES
The workshop will be divided into three main parts with the key goals of finding a more common language around problem setting, hybridizing practices for the development of criteria for new methods, and reflecting on the cross-disciplinary practices of each team.

Part 1. Problem setting: Organizers and participants will present and review several of the experience scenarios. Activity and discussions will center on developing a set of shared analysis and language for defining and problem setting interaction experiences. In addition to discussions, organizers expect group activities in the form of role-playing, re-enactments and re-articulations as a form of analysis.

Part 2. Practice and play: Teams will brainstorm and "prototype" new methods that could address the understanding of the problem articulations that emerged in part 1. The activities will shift from structured "brainstorming" to open ended development of a method within a condensed period of time. The activity will end with a "swapping" of methods to be used by another team to address the problem situations form part 1.

Part 3. Reflection and mirror-gazing: A key goal of the workshop is to identify criteria for new methods while also identifying the rich and diverse set of practices that can be pulled in within HCI in order to respond to experience interaction situations. Teams will be asked to discuss and report out on three key items: criteria for methods, identification of the intertwining of practices within their methods and methods from other teams, identify key disciplinary and non-disciplinary connections within the teams and in other teams. The workshop in plenary will discuss the reports as a possible group report that identifies issues of methods, cross-disciplinary knowledge sets, and key relationships and connections that could form the basis of a community of practice centered on human experience.

RELATED LITERATURE

Terry Winograd was among the first to identify a design practice whose outcome and focus was a qualitative process rather than a "thing" or an object [14]. He labeled this new practice as "interaction design". Winograd identified the need to focus on the perceptual and psychological aspects 'of human experience by rooting interaction design equally in graphic design, psychology, communication, linguistics and computing science. A key genesis point in the evolution of "experience" as a design concept is the work in the 1930s of the industrial designer Henry Dreyfuss [3]. Dreyfuss' work in ergonomics lead to the publication of the "Measure of Man", an extensive database of human measurement to facilitate the design of products tailored to a 'standardized' human body. In the late 1960's ergonomics split into the related science and kinesiology based field of human factors, the political and social movements in Scandinavia that became known as participatory design [4, 8], and the cognitive science and design methodology of user-centered design [11]. Design experience was seen in surprisingly different lights, one functional the other social and political. Enabling the audience experience was also a key goal of theorists and practitioners of the fields of performance and theater, namely the Russian, Vsevolod Meyerhold [1], and later the work of theorist and theater director Jerzy Grotowski [6]. This tradition directly informed the concepts of interactive design from the early work of Norman Bel Geddes [9] to today's interactive technology experiences and environments [2, 10]. In the field of computing science, particularly in the field of HCI (Human Computing Interaction), experience design is viewed as an extension of user-centered design methods [7, 13]. This approach has a particular focus on the "User Experience" aspect of design, in particular, quantifying the interactive experience as a means to determining standards for interface and interaction design. On a methodological note, some of the framework of this workshop is indebted to the work Donald Schön and Henrik Gednryd [5, 12]

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FlowField: Investigating the Semantics of Caress

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1. Introduction

We have created a new interactive experience piece called FlowField. Participants touch and caress a multi-point touchpad, the MTC Express, in a CAVE (CAVE Automatic Virtual Environment), directly controlling a flowing particle field. Collisions in the particle field emit musical sounds providing a new type of musical interface that uses a dynamic flow process for its underlying musical structure. The particle flow field circles around the participant in a cylindrical path. Obstructions formed by whole hand input disturb the flow field like a hand in water. The interaction has very low latency and a fast frame rate, providing a visceral, dynamic experience. In FlowField, participants explore interaction through caress, suggesting reconnection with a sense of play, and experiencing a world through touch.

2. Interaction Experience

The FlowField installation allows participants to immerse themselves in a virtual flow field of particles (Fig. 1) displayed on a four-screen CAVE. By using hands and fingers on the MTC Express, users can interact directly with the flow by introducing obstructions in the path of the particles (Fig. 2). The effect is not unlike placing one's fingers into a stream, experimenting with blocking the flow of water. The experience is complemented by a dynamic soundscape caused by the particles striking the obstructions. The combination of sound and visual sensations brings the interaction activity to life, ebbing and flowing in intensity with the particle flow, as directed by you.

By applying one's hands and fingers onto the MTC Express in different ways, interesting flow patterns can be developed that are aesthetically pleasing. Multiple touchpads can be used to enable a group of users to interact with the same flow field, creating an interplay of particle and sound between users, who can work with, independently, or against each other to generate complex interference patterns, all while immersed in the swirl of activity.

3. Motivation

The human sense of touch is as well developed as our senses of sight and hearing. Yet, while there are plenty of devices that deliver and receive visual and auditory information, the same cannot be said for the tactile sense. Even with very complex and compelling virtual reality display systems such as the CAVE, there is often little means of providing tactile input. The FlowField system instead uses the pressure-sensitive, multi-point MTC Express, developed by Tactex Controls, Inc. to give users a new form of tactile input.

Another purpose of this work is to explore the semantics of gesture and its application in interactive systems. In particular, the nature of the touchpad allows us to study interactions between the hand and a solid surface. The important property of this type of interaction is the inherent repeatability of gestures when performed on a fixed surface. This is in contrast to unconstrained gesturing, such as sign language, which can be recognized using glove-based devices or video capture.

4. Related Work

FlowField exhibits several attributes necessary for a compelling interactive installation, including instantaneous response, implemented with low latency and fast sample and rendering rates, and a balance between visual and musical quality [Fels et al. 1997; Fels and Mase 1999]. Furthermore, having a direct relation between action and result and a reflection of self in the stimulus (hand shape seen in obstructions) is an innovation.

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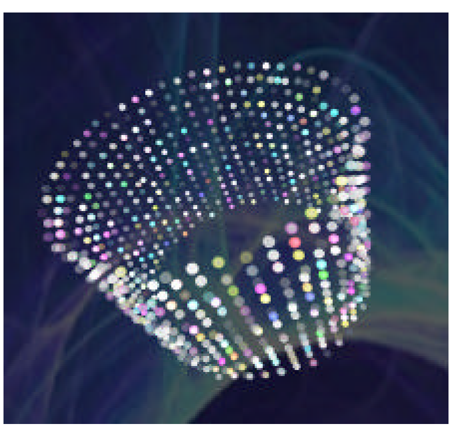

Figure 1: Cylindrical particle field. In virtual space, users are standing inside the cylinder while the particles revolve around them.

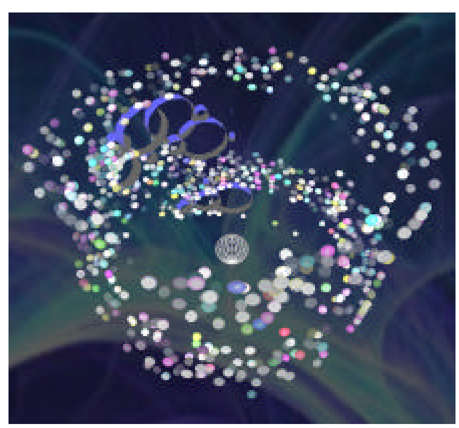

Figure 2: Whole-hand input from the MTC Express creates obstructions (blue circles) that affect the flow of the particles.

Extending Interface Practice: An Ecosystem Approach

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Abstract

Interface ecology is an emerging metadisciplinary approach, in which the creation of rich interactive experiences spans n disciplines -- such as computer graphics, mathematics, gaming, visual art, performance, and cultural theory. Interfaces extend beyond interactive artifacts, activities, and social spaces, forming intricate ecosystems. Interfaces are the catalytic border zones where systems of representation meet, mix, and recombine. Through this recombination, interface ecosystems generate fundamental innovations of form, experience, knowledge, and technology. This panel brings together a diverse range of practitioners who work from concept to experience not in terms of a particular discipline, métier, or medium but with a practice that interconnects multiple systems, forming a whole.

Keywords: interface ecology, interface, metadiscipline

1 Introduction

The creation of rich interactive experiences spans an n-dimensional conceptual space, in which disciplines -- including computer graphics, mathematics, gaming, visual art, performance, and cultural theory -- function as basis vectors. Interface ecology is an emerging metadisciplinary approach. In this ecological approach to interface, developers assemble diverse media (along with their epistemologies and creative, technological and semiotic processes) as expression. This gives form to human experience.

In social spaces, people's activities and behaviors are connected through interactive artifacts, processes and experiences. Interfaces extend beyond these artifacts, forming intricate ecosystems. Interfaces are the border zones where systems of representation meet, mix, and recombine. Through this recombination, signs - the semiotic units of meaning -- flow into new configurations that engage participants. The structure of interface ecosystems has a catalytic effect on these processes of recombination and engagement, setting emergent phenomena into motion. Interface ecosystems generate fundamental innovations of form, experience, knowledge, and technology.

This panel brings together a diverse range of practitioners who work within an ecological framework: *who ecologize*. Each of the panelists moves from concept to experience not in terms of a particular discipline, métier, or medium, but with a practice that interconnects multiple systems, forming a whole. They will discuss their processes of assemblage, and results that have emerged. They may also look to the future, and brainstorm about how the ecosystems approach will influence new interfaces.

2 Natalie Jeremijenko

Validating Interaction with Tangible Devices

Tangible interfaces to information technologies combine digital information and physical devices. These have proven popular, mediagenic, and yet remain difficult to validate. Of the accounts for the success of these interfaces, none provide empirical evidence or measures. I will present recent studies that examine the interactive activity with tangible interfaces, vis a vis a screen based display of the same information and purpose. The common claim, that Tangible Media is 'more intuitive' by virtue of its familiar physical form, is refuted by this data. Naive users made more errors with the tangible media devices than with the well-codified interaction strategies of screen based interaction. Nonetheless, this work does find evidence for the effectiveness of Tangible Media. Understanding how tangible media works requires the capture and measurement of the interaction through over and around, rather than with interfaces. This study presents evidence for understanding: a) the role of the physicality of tangible media; including its persistence and attention directing function; b) the role of peripheral participation, monitoring and interaction in the different contexts and applications; c) the role of shared use on interaction including: how errors are corrected and variability managed; how skill is developed; how to characterize a 'use career' of these applications; how multi-user interfaces effect the single user interaction; what aspects of the information and interaction scripts presented are legible to a wide variety of users and which are prone to more misinterpretation (or variability in interpretation); the role of open-ended interaction scripts.

I will show video data of the interactivity that is staged around the tangible devices in four studies. Building on these findings, I present several new projects that extend the potential of Tangible Media. One set of projects exploits mechanical actuation as the parameter with which to display information, and a second set of projects adapts the nonphysical strategies of tangible media to several screen-based interfaces.

Natalie Jeremijenko is a design engineer and technoartist, whose work examines how technology works, in technical and social accounts. Recently she was named one of the top one hundred young innovators by the MIT Technology Review. Her work has been presented at Tate Gallery, MASSMoCA, Rotterdam Film Festival (2000), Guggenheim Museum, Museum Moderne Kunst, Frankfurt, LUX Gallery, London, Whitney Biennial, Documenta, Ars Electronica, the Museum of Modern Art in New York, and at MIT Media Lab. She was a 1999 Rockefeller fellow. She did graduate engineering studies at Stanford University in Mechanical Engineering, and at the University of Melbourne in the History and Philosophy of Science Department. She is known to work for the Bureau of Inverse Technology.

2 Thecla Schiphorst

Body Interfaces: Navigating Sense and State Space

Dominant western paradigms underlying the development of digital technologies have typically excluded knowledge domains of experiential body practice. Interface design can be informed by, and extended through the application of methodologies articulated within these practices. These include fields of somatics, theatre, dance, and non-western movement forms such as tai chi and martial arts. Rigorously articulated, first person or experiential methodologies provide models for knowledge acquisition, information design, networked connectivity, remote sensing and ecological multivocality. Applications of these models suggest an ecosystem approach in which inter-activity is coupled with inter-subjectivity and inter-affectivity.

Body interfaces can share system states between multiple bodies and their multiple interactions. The answer to the question 'What is Body?' is an evolving, shifting construction in the arts as well as the sciences. Within interface practice, intentional grammars can be developed to intermingle meaning, presence and agency. We need to draw on our ability to dynamically map our understanding of 'what is body' into interface practice. We can alleviate current expressive impoverishment to extend dynamic range, by including the intimate, the intelligent, the sensory, and the taboo. I will illustrate these concepts through my work,

In *Bodymaps: artifacts of touch* (1996), the input of touch re-directs and re-posits the habits of our visual perceptual systems. This creates interplay between the liminal, sensual connections made through the direction of the body's attention. *whisper* is a new work based on small wearable devices and handheld technologies. The *whisper* [wearable, handheld, intimate, sensory, personal, expressive, responsive] system constructs networked messages based on inferred states of the carrier bodies [which host the small wearable devices]. *whisper[s]* are wearable body architectures. Intention functions to direct and apply whispered messages, which range between direct and subliminal, suggestive and overt, seductive and definitive.

Thecla Schiphorst is a Vancouver based computer media artist, and an Associate Professor in Interactive Arts at Simon Fraser University. She is the recipient of the 1998 Canada Council biennial PetroCanada Award in New Media. Her formal education in computing science and contemporary dance has shaped her work, which integrates models of scientific representation with the experience of the physical and technical body. She is a member of the original design team that developed Life Forms, the computer compositional tool for choreography, and has worked with choreographer Merce Cunningham since 1991. She is a PHD Candidate in the CaiiA-Star program at the University of Plymouth in the School of Computing, and has an interdisciplinary MA in computer compositional systems from Simon Fraser University.

3 Michael Mateas

Expressive AI

My work is in Artificial Intelligence (AI) based art and entertainment. I simultaneously engage in AI research and art making, a research agenda and art practice I call expressive AI.

Expressive AI has two major, interrelated thrusts: (1) exploring the expressive possibilities of AI architectures - posing and answering AI research questions that wouldn't be raised unless doing AI research in the context of art practice, and (2) pushing the boundaries of the conceivable and possible in art - creating artwork that would be impossible to conceive of or build unless making art in the context of an AI research practice.

The fusion of art and AI can be conceived of in terms of a shared interest in exploring what it means to be human, and a shared methodology of knowing-by-making. The field of Artificial Intelligence is a recent incarnation of an age-old quest or dream, the dream of building an image of the human in the machine. It is this dream, fueled by science fiction representations of AI such as Hal 9000 or Commander Data, which is the initial inspiration for many researchers entering the field. This dream is not just about modeling rational problem solvers, but about building machines which in some sense engage us socially, have emotions and desires, and, through our interactions with them, tell us something about ourselves. AI is a way of exploring what it means to be human by building systems. An AI architecture is a machine to think with, a concrete theory and representation of some aspect of the human world. Art also explores what it means to be human by building concrete representations of some aspect of the human world. Artists often explore aspects of humanity which have been under-explored or ignored in AI research.

Combining these two ways of knowing-by-making opens a new path which takes seriously the problem of building intelligences that robustly function outside of the lab to engage human participants in intellectually and aesthetically satisfying interactions which, hopefully, teach us something about ourselves.

My presentation will explore methodological and conception issues in expressive AI, particularly the notion of a doubled system which consists of a technical machine engaging in uninterpreted computation, and a semiotic machine which organizes the rhetorical strategies used to narrate the operation of the machine. These ideas will be illustrated with example AI-based artworks, such as the interactive drama, Facade.

At Carnegie Mellon, Michael Mateas is adjunct faculty member in the Entertainment Technology Center, Research Fellow in the Studio for Creative Inquiry, and a PhD student in Computer Science. Michael has presented work at SIGGRAPH, New York Digital Salon, AAAI, the Carnegie Museum, the Warhol Museum, and the Walker Museum. Previously, Michael worked at Intel Labs, where he co-founded GEAR (Garage Ethnography and Applications Research), a research group employing ethnographic techniques to understand how new computing technology fits into people's lives. Michael received his BS in Engineering Physics from the University of the Pacific and his MS in Computer Science (emphasis in HCI) from Portland State University.

4 Wolfgang Strauss

Interfacing Mixed Reality as an Ecology of Aesthetics

To connect the notion of interface with the term ecology reminds me of a passage by Paul Virilio: "traditionally architecture and design are related to interface the exterior world to the human, the design of landscape, buildings, stages etc.; now we have to care both for design of exterior and interior spaces; those new electronic interior spaces, mainly imagery, build up the look and feel of our electronic mindscapes. They are part of the urban ecology."

Unfortunately, ecology in our built environment is usually fed by very traditional visions directed backwards. This makes life quite boring. An example arises in Berlin, a former focal point of cold war. There is a serious decision about rebuilding the traditional heart of the city. The Schloss (castle) represents the hierarchical Prussian state of last centuries. Situated on the Schloss site, and opposite the central government building of the former GDR, the Palest deer Republic (palace of republic), has been renovated at a cost of 80M Euro, due to the ecological disaster of asbestos contamination. The palace building is now finished and will be closed for demolition. Estimated costs to run the building in a provisional condition, giving space for emerging culture, is just 1.7M Euro. Politicians say: "No money, no way."

The vanishing aesthetic awareness of public spaces is beaten by digitized consciousness, somewhere on the net, in favor of a castle in the air. What we really need are interfaces for living in mixed realities, creating ecosystems rather than constructing artifacts.

The goal of the development of netzspanung.org is an architecture for making visible the interrelations between media art, science and technology. In order to realize this, we are exploring the extension of the common notion of web platforms as means of presenting and sharing information, toward the model of an *online media laboratory*. By this, we mean a web-based platform that combines tools for contextualization of information into a collaborative knowledge space, with tools for active experimentation with networked media spaces. This takes into account the fact that the use of the web for creation and distribution of information in different disciplines (e.g. art, science, technology) is today perhaps the most significant example of mixed realities: the contents of the web represent a myriad of different perceptions of "realities", of "knowledge about" and representations of the world, expressed as networked constructs combining different media (text, image, video, 3D, mobile communications etc.) and often as a result of a collaborative process. Such a highly meditated situation of communicating and constructing knowledge requires new models for discovering contexts and relationships and for understanding how meaning is encoded in complex structures of networked media. This concern cannot be met with the "old" model of a passive user with arbitrarily intelligent" technologies. Rather, tools that enable (empower) the user to actively explore her/his own ways, and construct her/his own models for dealing with information, become essential.

Wolfgang Strauss is an architect. He has held teaching positions in Interactive Art at the HDK Berlin, at the KHM Media Art School Cologne, at the School of Fine Arts Saarbrücken and the Kunsthochschule in Kassel. He co-founded Art + Com, Berlin Currently he is research fellow at the Fraunhofer - Institute for Media Communication. In opposition to the theory of the disappearing body, he introduces intuitive interfaces for playful interaction. His work has been presented at ZKM, Nagoya Science Museum, SIGGRAPH, ICC Tokyo, Imagina, ISEA and was awarded with the Golden Nica at Ars Electronica 1992.

5 Will Wright

SimCity and The Sims

One of the primary roles of any designer is to fully represent the end user of a product. As a game designer I find myself not just standing in for the typical player but for all potential players regardless of their skill, interest or motivation. Many recent games are beginning to "leave the box", that is they're using web sites, player customization tools, databases of player-created scenarios and so forth to expand the scope of what users can do with the product. In a sense the players are becoming more and more an integral part of the development team. As a more diverse set of player activities becomes available the players themselves diversify to fill these niches. The different niches of player activity (tool builders, skin artists, web masters, browsers, casual players) grow to be quite interdependent and self-supporting. The game community functions as an ecosystem. As the activities around a product leave the box, so must the responsibilities of the designer. I used to think that my job as a game designer was to create a cool game, I now think my task is to facilitate the creation of a cool community with a game at the core.

Will Wright is the creator of both the SimCity and The Sims franchise. SimCity was released in 1989, and within a few months became a hit. The latest incarnation and definitive version of SimCity, SimCity 3000 Unlimited, has continued in this tradition. Wright's game, The Sims, puts players in charge of the lives of a neighborhood of simulated people. Released in February of 2000, this title has become a cultural phenomenon. The Sims has sold over 5 million copies worldwide to become the best selling PC game of all time. The Sims has inspired four expansion packs; Livin' Large, House Party, Hot Date and Vacation. Combined sales for The Sims' franchise total 11 million units life-to-date. Next up for Wright is The Sims Online(tm). Scheduled for release in the second half of 2002, The Sims Online will enable you to take your Sims to an online world where you get to be yourself or whoever you want to be.

6 Andruid Kerne

The Conceptual Space of Collage

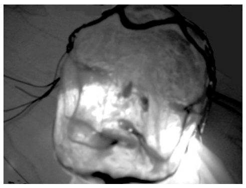
CollageMachine [http://mrl.nyu.edu/collagemachine] is a creative web visualization tool that learns while you surf. Instead of waiting for you to click a hyperlink, the program proactively crawls the web, seeking content of interest. *CollageMachine* parses websites, modeling the web as collections of linked documents and their constituent media elements - images and chunks of text. These media elements continuously stream into a dynamic, user-interest-driven collage.

You can use collage design tools to create your own look and feel. By engaging in visual design, you also express dis/interest in media elements. *CollageMachine* learns about what you like from these interactions, and annotates its model to represent your interests. Decisions about what content to pursue and how to build the collage are made according to the model. The Collage Visualization Grid allocates screen real estate and history-enriches collage elements as a representation of your intentions. Unlike typical information visualization systems, perceptible structure develops bottom up. Navigational trajectories and combinatorial concepts emerge. The user experience blurs boundaries between web browsing and art-making.

The *CollageMachine* interactive artifact and the interface ecology theoretical framework are being co-developed, through back and forth loops of reference on multiple levels. *CollageMachine* promotes the emergence of new ideas through hypermedia combinations. Interface ecology, as a metadiscipline, investigates the process of combining whole systems of representation. This investigation proceeds both structurally, and in the situated contexts of particular applications, connecting theory and practice. For example, through investigation of *collage* and *emergence* -- in the context of *CollageMachine* development -- their application on the conceptual level -- in interface ecology -- became apparent. Thus, in this co-development process, theory does not inform practice simply; rather strange loops of reference, operation, and influence emerge through multiple levels of collage.

Andruid Kerne [http://www.andruid.com] is a research artist scientist who specializes in information visualization, agents, databases, audio, video, distributed real time systems, and public installation. He opens the range of social processes embodied by computational artifacts, for instance, substantiating play as a mode of activity and interaction. His work has been presented at SIGGRAPH, SIGGCHI, the Guggenheim Museum, New York Digital Salon, ISEA, Milia, Ars Electronica, and the Boston Cyber Arts Festival. Kerne holds a B.A. in applied mathematics from Harvard, an M.A. in music composition from Wesleyan, and a Ph.D. in computer science from NYU. Andruid was recently a visiting professor at Tufts University, where he taught courses in human computer interaction, object oriented game programming, and public web installation.

pulp fashion | wearable archi[ves]tectures



[fabricating the whisper project]

authors: Thecla Schiphorst and Susan Kozel

on-line essay at:
http://deaf.v2.nl/deaf/03/ 221-117-229-207-116-102-152-49-79-100-19-11-14-99-208-171.py

wearable I handheld I intimate I secret I personal I expectant I response I system
wireless I heuristic I invisible I sensory I private I environmental I reproducing I system

networked I wireless I computer interactive I telepathy
video I audio I physical responseI invisible I desire
installation I performanceI mapping I unearthing

abstract

This essay explores the conceptual, technological and physical processes of the whisper *project.* whisper *is a major collaborative art research project based on engineering small wearable devices and handheld technologies resulting in a participatory installation.*

whisper *is a [**w**earable, **h**andheld, **i**ntimate, **s**ensory, **p**ersonal, **e**xpressive, **r**esponsive] system which constructs networked messages based on inferred states of carrier bodies – the hosts for small wearable devices.* whispers *are wearable body architectures. This essay elucidates the **creative and collaborative processes** which include collective first person methodologies, and our version of the 'sewing circle'; the phenomenon of the **participatory installation** as an emergent, non-hierarchical performative form; the **aesthetic** of* whispers *which emerge directly from handworked fabrication of the materials: (sensors, circuits, electronics embedded in latex, silicon, rubber, and the body) in a play across the opaque, translucent, transparent; and reconfiguration of **attitudes toward the body** which allow for our corporeal selves to be seen as fluid, networked and dynamic systems with concealed information to be unearthed and mapped onto linked and networked devices.* whisper *appropriates the attention, breath, brainwaves, heartbeat and affective qualities of a community of participants, rewriting them as shared signals on the network. Data flows are generated and represented in intimate connection with the bodies that produce and alter them.*

The concept of 'pulp fashion' is a metaphor for the impermanence of physical states. We borrow from Maurice Merleau-Ponty's concepts of the invisible and 'pulp of the sensible'. whisper *'pulps the sensible', de-frocking the habitual, shredding our non-physical rationality. It 'nips and tucks' at the subtleties of our bodies. As devices are*

designed to link our breath and gesture, pulp fashion also becomes a source of 'inspiration'. whisper *devices intimate the invisible as tactile and kinesthetic. Flesh is the connective tissue spanning the organic and the inorganic.*

.introduction

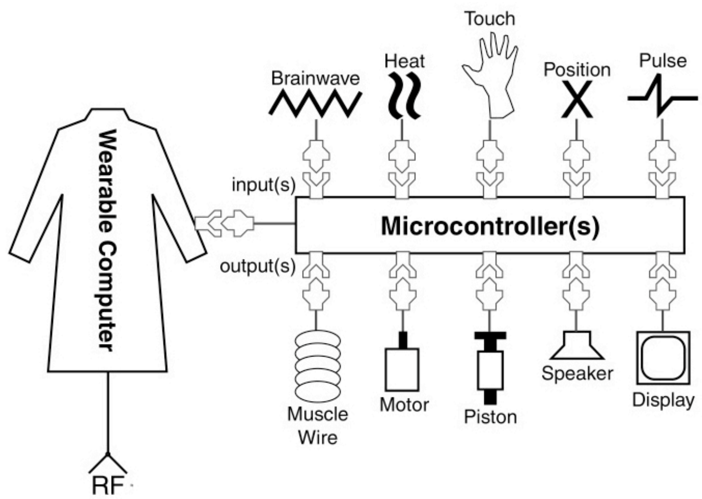
> *Visible and mobile, my body is a thing among things; it is caught in the fabric of the world, and its cohesion is that of a thing. But because it moves itself and sees, it holds things in a circle around itself. Things are an annex or prolongation of itself; they are encrusted into its flesh; they are part of its full definition; the world is made of the same stuff as the body.* *(Maurice Merleau-Ponty, 1961:163)*

whisper is a participatory installation based on small wearable devices and handheld technologies. *whisper[s]* are wearable body architectures. *whisper* networks the inferred states of carrier bodies – the hosts for small wearable devices. *whisper* takes place in an installation space and on the web. It generates and represents data flows in intimate connection with the bodies that produce and alter them. *whisper* builds upon physical practices such as dance improvisation, and manifests cultural and scientific theories of embodiment.

whisper aims to unearth physical data patterns of the body, mapping that data onto linked and networked devices worn close to the surface of the skin. Collections of wearable devices will be networked together, between bodies, or traversing a single body. *A* range of physiologically based input signals will be explored: breath, pulse, brainwave patterns, electrical energy, and temperature. *whisper* appropriates the attention, breath, and heartbeat of a community of participants, rewriting them as shared signals on the network. *whisper* extrapolates from the body onto the larger collection of networked bodies: effectively a **performance** piece in a **social space**.

Both the input and output components are worn close to the skin, on clothing, around the neck, wrist, or ankles, like jewelry, attached to a piercing, next to the heart, or on one's sleeve. Through the use of small motors and sensors, the components can output vibrations, temperature changes, sound, light, color, miniature texts & images, even low-bandwidth video displays. Basic analogue devices are used alongside more sophisticated components (including biofeedback – or brainwave – sensors). A wearer may configure their plugout device(s) to vibrate, tickle, or sigh when it receives data associated with a particular pattern set. Maximum configurability is accomplished by 'plugging in' components, by mixing and matching functions within this modular system.

whisper plays in an ironic way with domains of influence, visibility, and the shifting threshold between the tangible and intangible. The continuum that spans the range between intangible and tangible is a threshold of perception. *whisper* shifts our attention to this mobile threshold and introduces concepts of **future memory** as a function of mapping previous states and extrapolating them into present interactions. As the whisper system evolves over time, it re-visits its past decisions, in the light of current intentions, and recovers past potentials obscured by the initial instantiation of behavior. Not everything can be known at the point of its initial enactment; the past is incomplete and the *whispers* can revisit and reconstruct past views as they progress. The past is not replaced, it is augmented and restructured as the system perception grows. And the rediscovery of the past propagates into the future and the system's anticipated behaviors. Intention is constructed, communicated and functions to direct and apply whispered messages which range between direct and subliminal, suggestive and overt, seductive and definitive. Emerging behaviors are created and based on sharing sense-based communications between bodies that emanate their softly voiced messages within a space.



The overall aesthetic of *whisper* emerges through work with materials. Explicitly stated: the aesthetic of this project is generated by process and practice. We deliberately avoid conventional wearable aesthetics, such as cyberpunk or the current sports accessory look. Our aesthetic comes from designing for invisible connections. It is emergent and ambiguous, almost a 'reconstructed feminine' but with hard edges; it is a juxtaposition of what seems like the 'soft organic' with the 'soft & hard inorganic'. The look and feel emerge from our materials: latex, silicon, rubber, paper, circuits, wires and exposed sensors. Colours include: amber, white, clear, milky, some black and pink. The transparent, translucent and the opaque converge with skin.

> *a taste for the overlaid and the incised: translucency as well as total transparency. (Hawley, 1998:169).*

Skin is the richest source of inspiration: marked, mapped, extended, exposed, nurtured, celebrated. Ultimately, our devices will be fetish items, things people will desire to take home with them to relive their experience of *whisper***.**

> *my flesh and that of the world therefore involve clear zones, clearings, about which pivot their opaque zones, and the primary visibility (Merleau-Ponty, 1964:148)*

research & devising [fabricating] process

The r+d/fabrication process for whisper is based around the simultaneous creation of hardware, software, movement, and textural, material vocabularies. The process is in turn refined and developed through its own iteration. We are committed to social design, performance design, and technical design through **materializing** the *whisper* project. We craft **collective first person methodologies** as processes and strategies for collaboration across scientists, technologists and artists.

The *first person* of these methodologies comes into play through emphasis on design that is intimately connected to the body. Like phenomenology, collective first person methodologies are based primarily upon physical experience, but emphasis is shifted to the collective rather than the individual unit. Each stage of the research period is linked to exploration in the (movement + electronic) studio. Physical improvisation techniques determine emergent movement vocabularies and inform the design process. The process is not simply to import pre-fabricated devices into the studio. All materials and devices are tested physically in collusion with body knowledge, while the hardware/software design occur simultaneously. The creative development of the wearable devices is an embodied and performative process.

We call our process the **sewing circle**. Generally attributed to groups of women, domesticity and textiles, the term is associated with 19th century social and creative processes. This term is employed in the interests of rehabilitating a largely dismissed creative activity. The implied message is of crafting an artifact according to an inherently social and collective design process. Like the members of sewing circles and other creative collectives, we are building our own vocabularies, physical techniques and methodologies. We are also committed to working with textiles and mapping the skills of knitting and stitching onto device design. Our sewing circle may stitch latex and knit with rubber, but we will also wire our bodies into wearable devices and physically improvise, fabricate, and engineer in the studio.

> *The effort to create apertures became much more deliberate, and the pathways of both heat and light emerged as an essential component rather than as the result of applied aesthetics. (Hawley, 1998:173)*

The *whisper* design process iterates across physicalization, conceptualization, device construction, and software development. These are no longer first generation wearables which were basically "one-liners" (strap them on and get the point immediately). The whisper devices awaken in us the knowledge that we dwell in/with/through our bodies, and with dwelling comes a commitment to building relationships. Learning any physical technique is a process of building relationships between our centres of gravity, visual perception, kinaesthetic perception, muscle tension, and communication with others. We become liminal beings as our layers of subtle body knowledge are reconfigured with any new technique, orchestrating the internal with the external until these distinctions dissolve.

pulp fashion

The concept of 'pulp fashion' is a metaphor for the impermanence of physical states, and as such is, for us, vastly innovative and seductive. To fashion is to engineer, create, to sew, to ergonomically render, through a process of nips, tucks, slices and stitches. Enough has been written about commericalization and commodification of fashion (yet more can always be heard about fettishization…). The opulent is fundamentally not about cost but about sensuality. Fashion is the painstaking crafting of the changeable, or the ephemeral. Our bodies are ever changing fields: chemico-perceptual shifts, mood swings, neuro-physical peaks and valleys, kineto-tactile data feeds. Stasis is a myth. We can hardly keep up with ourselves. The suggestion that we are a nexus of information flows is accurate, but only partial. We are these, but we are flesh at the same time. Flesh is not the 'meat' of cyber-lore. Flesh slips through and smothers the tired dualities of mind/body, consciousness/meat. We exist in a network of flesh. Our bodies participate in the overarching "**pulp of the sensible**" (Merleau-Ponty, 1964:268).

Maurice Merleau-Ponty's enigmatic understanding of flesh encompasses bodies, organic and inorganic objects and what used to be known as space.

> *the flesh is not matter, is not mind, is not substance. To designate it, we should need the old term 'element,' in the sense it was used to speak of water, air, earth, and fire… (Merleau-Ponty, 1964:148)*

Flesh contains within its very fabric the connection we feel with the environment, the perceptual play of light and shadow, our embodied selves, and the bodies of others. It is impossible to understand our flesh as it enters into an exchange with the *whisper* devices without the related phenomena of the **invisible** and the **hidden**. The goal, when accessing the invisible (or subtle) is not simply to bring it to the surface so that it becomes visible, just as the point of *whisper* is not to de-frock the subtle, but rather to work in an ambiguous territory, within the realm of the physically and semantically tentative. This approaches the state between waking and sleeping, allowing oneself to remain in that state to witness one's own participation in an alternate flow of activity. A direct or literal exposure of deeper body knowledge would strip it of its essence. The whispering between devices based around the pluggable/unpluggable and reconfigurable inputs and outputs, give us the choice of acknowledging the invisible while retaining its hidden, subtle qualities.

> *the invisible is*
> *1)what is not actually visible, but could be (hidden or inactual aspects of the thing – hidden things, situated 'elsewhere' – 'Here' and 'elsewhere')*

> *2) what, relative to the visible, could nevertheless not be seen as a thing (the existentials of the visible, its dimensions, its non-figurative framework)*
> *3) what exists only as tactile or kinaesthetically, etc … (Merleau-Ponty, 1964:148)*

participatory installation

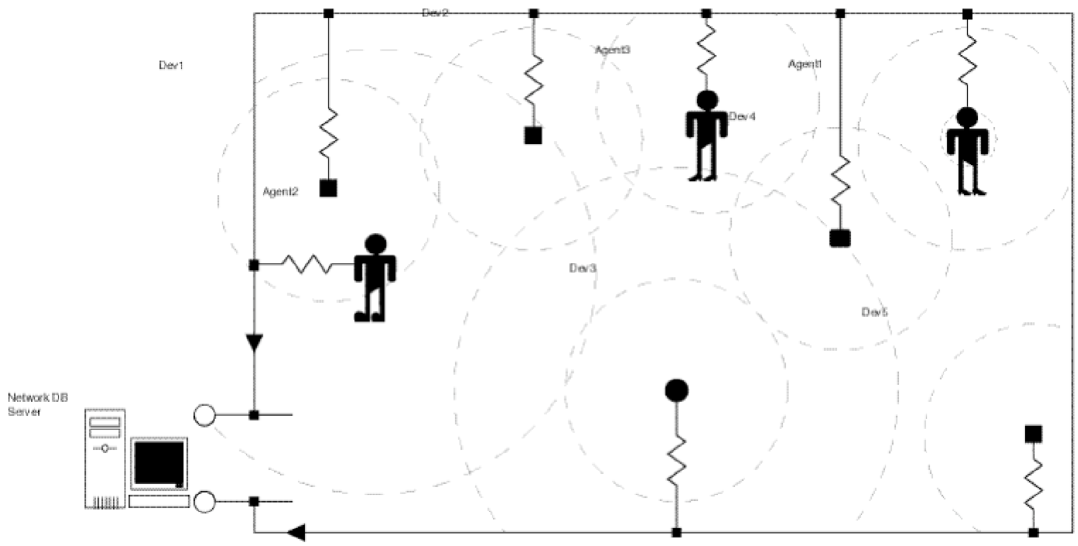
The space of the installation can best be described as a networked ecosystem containing input and output devices. Up to 12 participants may move and browse in and out of the space with access to a set of devices sewn into a jacket or cape, hanging from the grid above or lying on the floor waiting to be picked up. Sound is generated on the body and is affected by the networked data as it is transmitted. The devices will resemble a cross between cyber-jewellery, exquisite art objects, creepy prosthetics, peculiarly ornate theatrical costumes, and body sculpture; they will be a weave of analog and digital components and circuitry. Participants visiting the space enter a community of bodies and objects which have a functionality yet to become manifest. They will be invited to take their place within this ecosystem.

Instead of situating the participants within the flow of a pre-scripted event, they will be involved in a conceptual, physical, aural and visual journey that unfolds according to their participation as a body, as a system. Their responses will drive the experience, and encourage the development of other senses within our synaesthetic matrix of sensory perception and proprioception. It is for this reason that we have coined the term 'participatory installation' to describe form of *whisper.* We foster "a being by porosity" wherein our bodies and the distances between ourselves and others "participate in one and the same corporeity or visibility in general" (Merleau-Ponty, 1964:148).

emanating relationships

Interaction in *whisper* is based on creating and emanating relationships through subtle exchanges between the devices. Each *whisper* device emanates its state to the other whisper devices that are within range. The receiving whisper perceives and incorporates the state space of the other[s]. The state of the whisper device is a direct function of the body that wears it, along with its memory and future memory. Emanation is abstract but perceptible, it implies a sender [source; originator] and a receiver [of the abstract and perceptible thing], and suggests outgoing and incoming signals.

Each device has a *whisper* device-state, and the collection of devices defines the current global whispers system-state. Device states emanate from or are whispered to other devices within proximity of the range of influence. *whisper* devices also 'perceive' these emanations based on their current state, and alter their own state, based on incoming perceptions. *whisper* device states are learned and emerge from living on a specific body, thus representing that body. The whisper devices also remember past bodies and states, and these past lives influence their behavior.



The **device** is a gadget, tool, apparatus, mechanism, appliance, gear, invention, analytic tool, metaphor and literary technique; the device is gendered, an extension of the self, an interface, prosthetic and fetish object. It is an object of industrial design. The design of the device incorporates dominant cultural narrative within its functional and aesthetic properties including the displacement of taboo and desire; the device is a network object, a browser, a search engine, a system and theatre, the device is thought, is telepathy, is our own body.

Our **body as system** creates a metaphor for the operating model of *whisper*. Our bodies are composed of multiple networked systems, which communicate autonomically with each other. So do the devices in whisper. Our bodies are shaped with multiple thresholds that operate in stealth at one moment, overtly at the next moment. These thresholds lie at the liminal boundary of our perception. Our bodies are fluid, networked, and dynamic. Our bodies have secrets, contain multiple intelligences, conceal information in unlikely places, and develop strategies for the expression of current and archived states. So do the devices of whisper. Our bodies surrender things to one another. Our bodies learn, habituate and unlearn by applying directed attention. So does whisper. Any one of our bodies is a 'we'. When our bodies are together they can operate as an 'I'. So can the devices in whisper.

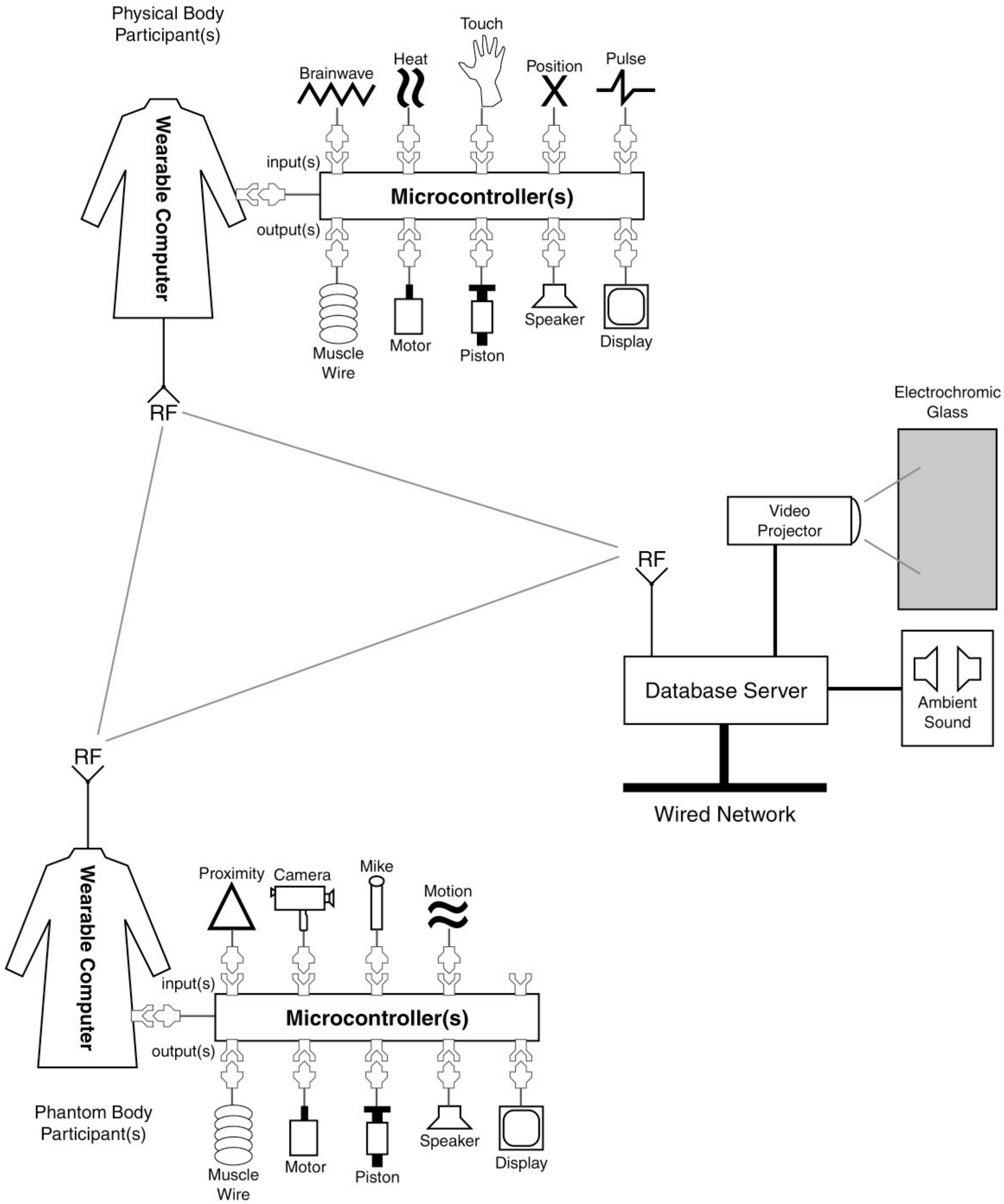
The interconnected, autonomous wearable sensor | actuator collections of the *whisper* system are combined with a local processing module. The processing module, along with the sensors | actuators connected to it, are worn or carried by the body. This processing module (a micro-controller, such as the BASIC Stamp, PIC or a VIA II), gathers the data from multiple sensors and whispers to (communicates with) its neighbors, and a central whisper server, via low-power radio frequency (RF) transceivers. The server, database and micro-controller systems together determine the response to the actuators. They provide feedback in the form of sound, graphics and tactile feedback devices that are worn on the body, along with the sensors. The whisper central server also visualizes and displays a dynamic representation of the system-state both on the web, and projected onto the electrochromic projection display within the installation space.

The sensors that are configured can be roughly divided into three major categories. Direct manipulation sensors require active participation by the body that wears them. Autonomic sensors capture physiological data that is indirectly controlled by the body that wears them, and environmental sensors measure attributes of the space, rather than of individual bodies within the space. Examples of these sensors are:

1) direct manipulation: include touch-sensitive pads, microphones, tilt switches, strain gauges (peizo-electric, bend-sensors).
2) autonomic: include sensors which detect body temperature, galvanic skin response, breath-sensors, brain waves and heart-rate
3) environmental sensors: include ambient heat, motion detectors, position sensors, pressure plates, video and still cameras.

Not all of these sensors need to be used simultaneously. The system design is constructed to enable dynamic configurability and flexibility. This means that different combinations of sensors can be used at different times. There could also be sensor-less microcontrollers that provide localized processing for the system as a whole.

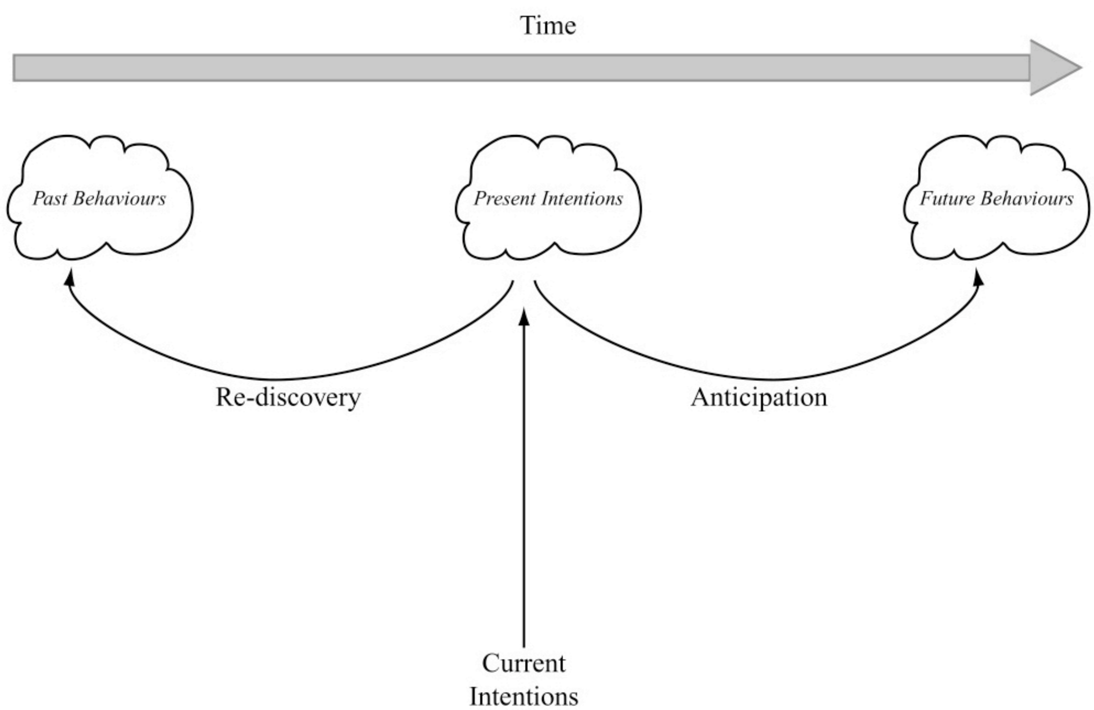

Physical Body
Participant(s)
Wearable Computer
Brainwave
Heat
Touch
Position
Pulse
input(s)
Microcontroller(s)
output(s)
Muscle
Wire
Motor
Piston
Speaker
Display
RF
Electrochromic
Glass
Video
Projector
RF
Database Server
Ambient
Sound
Wired Network
RF
Wearable Computer
Proximity
Camera
Mike
Motion
input(s)
Microcontroller(s)
output(s)
Phantom Body
Participant(s)
Muscle
Wire
Motor
Piston
Speaker
Display

future memory

In *whisper*, the concept of future memory is represented through the dynamic visualization of its own system state. *whisper* maintains and displays a dynamic representation of its memories, the computational equivalent of precognition, electronically augmented telepathy. The whisper devices and participants, through their behaviors anticipate potential future behaviors and state. The state flows from the past to the future; the intentions are always dynamic, as velocities and accelerations of behavior.

As the whisper system evolves over time, it will be able to re-visit its past decisions, in the light of current intentions, and recover past potentials obscured by the initial instantiation of behavior at that time. Not everything can be known at the point of its initial enactment; the past is incomplete and the whispers can revisit and reconstruct past views as it progresses.

The past is not replaced, it is augmented and restructured as the system perception grows. And the rediscovery of the past propagates into the future and the system's anticipated behaviors.



In whisper, communication is characterized by its context: whispers can be *qualified* [in contrast to quantified]. Qualified communication deals with intent: gesture, tone, pitch, repetition, redundancies: are all qualified elements of communication because they provide *context*.

unearthing I hiding

whisper is a foray into the cultural study of telepathy and of mapping techniques: impressions are transferred invisibly, mediated both through body and technology. The research process explores invisible datastreams as wireless networks and suggests, both playfully and literally, that telepathy is the ultimate wireless network. *whisper* builds **wearables for the telepathically impaired**: as 'aware-able' devices, they make bring to awareness functions of embodiment and perception that were previously ignored.

The concept of mapping as a dynamic unearthing knowledge is critical to design and research, and is related to the 'aware-able' device. Mapping is a technique that can help to reveal or define underlying patterns of processes and information. Mapping offers a new view on an idea, a process, an event, an object or a place. Maps provide a means of visualization that might unearth patterns within one of these views. Mapping is a discovery: it may reveal new knowledge within an area thought previously to be known, or it may help in the acquisition of knowledge or experience of what is not known. Rediscovery within known areas is often achieved by combining views which might, at first seem irrelevant to each other, like mapping processes that are not normally regarded as important. This research will map data signals from collected and networked bodies, using sensors that collect physiological data. This reflects the awareness that our bodies are subtly evolving maps of our identities and our lives. *whisper* excavates the invisible. It is a search for lost things.

movement that touches
and movement that is touched
(Merleau-Ponty, 1964:148)

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Using a Gestural Interface Toolkit for Tactile Input to a Dynamic Virtual Space

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Abstract
In this paper, we describe the development of a gesture interface toolkit that has been applied to an application of tactile gesture recognition within an artificial life environment. The goal is to design a gestural semantics of caress, in which qualitative attributes of gesture are expressed as a function of tactility. A touch–sensitive tablet capable of detecting multiple simultaneous contacts was used to provide a source of tactile gestures (stroking, pressing, tapping, wrapping, spreading, pinching, nudging) which were then interpreted by the software as events to be sent to the active creature in the environment. Participants could observe the creature reactions within a three–dimensional immersive display system.

Keywords
gestural analysis, tactile input, gesture recognition, gesture toolkit, immersive environment, Laban Effort-Shape analysis, movement analysis, gesture-based interface, whole hand input, CAVE, Max/MSP, Tactex MTC

Introduction
The Gestural Interface Toolkit (GIT) is an Application Programming Interface (API) for developing responsive systems that require access to tactile feedback devices. The objective of the toolkit is to provide uniform and consistent handling of several classes of input and output, and to support complex analysis and recognition algorithms directly [3]. In this initial implementation of the GIT, Tactex Controls Inc. [7] pressure-sensitive material called Smart Fabric, is being used. This optical fibre array has been packaged into a device called the Multi-Touch Controller (MTC). Data from the device is in the form of a continuous stream of pressure values, which can then be used to detect multiple simultaneous contact points or touches [10]. The sampling rate for the device is comparable to video frame rates, so that the appearance of smooth, instant response is achievable.

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Our goal of developing a gestural semantics of caress requires the development of qualitative models for data flow and data–architecture and the development of semantics for gesture that refines the extension of tactility [2]. Although not yet implemented, new devices, such as six–degrees–of–freedom (6DOF) tracking devices or 6DOF trackballs, biological (heart–rate, galvanic response, brainwave) sensors and as well as sound, graphical and other tactile sensors can be integrated into the Toolkit to provide new modes of interaction [6]. As an infrastructure, the Toolkit has mechanisms to support remote attachment of devices and collaboration between heterogeneous systems, via support of messages through TCP/IP channels.

An existing artificial–life environment was selected as a test–bed for the innovative use of tactile gestural input [4,5]. The environment consists of a community of creatures that evolve under the guidance of a genetic algorithm. There is also a mechanism by which external agents (web browsers or direct keyboard input) can influence the behaviour of the creatures. New "verbs" were added to the system to accommodate the expected behaviours from the Toolkit, which was subsequently adapted to provide a mapping from the detected gestures to this mechanism.

Implementation
Implementation of qualitative semantics is based upon definitions from Laban Effort–Shape Analysis [1] which defines movement efforts based on Time, Space, Weight and Flow characteristics. In Laban Effort–Shape qualitative characteristics can be aggregated and expressed as 'drives' and 'states'. The pressure data from the MTC device is mapped into a rectangular coordinate space and then filtered and processed using techniques from image processing and recognition. The software for this process is an image processing tool [8] that is an extension of the Max/MSP programming environment [9]. Parameters are extracted from this raw image data, which are used for preliminary gesture recognition. These measured parameters are

interpreted in terms of subjective linguistic terms, which lead to the effort-shape model. Gesture divisions are not extracted at this stage, and the more data-intensive pathways are not determined, as the goal is not to match previously performed gestures but, rather, to obtain the subjective quality of movement represented by caresses on the MTC device.

In Laban effort–shape movement analysis, the attributes of Time, Space, Weight and Flow are defined as follows: Time is represented on a Quick/Sustained continuum, Space on a Direct/Indirect continuum, Weight on a Light/Strong continuum and Flow on a Free/Bound continuum. Information is extracted from the device in various categories, differentiated by the level of calculation required to extract them. These categories are direct parameters (Location, Size, Start Time, Stop Time, Intensity and Number), which are measurements from the device, calculated parameters, and inferred parameters. Indirect parameters (Duration, Speed, Direction, Direction Change) are those that are calculated from the direct parameters. All of these parameters are quantified into three or four levels of activity. For instance, intensity is quantified into values between light and strong, which map to the Laban *weight* effort. The quantified value is subjective in nature and corrected via threshold adjustments based on experience over time.

Results

The combination of the artificial–life system with the GIT created a very responsive environment in which natural gestures (the petting of the creatures) resulted in immediate and relevant responses. This gave a feeling of connection and familiarity to the experience, despite the extremely abstract representations used for the artificial life forms.

The integration of the GIT with the application was successfully mapped, as the gestures could be recognized in real–time and quickly converted into the commands or "verbs" needed for the environment. By physically separating the gesture processing from the application, it was possible to easily explore alternative solutions for the gesture mapping and interpretation.

Implications to HCI

Gestures appear to provide a very natural means to interact with an evolving environment such as this artificial life simulation. Rather than aggressively moving objects from point to point, pushing buttons or grasping, as is often done in virtual reality (VR) systems, the gestures used can be gentler, less invasive, and with a greater dynamic range. This permits the system to develop with perturbations that are proportional to the forces applied. As well, the nature of the gestures ("petting" or "stroking") is much closer to the way children interact with animals. They don't attempt to dominate other creatures – they express interest, affection and wonder. These modes of interaction are not exhibited in such domains as video gaming. The MTC device is a viable alternative to conventional touch surfaces, with sufficient sensitivity and responsiveness for use in hand gesture recognition.

Future work

The GIT primarily needs to be enhanced in three directions:

1) Further work on the gestural language, with provision for handling gestural phrases or time–dependent inputs,
2) Support for more devices and characterizing its behaviour with multiple devices, possibly networked and
3) Reduction of the size of the system(s) required to implement the GIT, so that a wearable version can be developed

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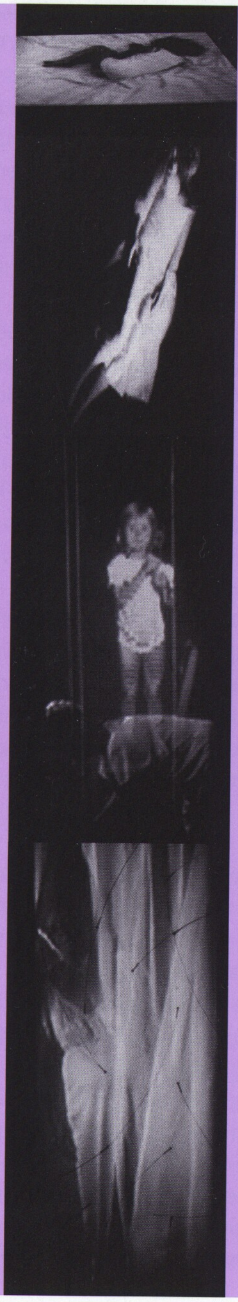
Thecla Schiphorst



Body, interface, navigating sense and state space

Thecla Schiphorst is a Vancouver-based computer media artist and Associate Professor in Interactive Arts at the Technical University of British Columbia. She has an interdisciplinary MA degree in computer compositional systems from SFU, did undergraduate studies in dance and computer systems, and has a Diploma of Technology from BCIT in Computer Programming and Systems Analysis. She is a member of the original design team that developed *Life Forms*, the computer compositional tool for animation and choreography, and has worked with choreographer Merce Cunningham since 1991. She has published numerous essays and articles, and lectures extensively, facilitating workshops and exhibiting her work. She is the

I am going to give you a little bit of history about my work and how I became interested in this area of research, which I have been doing for the last 15 years. An important aspect of that research is this question you see above my head: What is body? I will begin by looking at some examples of my previous work. Like Chris Speed, I am also quite interested in navigation from a very particular point of view. Navigation is movement through space. I am interested in the way a body recognizes and constructs knowledge in spaces in general, including in data spaces.

I have a background in both software engineering and in performing arts practice. I am a dancer and choreographer, and I worked in theatre for many years when I was a young girl. I studied computer and after getting my undergraduate degree, I studied for my Masters degree. When I did my Masters I began to explore some of the relationships between body knowledge and the language which is used in studio-based practice. This is what I call 'experiential body practice' and I use this to build tools, software systems, software and hardware artifacts and construct artwork which is both installation and performance-based. From my personal history and my own live performance experience I developed the notion of body knowledge and what I call 'first person methodology' and use this as a basis for interface design. An area of experiential body practice outside of dance and theatre, for example, is the study of somatics, the study of the body as it is experienced from within the body. An incredible amount of knowledge, methodologies, practices and techniques has been incorporated in both the study of somatics and the study of movement and theatre.

I am sure that, as performers, many of you understand that improvisation methods are first person methodologies, which are

past chair of the *Conference on Dance and Technology* held at Simon Fraser University in July 1993, and she has served on numerous juries including Siggraph, CHI and the Canada Council for the Arts. Thecla Schiphorst is a co-founder of Digital Earth, a non-profit cultural society and co-curator of the web-based project *The Ecology of Communications*, and Transverse Worlds which is hosted by digital eARTh. Thecla Schiphorst is the Co-Director of Then/Else, Research Interactivity Center at TechBC. In 1988 she was awarded the *PetroCanada Award for New Media*.

based on exploring a way of navigating in time and space, a way that is differentiated from the teleological systems of navigation that Chris Speed is talking about. But improvisation is only one particular kind of practice in methodology. It is built within some kind of a structure so that quite often when you begin to look at improvisation either in music, in dance or in theatre, you are developing structures, you are making rules or practices into which you build certain kinds of outcomes. These kinds of methods and methodologies are really interesting to me and from my dance study, I know that not only do these kinds of techniques enable us to access knowledge, but we also construct knowledge through these methods and methodologies. One thing that experiential body practice has in common with this, is that it uses a direction of attention which is our own intention to produce a 'body state'. This notion of using direction of attention to produce specific body states is something which I have explored in my work in quite a number of different ways.

I was one of the original designers of *Life Forms* which is a computer choreographic tool. I worked with Merce Cunningham for about ten years to develop a vocabulary for movement and studied the relationship between interface design and the way in which one explores compositional ideas, in this case compositional ideas about movement. I have also worked with movement gesture systems; interfaces using motion capture and transforming the information so that the outcome was compositional rather than a literal replication of the recorded movements. I have built navigational systems for art databases which explore modes of navigation and states of navigation where you can express various ways of moving through a space.

What is body? Well, we all have one and we have very specific notions of what a body does, of how we perceive, and of the limits and thresholds of constructing knowledge and perception based on the input sense data and the output data of our bodies. Of course, we all recognize that this knowledge is just a model of what we are. We know that these models are multiple models which are changing all the time. Some of the work that is done now in neuro-physiology and cognitive science is, quite radically in some cases, restructuring these models and forcing us to rethink what is body and what is perception. I am interested in thinking of the body in relation to the construction of systems. I can describe the body as being fluid, re-configurable, having multiple intelligences, as being networked, distributed and emerging. You will notice that many of these words are similar to the way that we describe our technologies and our technological systems.

The body is fluid and re-configurable. An example of this is sensory substitution on which experiments have been done over a number of years. In the early sixties Paul Bach-y-Rita did an experiment where he placed a camera on the head of blind subjects. These subjects once had the ability to see but lost their sight later in life, so they did have access to neural-physiological patterns which could detect sight. It is important to know that their brains had knowledge of seeing at one point in time. These blind subjects had a camera on their head and the data from a very low-resolution camera was used as input into their bodies through their skin, so the visual data was transformed into tactile data. There were two groups. A control group which did not move their heads, they simply sat in the room and things moved in front of them. And an experimental group who could move their heads in the space and in which they moved around in the room. The results of the experiment were as follows: after about two hours the brains of the subjects who could move their heads started to re-pattern the sensory information which was coming into their arms as tactile data in such a way that they were no longer feeling the data in their arms, but they were seeing three-dimensional objects in as low-resolution as the camera was providing. In other words, they were seeing, you might think of it as holography, but what was actually happening was that their brains were re-patterning, substituting the sense of touch for the sense of vision within their own bodies. This is an example of the fluidity of the way in which our bodies operate. It is an example of a way in which we are re-configurable.

We know that having multiple personalities is a pathology. And we all know we also have other sorts of more fluid multiple personalities, in the way we speak, in who we are at different points in time. These personalities are state-based, so as we shift our state, we shift the way in which we present ourselves to the world. In studies of multiple personalities it has been shown that different personalities within the same body can have totally different physical attributes. One personality, for example, would be allergic to oranges and have imperfect vision. Instead of having 20/20 vision maybe this personality had 20/100 vision. Another of the multiple personalities was not allergic to oranges, had perfect vision but was a little bit hard of hearing in one ear. If the subject ingested an orange when he was in the personality which was not allergic, but then switched to the other personality, he would immediately have an allergic reaction to the ingested orange in the body. The body, from the moment in which the personality switched, totally reconfigured itself; shifted its vision, shifted its hearing, shifted its own internal relationship to what kind of data was traveling through it. So our bodies have these kinds of properties. We are used to teaching ourselves to perceive in certain ways and many of us believe that perception is not something that can be shifted consciously, but indeed, there are many studies that show that our range of perception, our bandwidth, and the interconnection between our senses is much more fluid and much more controllable through conscious effort than we had previously believed. If you have studied movement or theatre or any kind of art form in which the body becomes an instrument, you know that this is an important critical aspect, in that you learn and can construct repeatable states in the body. In dance and in theatre, for example, it is important to be able to construct a repeatable emotional state or a repeatable physical state to be able to re-enact a point in time or a characterization. These kinds of ideas are the kinds of ideas which I am interested in, and how they relate to our definitions what our technologies are, how we define what our interfaces are capable of, and how we can re-define and re-work our technological systems.

You may have heard of *Life Forms* as a choreographic tool and compositional system for movement. It was something I worked on in the late eighties and early nineties. It was interesting to look at multiple levels of abstraction in compositional processes and design processes. We investigated how moments really occur as intersecting layers by looking at things from different points of view and blurring the boundary between the representation of space and the representation of time. And we also studied some non-literal representations of the body. Indeed, studies on movement illustrate that we recognize and can illustrate and perceive movement. The work with Merce Cunningham was important in the development of this tool, particularly in the early nineties. He was a very important twentieth century choreographer and artist. He was the partner of John Cage for over fifty years. Together they explored the relationship between chance operation and chance procedures, non-literal forms of representation. They radically altered the way we think about the compositional process. A lot of these techniques were used in Merce's work using this particular tool. One of the things we found out about is how we visually process data when using digital technologies. Since they tend toward precision in representing outline and surface, our reading of that tends to completion, to a completed object and to a completed sense of movement.

At the same time we found that in notional representation, the idea of the process is not something complete and can be shifted. We haven't come to terms yet with the way this relates to digital representation. This is just a small example of something that Merce constructed. What you can see, first of all, is that it doesn't necessarily look life-like, it doesn't have sort of warm, normal human rhythms, but is inter-cut and idiosyncratic. One of the important ways in which he worked was, first of all, not to necessarily conflate the idea of whether he liked it or not, with what I did. He would use his idea of chance and how that can be constructed from the computer system and apply it in the world. He also did not attempt in any way to make it look real. He was interested in exploring the question of: What is movement? and was actually more interested in de-habituating the way in which he thought of movement than in trying to reconstruct something that he had been seen before.

The motion capture system I sometimes use, wires the body and captures the motions real time in 3D. It is used in animation to get a highly precise literal digital representation of the motions made by a human body in 3D space. Since I am more interested in re-mapping aspects of movement in a choreographic way, I built a system that would enable parts of the body, an arm, a gesture or the entire body to be re-mapped, and then I do things like phase shifts, and use compositional techniques. I do many things that are usually done in sound composition where you work with algorithmic layers. I take the movement of the arm and put it on the spine, accelerate or decelerate it in time so you can functionally use the same kind of input and re-map it onto the body. Usually what comes out of this is that it is quite an impossible movement to actually perform, but it was simply the result of using of digital technology which leads to this notion of impossible dances, where the construction of movement is based on an exploration of movement. It could be performed by the body but not in the way that you would illustrate it, if it were a notational tool.

Another area in which I worked is the area of interactive performance where a performance space is wired, for example, and performers interact with that space, and again, in music this is quite common. I became interested in the exploration of how, from the dancer's point of view, you get a totally different sense of the space, since the direction of the dancer's attention is changed by the fact it is mediated. But the audience is still sitting out there. It is not an exploration of the same kind, i.e. of the direction of the audience's attention in relation to the performer's attention. This breach is one of the things that moved me into working with installation space. Here the audience and the performer are embodied within the same person, the audience becomes the performer. And the question becomes how do they interface with that space which is the interface between themselves and the mediated technology, the art interface?

In 1996 I created a piece called *Body Maps* which is an interactive installation in a darkened room. When you enter the room, you see a table which has video projected onto it. The room is essentially silent except for the sound of a single drop which is coming from the projector. The piece is silent and still until it is touched. In a sense it is begging for interaction through the touch, through the caress, of the participant in the space. I worked with engineers to construct some of the sensor technology. We programmed it in Max. The video and the sound were developed in order to construct a local interaction at the moment of contact with the surface. It worked not only with touch but also with proximity, a notion of skin consciousness. You are sitting fairly close to each other and you will notice that you may be in the proximity of the person next to you. You can sense their proximity, you can sense their distance. Clearly our skin is a boundary in a sense, but our ability to perceive is something that emanates past the surface of our skin.

This idea of what skin is, what skin consciousness is, how touch can re-direct the way in which we understand ourselves, is what I was interested in. In this piece the participant and the audience become one. It deals with a lot of issues that have to do with the idea of attention state. It is a highly auditory-visual piece, it is synaesthetic because touch is used as a way to begin to hear the visuals. Sound is a way in which we touch ourselves in this kind of space. In western culture we are taught to use our eyes in very specific ways. A simple example is that not all cultures use perspective in representation. We fall for tricks like these e.g. when we see two lines which have exactly the same length in perspective, but one has arrows going that way, and one has arrows going the other way; we see them as being of different lengths. Not everybody is prone to these mistakes. We are taught to see in these specific ways and we are also taught to use our eyes to differentiate subject and object. It is very much a construct of the way in which we deal with knowledge in our culture. We have to find a way to shift that in the interface itself, in the experience of the interface.

I talked about the notion of skin consciousness. Kinesthesia is our way of perceiving movement. When you are a performer you will notice the way your body responds to movement in another space right away. That is your kinesthetic response. I talked earlier about sensory substitution and that our senses share the space of our body and they are not as easily separated as we have defined them to be in the constructs of who we are. We have to include synaesthetic notions, such as the kinesthetic eye listening as an act of touch, and the skin as an organ of autonomous response. Brian Massumi, a cultural theorist, has written about the autonomy of affect in an essay which explores the relationship of affect to the skin itself. In his view our cognitive and perceptual systems do not all operate in the same time frame nor do they recognize the same data. The skin is an affect center operating in a different way than the brain and the linguistic system. It turns out that skin measures affect even though the brain is saying something else. That means that as we touch, we have access to this whole range of what we perceive and who we are. I was interested in trying to build a system, a container, which would enable some of that exploration through interaction of the body in the space. Touch is not discrete. This is not only because of the continuity of sensory information but also this idea of indiscretion implies that we can't lie to ourselves through our skin. Touch is also a way of subverting the primacy of vision. Physical interaction is a totally different experience. We have privileged seeing to such a high degree, as something that gives us so much information, but touch can subvert that in a certain sense, and bring us back to our senses in another way. We have dealt with the visual arts for such a long time. Interactive art, even though it uses visuals, can be used to collapse the visual in a sense. The visual is a way to draw in, but this moment of contact, where the interaction occurs through other senses, is what the interface is about.

The next piece I made was called *Felt Histories* and it is a piece that explores touch. It is a twenty-foot long corridor, quite narrow but four-foot wide. You have to walk through the entire corridor to the end where a doorframe is located. The doorframe is a Plexiglas surface onto which video images are projected. I began to explore this idea on *Felt Histories* after the work I did in *Body Maps* and on this notion of gestural access, and from prior work on databases and different ways that we can access and search databases. Video and sound are networked across computers. They are activated by the physical act of the caress. The sensors are embedded in the Plexiglas frame. Plexiglas is somewhat pliable, as you know, so there is some movement but it is not a totally flexible surface. There are zones of sensitivity, the projection surface has to be touched in order to activate or navigate. The directionality and the energy and the length of time that you touch the surface are used to calculate direction, location, relative location, velocity, and acceleration, etc. Those were the variables that were used to search and navigate the database. A whole system was set-up which is pseudo episodic, in a way it was a pseudo narrative. It was not really narrative but it had a narrative quality to it.

The sensors were drawn from the lines of my hand, so it is about the idea of scale, the micro and the macro. It is about the way you touch the surface of a hand, that is how the sensors were constructed. Four different episodes were used to respond to the image and the sound in different ways. The visual material was organized into visual episodes and each of the episodes had a particularity in terms of how the navigation occurred, and how the images were connected with one another. There was no cutting, so everything dissolved into one another. It was really meant to be a very sensual experience. It wasn't that you were aware that you were reconstructing a story but you were given an opportunity to construct a relationship with a sort of body in a space. There were specific rule sets for each of the episodes for the selection and mixing of the video material. In *Body Maps* I used my own body and I performed the piece. I directed the video but I didn't direct it by visually composing it, but by physically composing it. Very much like you would do in a theatre or performance, I went into a number of specific physical sense states to access the range of physical relationships that would occur through touch. From the highly sensual and the highly erotic to a more violent kind of response that was very much identified with inside my own body. At the same time, in this piece, I began to explore the idea of desire within decay and resolution and the relationships between them.

For the last year and a half I have been investigating wearable technologies. This idea of wearing yourself can be extended into a network distributed over a small wearable device system with intelligence which is shared between people. We do wear ourselves and our many selves all of the time. The notion of modeling some of the systems of how we understand ourselves is part of what this is about and I think probably much of the kind of work that is done in media technologies is wearing yourself. For instance: on your sleeve, under your skin, in your ear, near your heart, in your hair, under your skirt, between your toes, off your back, between your eyes, around your thought, in your hand, shared amongst others, divided between yourselves, unknown to the left hand, hidden from your own eyes, substituting your senses, substituting other's thoughts.

The way that we learn is that active intention through movement is the basis of the thought process as it develops in the body, from the time that we are very young children. So if an aspect of that is missing, either the intention or the movement or the link between the two has not been developed in our cognitive system. In other words it is necessary for us both to intend and to move that intention in order to think and develop thought in our bodies. Di'Mazzio has written two books about Descartes' vision of looking at the necessity of both emotion and the rational states, which are not separate within our body. People cannot act in the world if the emotional aspect of the brain is damaged and they are only left with the rational side, even though that body may score well in a written IQ test, for example. They are incapable of physically acting; our rational behavior requires our emotional mind to be connected with it. These kinds of notions are not separate elements but are co-wired in our own bodies.

At present, I am working with Tactex, a company in Victoria. Victoria is a city very close to Vancouver in British Columbia. Tactex is developing a marketing technology which they call *Smart Fabric*. This is a fiber-optic array which has X and Y-axes and Z pressure so every place where the optic fibers intersect with one another is one of their tactiles. This technology is really interesting because it can be constructed into different form factors, for example, wearable form factors. I am working with them in finding different kinds of ways of using the fabric in wearable technologies as an element of the input device, but I am also extending the range of input and output. This is just a little bit of an ironic twist, but if you think about transmission, the network's transmission of thought and communication, you could say that, in a sense, telepathy is the ultimate wireless network. Even though there is an irony to it. I am sort of implying that our bodies, the technologies we are developing are as much about how we re-model ourselves, how we think about ourselves, even though we may not be doing this consciously. The working title of this piece is *WHISPER*, it can be read as an acronym of Wearable, Handheld, Intimate, Secret, Personal, Expectant, Responsive system or of Wireless, Heuristic, Interactive, Sensual, Private, Expressive, Reactive.

The work is based on small wearable devices and handheld computers. Participants move within a networked ecosystem which could be a space like this, but it could also be outside on the street. The space contains, and they wear, small intelligent devices which emanate their state. In other words, they whisper to one another and they can whisper with the knowledge of the person wearing them or of their own accord, based on the wearer's movement and intention. The whispering devices are networked to a database server which constructs a system state visualization. The entire system itself is alive and the communication and its visualization are transmitted to a projection surface in the installation and also to the Web.

The database system is based on the notion of future memories and on the history of the devices themselves. A device can be left behind and worn by somebody else. So in a sense the devices themselves have their own past lives based on who the wearer was before. They remember that state and the database serves as sort of a representation of state time as well. We know, for example, that when we have a radical change in how we understand something about our lives that may be in the past, we have a different view of that event and so in a way you could say that you are altering your view of the past. Similarly, whatever kind of attributes we have in terms of the way we look at things now, these can be extrapolated into the future, so the state visualization has this ability to reconstruct the past and extrapolate it to future memory. So memory is not just an archive of the past. Memory is something which is active, in which you are modifying the past and modifying the future based on how you are currently interconnecting with the devices and this part of the visual representation. Each of the devices has states which are shared with the other devices.

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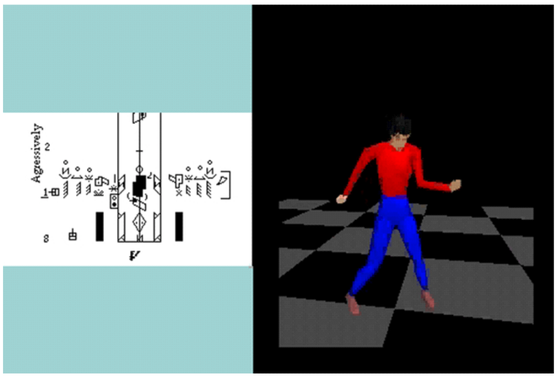
http://www.caiia-star.net/people

paper



intentional grammars:

networked gestural analysis for mixed realities

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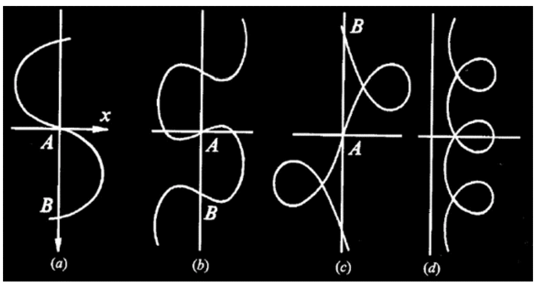
Abstract

The Intentional Grammars research is investigating, designing and implementing a predictive and encoded gesture-based approach to transform and reduce the motion data for transmission in a networked environment. This research will be based on emerging knowledge in the domain of experiential movement analysis, and is being built upon Credo Interactive's Life Forms movement tool and its new research project, the I-Move single stream video translation system. Gestures encapsulate the intent of the motion performed by the user in an input video stream. Thus, only the important characteristics of the motion are transmitted to other users in a multi-user application. The transmitted gestural information will also contain encoding for synchronization, interpretation and re-creation of motion data at the destination. An example is a multi-player networked game scenario, where players use video camera input to represent their movement and interactions while connected to their computer. A key to the analysis and categorization of gesture will be modeling intentionality within the gesture.



Keywords: gestural analysis, gesture-based performance, dance and technology, perception of movement, gestural recognition, design process, full-body interface, intention, action theory, effort-shape analysis

Project Partners: Credo Interactive, TechBC [Technical University of British Columbia], Electronic Arts, NewMic Foundation

1. Introduction

Research and development in game interface dialogues and architectures can be informed by, and benefit from the research domain of gestural movement analysis. Movement analysis techniques incorporate interdisciplinary knowledge domains such as computing science, cognitive science, psychology, kinesiology, somatics, and the performing arts. In the latter categories, [somatics and the performing arts] movement analysis methodologies are constructed from experiential body practice which provide a means to accessing and constructing knowledge.

The Intentional Grammars research is investigating, designing and implementing a predictive and encoded gesture-based approach to transform and reduce the motion data for transmission in a networked environment. This research will be based on emerging knowledge in the domain of experiential movement analysis, and is being built upon Credo Interactive's Life Forms movement tool and its new research project, the I-Move single stream video translation system. Gestures encapsulate the intent of the motion performed by the user in an input video stream. Thus, only the important characteristics of the motion are transmitted to other users in a multi-user application. The transmitted gestural information will also contain encoding for synchronization, interpretation and re-creation of motion data at the destination. An example is a multi-player networked game scenario, where players use video camera input to represent their movement and interactions while connected to their computer. A key to the analysis and categorization of gesture will be modeling intentionality within the gesture.

Gestures can be defined as "body movements that are used to convey some information from one person to another" (Väänänen & Böhm, 1993). If our goal is to get away from pre-defined interaction techniques and create natural interfaces for human users, we should concentrate on the type of gestures that are used in normal human communication. We know that listeners attend to unplanned, unselfconscious gestures, and that they use gesture in communication to form a mental representation of the communicative intent of other gesturing human body.

What kinds of meanings are conveyed by gesture? How are these meanings extracted by viewers | players? Does gesture in mixed reality environments and experiences differ in intention, scale, resolution, or range from other types of gestures? How does gesture enable a greater level of immersion in immersive environments?

Rudolf Laban's movement analysis [Laban], and the work of other researchers [Bartenieff et al.], [Dell], are examples of gestural typologies that analyze and specify a range of qualities and modes of movement for gesture recognition. They present possibilities for exploration into ways that the computer can recognize different aspects of movement, and define a means to approach recognition of gesture systematically. Movement theory can be incorporated as an analytical framework for real-time recognition. The purpose of the research is to find a means to use gesture to control interaction within a 3-d environment. Along with extracting quantitative movement information, building a categorization schema for the qualities of movement being performed can enable an initial model of gesture intention. Intentional grammers can form an interaction with the computer that augments current technologies by extending the input paradigm.

The intentional grammars project will provide the grammar, vocabulary, and knowledge base for a specific domains of movement. Definition of specific movement domains will be an aspect of the project. Intentional grammars for motion encapsulate the "intent" as well as the "kinesthetic" aspects of the motion domain.

1.2 Background

Life Forms was developed at Simon Fraser University at the Computer Graphics and Multi Media Research Lab under the direction of Dr. Thomas Calvert. [Calvert et al, 1991, 1993], as a pilot project in the research of compositional and design processes in movement, dance and technology. Life Forms is a movement tool for choreography and animation, and has innovated a visual way of representing, manipulating, and experimenting with human motion. Merce Cunningham has been composing with Life Forms since December 1989. Cunningham's early work with Life Forms enriched and expanded the interface to a high degree. Today, Choreographers use it for discovery, planning, and visualization [Schiphorst, 1997]. In addition to Merce Cunningham, its users include Michael Cole a former principle dancer with the Merce Cunningham Dance Company, Jimmy Gamonet de los Heros, and Professor Rhonda Ryman from the University of Waterloo. Cunningham's use of Life Forms is primarily a procedural tool for exploring non-habitual ways of constructing, viewing and developing movement for performance. Cunningham continues to use LifeForrms in an on-going basis to invent movement sequences individually that form the basis of a new major work. Jimmy Gamonet de los Heros, an independent choreographer formerly with the Miami City Ballet Company, uses Life Forms as a tool to visualize or transform his dance from an internal choreographic visual gesture, to a large ensemble of sometimes 40+ animated dancers.

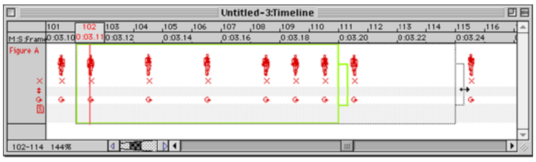


Figure 1. Lifeforms Timeline

Rhonda Ryman, Professor of Dance at University of Waterloo, uses Life Forms is to recreate digital libraries of ballet and modern dance vocabulary for education and preservation. Today, Credo Interactive develops and distributes LifeForms movement animation software and is partnering in research which includes features that support higher level compositional activities in motion analysis, capture, editing, visualization improvisation and composition.

1.3 Current Research in Movement Notation and Translation

The Intentional Grammars research is an aspect of current special research projects for movement notation and video extraction. One of the most recent research projects is the collaboration between movement notation and Life Forms animation. Credo Interactive, with the Dance Notation Bureau and TechBC, is working on a major initiative to translate between movement notation and Life Forms 3d animation. A related observation is that reading notional script requires domain knowledge, i.e. the reader or notator adds information in interpreting the notation. They fill in the gaps of notation with domain specific knowledge based on specific movement vocabularies as found in context specific traditions of modern dance or ballet. In addition to Laban and Benesh notation, there are, and has been, many other movement notation languages, some that are very narrow designed specifically for the specific domain they represent.

I-Move is another research technology project under development for partial- and/or full-body motion control for interactive entertainment and online community. The I-Move project is the underlying technology that Intentional Grammars is based upon. I-Move is a key strategic project for the extraction of 3D motion data from a single markerless video stream (e.g. Fig 2. Notation translated to 3d movement of human motion). A related problem is the synchronization of motion from different people in an online multi-user platform that is subject to load-based transmission delays.

The I-MoVE project investigates and develops new knowledge-based technologies and user-directed tools for analyzing, extracting and reconstructing 3D human movement from 2D image streams. Due to the complexity of human movement, the state-of-the-art only provides partial solutions for the reconstruction of 3D movement from single view 2D video streams.

The objectives of the i-MoVE project are:

- development of new algorithms for 3D motion reconstruction from 2D imagery;
- enhancement of algorithms for component technologies (e.g. more "natural" solutions for inverse kinematics computations);
- design of editing tools that integrates video into the animation process; and empower animators and other users with next-generation 3D tools.

The stream of extracted 3D data can be used to control a 3D character in an interactive application (e.g. a computer game) or an "avatar" in an online community. However since the extracted 3D data is mostly on a frame-by-frame basis, the data stream is dense and not optimal for transmission over the internet for online community applications.

1.4 Intentional Grammars

With a single video stream, there is incomplete information for reconstructing 3D human motion, and thus, heuristics are being explored to guide the reconstruction process. The project team's knowledge of movement, and specific domains of movement, can provide information to assist in the reconstruction process. For example, with I-Move as a core-technology, tai-chi movement could tracked and reconstructed as 3D motion. The rules and the knowledge of the actual tai chi motion grammar/vocabulary are necessary in order to analyze and extract valid movement, transition and blending from one movement to the next, expected sequences of motion. The key element is to couple analysis and reconstruction with heuristics and prediction techniques.

The research will investigate, design and implement a predictive and encoded gesture-based approach to transform and reduce the motion data for transmission over the internet. Gestures encapsulate the intent of the motion performed by the user in an input video stream. Thus, only the important characteristics of the motion are transmitted to other users in a multi-user application. The transmitted gestural information will also contain encoding for synchronization, interpretation and recreation of motion data at the destination. An example in a mixed reality scenario is where users are standing in front of a video camera connected to their computer.

Each user could be in their own personal local space while interacting with others in a shared virtual environment. Their motion must be synchronized in the shared space, viewed locally, and maintained centrally, particularly for contact points in the motion. Each user's local view is impacted by their individual transmission (and to a lesser extent computational) delays. A gesture-based approach to "compression" of the motion data will provide that synchronization needed for an engaging experience.

1.5 Investigation questions

Investigation questions include the following:

- What kinds of meanings are conveyed by gesture?
- How are these meanings extracted by viewers | players?
- Does gesture in game play differ in intention, scale, resolution, or range from other types of gestures?
- How does gesture enable a greater level of immersion in gaming environments?
- What are techniques can be applied for recognition and categorization of gesture gradients (how fine or broad is a "gesture")?
- What techniques can be applied for recognition and integration of partial body gestures?
- Is the gestural information layered and contained within unique channels (i.e. a separation of arm and leg gestures)?
- How should interruption and discontinuation of a gesture be handled by the system?
- What are the issues in mapping gestures from the input body (e.g. human body) to a virtual body?

1.6 Related work at Then | Else Interactivity Centre

As a research partner, Then | Else the Interactivity Research Centre at TechBC [the Technical University of British Columbia] is engaged in a number of research directions which complement this research. This includes: gesture-based performance environments and interaction; development of 3d behavioral animation; perceptually-based video compression; avatar interaction in virtual environments

1.7 Value to game development

The technology [intentional grammars coupled with Credo's i-Move technology] can be applied to immersive online environments in gaming, performance and other tele-present applications. The motion domain knowledge itself can be applied to other types of development where movement analysis, recognition or performance is a key element of the experience.

1.8 References

Somatics education is a term applied to several disciplines developed during the twentieth century in Europe and America. The field has been called Somatics by American philosopher Thomas Hanna, and Somatotherapie by French physicians and educators. Hanna founded the American journal Somatics in 1976, and French psychiatrist Richard Meyer the French journal Somatotherapie in 1989 to review theoretical and practical work in the field.

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poster

affect space

semantics of caress

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Abstract

This project focuses on the development of a language of interaction based on developing an affect space in collaborative sensing environments. The goal is to design a networked semantics of caress, where the interactivity can recognize, understand, and even express non-rational states such as emotion or intention . This suggests the development of qualitative models for data flow and data-architecture and the development of languages of intimacy, gesture, and the extension of tactility. This project builds a suite of inter-related networked devices within the collaborative sensing environment.

Initially we are prototyping several wearable or portable input and output devices with the goal of developing a networked performance environment. Central to the creation of the suite of devices is the gestural interface toolkit (GIT) which integrates input and output devices and networking necessary for encoding, transmitting and synthesizing affect data. A key input technology is the advanced optical smart fabric, developed by Tactex Controls Inc. This fabric recognizes multiple simultaneous points of contact, and can measures hand movement space so that touch can be transformed and recognized qualitatively. In the output domain, input 'affect data' such as gesture, caress or physiological data such as heart-rate can be transmitted to a remote location as 'gestural output'.

Keywords: interface design, multi-modal device design, remote sensing, networked wearables, sensory extension, collaborative sensing environments, whole hand input

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1. Introduction

This project focuses on the development of a language of interaction based on affect space and the semantics of caress. In order for interactive systems to genuinely model intelligence, we must enable the development of interactivity that can recognize, understand, and even express non-rational states such as emotion or intention . Emotional intelligence systems, [as distinct from artificial intelligence systems] suggest the development of qualitative models for data flow and data-architecture, the inclusion of models for navigation through liminal space [where boundary conditions are fuzzy, transparent, or fluid], and the development of languages of intimacy, gesture, and the extension of tactility. An initial focus of the work is the notion of 'tactics of caress'.

This project builds a suite of inter-related networked devices within a collaborative sensing environment. Initially we are prototyping wearable or portable input and output devices to explore the 'affect space' and semantics of caress with the goal of developing a networked performance environment. Previous work in gestural languages generally focus on the pragmatics of interaction such as manipulation semantics (reference needed: MacKenzie, Mulder, McNeil.

Central to the creation of the suite of devices is the gestural interface toolkit (GIT). The toolkit integrates input and output devices and networking necessary for encoding, transmitting and synthesizing caress. A key input technology we explore is the advanced optical fabric, 'Smart Fabric' being developed by Tactex Controls Inc. The Smart Fabric is based on Tactex's Multi-touch Controller (MTC) that measures hand movement space so that touch can be transformed and recognized qualitatively: a stroke can be differentiated from a caress, for example. While the movement space of a caress has meaning in the physical domain, it also has meaning in an emotional domain as well. We are working with Tactex 'Smart Fabric' to design a range of form factors for wearable or portable application of this technology.

In the output domain, input 'affect data' such as gesture, caress or physiological data such as heart-rate can be transmitted to a remote location as 'gestural output'. An initial output prototype is a wearable 'hug' device which caresses the surface of the wearers body in response to input data

A central functional property of the Gestural Interface Toolkit (GIT) is the development of a prototype intention grammar. Gesture | Intentionality of the giver/sender can be recognized by analyzing the physical dimensions of input affect via caress and bio-sensor data. At 'the heart' of this project is the key notion that interface and device design can benefit from knowledge expressed within disciplines that incorporate experiential or body practice as a means to accessing and constructing knowledge. This knowledge is codified and exists in the forms of specific technical methodologies within the fields such as somatics, theatre, dance, bio-kinesiology, and non-western physical forms such as butoh. The giver/sender communicates through a language of interaction based on 'tactics of caress' sensing environment, devices and intentional grammars.

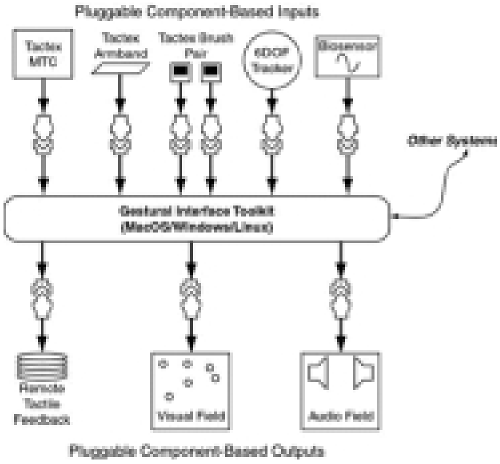
Contemporary research in neuroscience and the cognitive sciences suggest that the sensori-motor systems of the body are inter-connected to such as degree that the body can be seen as a 'fluid' system, capable of re-configuring functionality.[Varela, Damasio]. This metaphor of the body as fluid, re-configurable and networked provides the basis for the system design of our research. Various methodologies incorporating experiential body practice share the existence of definable processes based on the direction of attention in order to affect, alter or produce body state. Within Somatic disciplines, for example, retraining of perception through attention is produced through application of directed movement in the body [Sweigard, Benhke, Bartinieff, Cohen]. The concept of 'repeatability' of body-states, suggests that through the direction of attention along with a definable set of procedures the body can be trained to access or construct specific body states. 'Tactics of caress' borrows from these physical metaphors notions of re-configurability, direction of attention, state-space and networked connectivity. Our multiple configurable and networked selves are the blueprint for devices, networks and collaborative sensing environments.

1.1 Language of Caress

To develop the language of caress we have developed from both a top down, affective perspective and a bottom up perspective looking at the semantics of whole hand input and body gesture.

The affective aspects of caress involve the relationship between the sender and receiver. The sender's action and intention can 'touch' the receiver. The intent of touch is critical to the sense of the caress, where the sender may actively or passively caress with specific intent. These intentional gestures can be analysed to form a prototypical intentional grammar. As such, caress is an experiential phenomenon and the exploration of the affective space provides directions for development conceptually, culturally, as well as technically. The pragmatics of gesture form the basis of a bottom-up approach to understanding caress. Whole hand gesture pragmatics can be classified into grasping, claying, chiseling [Mulder, 1998]. Other manipulation semantics can be found in [Kendon] [MacKenzie][MacNeil].

1.2 Technologies for Caress



In order to realize a computer-supported networked language of interaction based on affect, intimacy, gesture and caress system, we consider four areas: input (incoming affect data), output (remote gestural feedback), network connectivity and signal processing (GIT - gestural interface toolkit). The basic structure of our architecture is shown in figure 1.

With incoming affect data, we are primarily concerned with capturing information artifacts that are often far less structured than is usually the case with computer-based systems. Traditional input devices, such as keyboards and mice, do not reflect a range of modes of human interaction involved in a collaborative sensing environment where a 'caress' can be recognized as containing properties that reside in the physical, emotional, as well as intentional domains. From the technical standpoint we are currently looking at three categories of input sensors: pressure, biometric response and location/position sensors. A device of particular interest is a pressure surface known as 'smart fabric' (developed by Tactex Inc.). An initial stage in our blueprint project is to extend the form factor of the pressure sensitive pad in order to incorporate a wearable armband. The data from the sensors are blended, transformed and interpreted by the GIT and delivered to the output space. We are using a wearable 'hug' device (in development), auditory and visual displays, including a CAVE, for affective rendering. Together, the whole system provides the affect space.

1.3 Affective Space: Applications of Caress

One direction for using the affect space considers the elements of navigation from the literal, expressive and symbolic perspective. Touch and caress play an active role in our desire to navigate affective space. Sensing interaction with the pressure-sensitive pad, made wearable and hand-held, enables logical navigation through a virtual dynamic environment or space. The navigation may be: literal, as in current desktop and web applications, expressive as in on-line gaming, installation spaces, computer animation and choreography, or symbolic, as in applications requiring semiotic interpretation of caress. Symbolic navigation is a context dependent, context aware, and configurable navigation space.

As an example of expressive navigation we are using the pressure sensitive devices for navigational within in an immersive collaborative VR environment such as the CAVE. The visual representational field is a fluid particle space composed of discrete particles set in motion, interacting with one another other through their own motion, and through the motion induced by the gestural interaction of the participants. This fluid particle field can be thought of as a 'verb' space, where the gesture of the participants is enacted through their input. Gestures such as cupping, funneling, pushing, dispersing, molding, and collecting effect and 'enact' the visual particle field. A gestural taxonomy can be contructed based on a variety of gesture classifications modeled in movement theory and practice.

1.4 Summary

Affect Space builds from a key notion that interface and device design can benefit from knowledge expressed within disciplines that incorporate experiential or body practice as a means to accessing and constructing knowledge. We are creating an ensemble of tools that explore the pragmatics and expressive possibilities of affect space, particularly in the context of tactility. Inter-related networked devices creative affect space within a collaborative sensing environment. Initially we are prototyping several wearable or portable input and output devices to explore the 'affect space' and semantics of caress with the goal of developing a networked performance environment.

A key input technology is the advanced optical smart fabric, developed by Tactex Controls Inc. This fabric recognizes multiple simultaneous points of contact, and can measures hand movement space so that touch can be transformed and recognized qualitatively. In the output domain, input 'affect data' such as gesture, caress or physiological data such as heart-rate can be transmitted to a remote location as 'gestural output'.

At the bottom level we are creating a suite of software and hardware tools to encode, transmit and synthesize the elements of touch. At the middle level we are developing a language of caress that enables the interpretation of touch and affective sensing such as the bio-sensor data.

The representation of tactility in a language of caress enables intent to be communicated and modeled, and through the development of an intentional grammar, provides a foundation for the top-level of applications. We are actively developing prototypes to explore the elements of caress and affective responses where remote tactility constructs intimate data spaces.

1.6 References

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