soft(n):
Toward a Somaesthetics of Touch

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Abstract
This paper explores the concept of *somaesthetics* as an approach to the design of expressive interaction. This concept is exemplified through the design process of soft(n), an interactive tangible art installation developed in conjunction with V2_Lab in Rotterdam. Somaesthetics is a term coined by Richard Shusterman, a pragmatist philosopher interested in the critical study of bodily experience as a focus of sensory-aesthetic appreciation and agency. In the context of interaction, somaesthetics offers a bridging strategy between embodied practices based in somatics, and the design of an aesthetics of interaction for HCI. This paper argues for the value of exploring design strategies that employ a somaesthetic approach, presents a definitional framework of somaesthetics that can be applied to interaction, and links the concept of somaesthetics to a specific design case in which tactile interaction is applied to the design of a networked, tangible interactive artwork called soft(n).

Keywords
Somaesthetics, Touch, Tactile interface, Somatics, Interaction Aesthetics, Movement Analysis, Art/Design installation, Play, User Experience, Embodiment, Materials Exploration, Kinaesthesia, Emergent Behaviour

ACM Classification Keywords
H5.2. [User Interfaces] Interaction Styles, Theory and Methods, User-centered Design

Introduction

Human computer interaction is becoming more intimately connected and embedded within our everyday experience, lying closer to our skin, embedded in our clothing and literally touching our lives. As our bodily experience is physically materialized more and more directly through technology, the need to account for the body and its experience continues to gain significance. This paper contributes to the discourse of embodiment and the aesthetics of interaction within human computer interaction by introducing the concept of Somaesthetics [19] as an approach to designing for human computer interaction. Richard Shusterman [33,34], a philosopher and somatics practitioner, following in the pragmatist tradition of Dewey [6] and William James [17] has defined somaesthetics "as the critical study and cultivation of the experience of the living body as a site of sensory-aesthetic appreciation." Shusterman's stance has much in common with philosophers such as Alva Noë [25] whose enactive approach to perception suggests that our ability to perceive is constituted directly by somatic sensorimotor knowledge, and Mark Johnson [18] who explores aesthetics of human meaning as growing directly from our visceral connections to the bodily conditions of life [18]. The overlapping interest and exploration of embodiment research across somatics, philosophy, cognitive science and human computer interaction has become more and more prevalent [7]. Yet, there is a need for practice-based methods that can provide practical examples of these conceptually rich theories. This paper contributes to this discourse through arts-based research: providing physical examples from an ongoing sustained and reflective artistic practice that exemplifies specific technologically mediated design in wearable and tangible interaction. This research explores practical articulation of these important philosophical concepts of embodiment.

In the following pages, the concept of *somaesthetics* is explored specifically as an approach to the design of tactile interaction. This is exemplified through the design process of soft(n), an interactive tangible art installation developed in conjunction with V2_Lab in Rotterdam. As a conceptual resource, somaesthetics offers a bridging strategy [29] between embodied practices based in the study of somatics [14], and the design of 'aesthetics of interaction' explored within HCI [9,24,26]. This paper argues for the value of exploring design strategies that employ a somaesthetic approach where embodied techniques are proposed within the design method (process) as well as the design outcome (goals). The following section presents a definitional framework of somaesthetics that is applied to the design of a tangible interaction artwork, soft(n). This definitional framework includes the themes of experience, poetics, materiality, and semantics of interaction. The remainder of the paper links this framework of somaesthetics to specific stages in the design of soft(n). Within this framework tactile interaction is applied to the design of the networked, tangible interactive artwork soft(n).

A History of Somaesthetics

The term *Somaestheics* was originally framed by Richard Shusterman [33], and explicitly references somatics through the embodied nature of an aesthetics

of use[9,26,33]. While Somatics itself is a field of practice that references the experience of the lived body [14], Shusterman's philosophy of Somasethetics has coupled somatics with aesthetics while making a case for bringing the somatic embodied nature of aesthetics into everyday experience. Somatics, one of the two threads that defines somaesthetics, is a set of body-based traditions developed largely outside of academia. Somatics offers an account of experience enacted through first-person methods and has historical ties with performance and movement practices [14]. It can be traced to philosophical underpinnings within contemporary phenomenology and pragmatism and to ancient concepts of the 'self' that date back to Hellenistic traditions and Eastern philosophic thought [29,36]. Within Somatics self-reflexive techniques are structured to transform one's experience of the 'self in the world' and form part of a larger history of practices of subjectivity and self-cultivation. Shusterman's concept of somaesthetics brings the practice of somatics into the pragmatics of aesthetic valuation and experience. Based on Dewey's [6] previous work, somaesthetics reinvigorates the field of aesthetics by reclaiming the lived experience of the body and particularly the notion of cultivating the self through attention to experience. A pragmatic aesthetics gives precedence to enactment [25] by referring to the importance of *experience* to produce or enact the aesthetic response. Somaesthetics embraces the *quality* of attention and awareness and provides an opportunity to explore the self's relationship with experience through technology [29]. Within HCI, previous references to Somaesthetics are sparse but include an introduction in Kallio [19] and in Lim, Stolterman, Jung and Donaldson's development of a model for Interaction Gestalt [22].

Figure 1. soft(n) uses active touch to enable participants' tactile attention to explore and illicit qualities of touch that can be communicated to others via the networked system

Toward a Somaesthetics Of Touch

In the art installation soft(n), touch and tactile interaction is used as an exploration of the experience of *active touch*. J.J. Gibson describes *active touch* as simultaneously objective and subjective and defines sensation as "the detection of the impression made on a perceiver while he is primarily engaged in detecting the world"[12]. Active touch elicits experience that can 'attend' to our inner state through intentional qualities enacted within touch. Touch is sometimes called "the first sense", and is associated with intimacy and empathy. Touch is also an important sense in the field of Somatics in its application of attention as a tool for self-change and knowledge. The philosopher Alva Noë regards perception as a method of *acting* that is touch-like. His enactive approach emphasizes that our ability to perceive is constituted by sensorimotor knowledge [25].

soft(n) explores somatic approaches to design aesthetics that highlight the senses, body, and movement through critical physical inquiry [10,15,16, 32]. This approach to *Somaesthetics* forms the bases of an underlying design framework that encompasses four themes: 1) Experience, which frames questions of cultivating embodiment, sensory perception and links to techniques of somatics; 2) Poetics of Interaction including meaning-making and open interpretation, which explores perception and cross-modal relationships between touch 3) Materiality, which emphasizes the importance of the physical body as well as the physical material, texture, shape, and form that support experience within the installation; and 4) Semantics of Caress, investigating the meaning of touch as applied to tactile interaction (how can models of meaning be applied to a computational model for interaction). This framework is the basis of the design case-study presented here.

The soft(n) Installation

soft(n) is an interactive installation that explores the somaesthetics of tactile interaction. *soft(n)* is concerned with intimacy, experience, sensuality and play while creating a poetics of imaginative physical exploration. soft*(n)* is a tangible network made up of 10 soft objects that exhibit emerging behavior when touched and moved about in a space. A pragmatist approach to somaesthetic interaction is based in an aesthetics of use [9,33]. The embodied and experiential nature of tangible interaction is highlighted in its coupling with somatics [14] and aesthetics [19]. Attention to aesthetic qualities within interaction is instrumental to the embodied nature of user experience design and has a direct effect on use, usefulness and usability [9,26]. In *soft(n)* touch provides an aesthetic qualitative experience that is recognized by the system and communicated as meaning to other participants. soft(n) couples touch with movement. Touch is intrinsically active, acquiring content that is delivered through movement [25]. These concepts are implemented using Laban Effort analysis [21,31]. soft(n) uses a tactile implementation of Laban Efforts which recognize *qualities* of tactile impressions on a specially designed fabric textile tactile surface. This somaesthetics of tactile interaction is the basis for the heuristics of touch employed in the art-work, which emphasizes a concern with creating meaning through 'softening' experience. In the case of soft(n) the physical tactile surface is flexible, soft and intelligent. Its sensory grid surface is crafted from conductive strands of fabric and foam that interpret qualitative meaning from tactile responsive gesture.

Figure 2. *soft(n)* objects are networked to one another and respond playfully to touch and movement through actuated vibration, sound and shared light patterns

The definitional framework of somaesthetics that is advocated through the design of the artwork soft(n) includes the four themes of experience, poetics, materiality, and semantics of interaction.

1 soft(n) Experience Within Installation

The first theme in the somaesthetics framework presented here, is that of experience. In Shusterman's conception of somaesthetics, bodily experience is inextricably tied to the meaning of our sensory selves. Experience is at once sensory and aesthetic [33,34]. Other philosophers such as Dewey have defined art itself *as* experience [6], and more recently the field of HCI has recognized the centrality of experience within technology design [7,23] exploring concepts such as gestalt [22] and empathy [35] within a focus of interaction. The design of soft(n) explores experience from the perspective of embodied interaction [7] incorporating Laban's somatic concepts of qualitative experience [21] in its somaesthetic framework. The remainder of this section describes the theme of experience of soft(n) from the perspective of the participant, while the next section describes the design poetics of that experience. The description of the themes of materiality and semantics of interaction describe the construction and design of materials and meaning that support the participants' experience.

The *soft(n)* installation is an intelligent tangible network comprised of soft physical objects that exhibit emergent behavior through interaction. *soft(n)* is a group of 10 interactive soft objects, each containing a specially designed and custom-engineered multi-touch soft input surface and motion detectors. Each soft object has an ability to actuate vibration, light and sound in response to its tactile induced state.

Figure 4. Accelerometers trigger the sound of '*weeeeee!*' as soft objects are thrown into the air

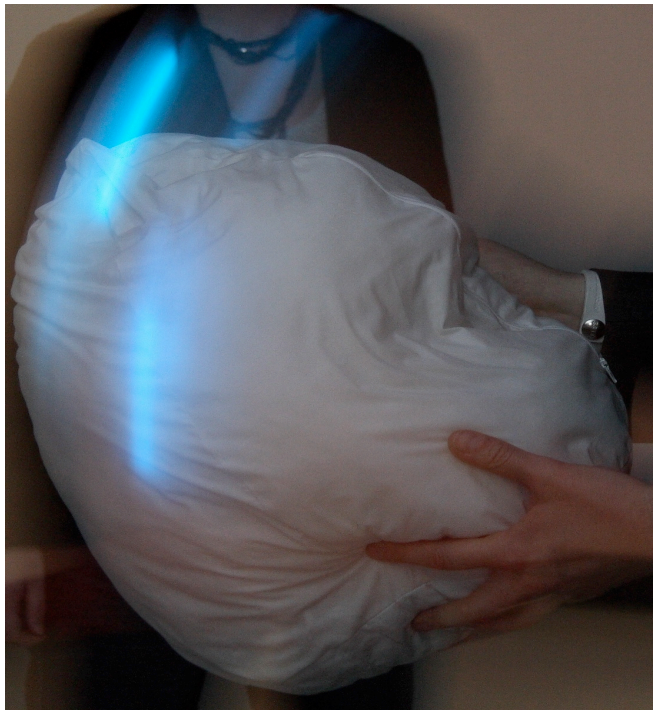

Figure 3. Moving Light Patterns Communicate the Inter-relationship of a Group

Each soft object is able to communicate wirelessly to multiple others as a group. Each of these actuation patterns enables a specific proximal layer of communication. Vibration (movement) is a local or intimate sense because vibration patterns can only be felt when a participant is in direct contact with the soft object, holding it, or placing ones hands or head or body in direct tactile contact with the object. While vibration is the most proximal local sense requiring contact through touch, sound is mid-range, and light is the most distant sense.

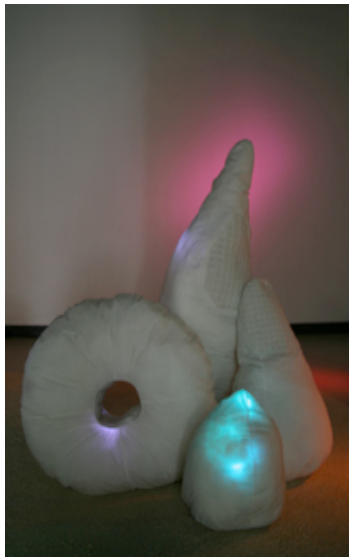

Figure 5. soft(n) illustrates a poetics of interaction

Sound output is relatively quiet, and can be heard in the near vicinity of an object without physical contact with the object. The lower sound volume is designed to maintain the need to be in close proximity to the object. For example, if objects are 'sleeping' but not being interacted with, a specific 'wheezing' and 'teasing' sound can be heard that is quiet, relatively local, and can be altered through direct physical contact with the object. When an object is thrown in the air, the soft object sings out an elongated "wheeee" sound reminiscent of a small child being thrown in the air [Figure 4]. The participant who has thrown the object and others in the near vicinity can hear this sound. The state of the "thrown" soft object is communicated to other objects and the sound is then shared between and amongst objects that are listening. In this way, sound is a 'mid-range' sense, localized, but not requiring one on one tactile interaction in order to witness the sonic response.

The *light* pattern output of the soft objects is perceptible as the most distant sense. Light patterns move through the objects in groups much the same as sonic patterns, however, light patterns can be seen and recognized from a greater distance, and can therefore illustrate and communicate group dynamics and behaviors from a more non-local perspective.

Communication between the soft objects elicits behaviors such as sighing, humming, shaking-shivering, and a shared 'glow-on': moving light patterns that communicate the inter-relationship of the group. The output patterns that move between the objects illustrate the physical path of the communication of state-qualities.

2 From Embodiment to Poetics of Interaction

The second theme of the proposed design framework for somaesthetics is that of the poetics of interaction. Within HCI, theories of experience and embodiment describe ways of valuing the senses, perception and meaning-making and are becoming increasingly central to articulating design for experience [6,23,35]. soft(n) is based on artistic strategies that incorporate embodied interaction in explorations of touch, movement, sensuality and intimacy [20, 30] and that focus more on phatic technologies where sensual or non-verbal connection is valued over textual information [11]. A poetics of interaction supports a somaesthetics framework because it acknowledges that meaning is simultaneously constructed on multiple levels: conceptual, experiential, material, and computational (or technological). Meaning derives from our experience [6] and the imaginative interplay between our self and our environment [18]. In this vein, the artistic goal in soft(n) explores *poetic* notions of embodiment through touch and movement. Tactility and kinesthesia in the physical world are rich, intricate, and full of resolution and expressivity [12,30]. A poetics of interaction allows for a critical and playful approach to design and affords greater access to the imagination of users, allowing both feeling and thought to be engaged [3,15,16]. Patterns and movement of light, sound and vibration purposely allow an open interpretation, multiple meanings and associations [32]. This design strategy is commonly used in artistic practice as a way of poetically evoking experience, thoughtful reflection, and resonance [16].

Poetics and Metaphors

There are a number of poetic metaphors that underly the design of the characteristics and behaviors that led

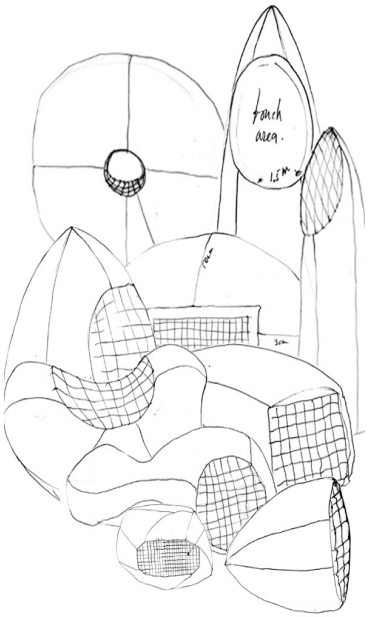

Figure 6. sketch of a family or ecology of soft(n) objects illustrates concept development underlying networked emerging behaviors

to soft(n). Included in these is the notion of 'past lives' of objects, cherishing and memory, the notion of softness and pliability, and emotional attributes contained within objects such as forgiveness, stubbornness, resistance and glee. Touch is a proximal sense, and combined with the soft pillow-like object [1,8,27] can 'arrest' us, creating a window of stillness, creating a space to be held, to bolster, to cushion, to dream. Other artists have explored poetics in objects such as pillows [8,27] and acknowledged the importance of open interpretation, [32] interaction that is resonant [16], contemplative [15] or that provokes awareness through ambient approaches to design [10]. The installation is also contained within a poetic frame of space. It takes place within a social setting where the space of a room holds a soft tangible network. The network lives through its own interaction, and is intervened by its audience, its users. The network can be 'troubled' by its visitors or held by them.

These poetic concepts create a set of somaesthetic markers [19] that we used in a design process to construct possible experiences for participants within the system. The use of somaesthetic framing through poetic forms allows for flexible, meaningful, value-laden design choices that support experiential outcomes.

3 Materiality: Sewing the Pieces Together

The third theme of the proposed somaesthetic framework is that of materiality. This theme emphasizes the importance of embodiment and its application to physical materials; the texture, shape, fabric and form that support experience within the installation. Recent work in HCI has recognized the value of exploring textiles to investigate computational technology as design material [2,13,28].

soft(n) continues this trend with an emphasis on materiality of the physical form designed to enhance the experience of touch. The theme of materiality is dependent upon and inter-connected with the somaesthetic framework as a whole: sustaining experience for the participants (theme 1), the poetics that frame its meaning and sense perception (theme 2), and the soft objects technical design, or 'semantics of caress' that can recognize and respond to tactile states (theme 4). This research integrates custom engineering for soft fabrics, textiles and interactive object design to enable tactile quality recognition.

Figure 7. a *soft(n)* family portrait illustrating the 10 interactive soft objects each containing a hand sewn tactile input array

The scale of each soft object ranges from 2/3 to 1 meter, an almost human scale [Figure 2]. They do not overwhelm the participant's size thereby giving each object a sense of 'livingness'. The shapes are intended to be somewhat abstract or non-literal (not shaped like people, not like animals, not like known living things) yet reminiscent of large vegetables or perhaps human organs. They can be moved, thrown, or placed, so interaction is flexible and various scenarios may emerge based on participants' imagination.

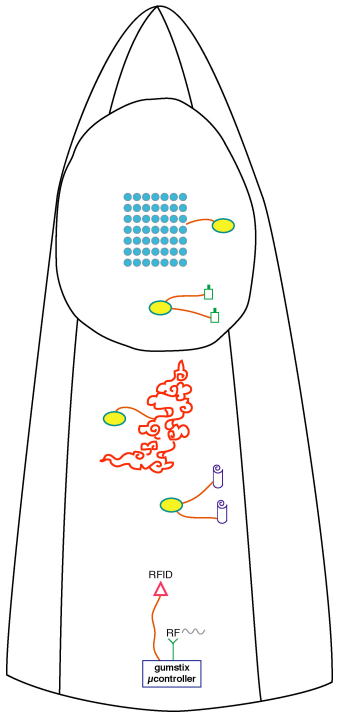

Figure 9. Functional Schematic of soft object

Design Prototyping

In soft(n) a range of physical prototyping forms were explored. Prototypes were a way to test and validate experiential, conceptual (poetic), material and technical concepts. Prototypes included materials exploration at all levels of design iteration: designing for expressivity, sensuality, softness, form factors as well as the technical buildup of the fabric touch surfaces that operate as multi-touch recognition areas [figure 10].

Materials Exploration for Touch Pad

This section highlights the material design used in the construction of the interactive custom-made touch pad that lies at the surface of the soft-object. Conductive silk organza is used (shown in Figure 8 and 10) in two distinct ways: as an aesthetic aspect of the materials design [Figure 1,7,8] and as a 'soft-wire', that conducts an electrical signal, indicating the pressure of contact with a 'taxel' (a single touch pixel within a touch matrix). Each of these taxel presses forms the basis of the object's tactile quality recognition. Various textures and fabric weights were explored as a skin (cover); as a surface (rough, smooth, warm, cold); and as a container (able to be stuffed and to hold embedded electronics).

Conductive Fabric Cables

The *soft(n)* conductive silk organza [2, 28, 31] cables send data signals from the touchpad to the embedded processing unit. The soft object serves mainly as an affectionate sensory transmitter that provides a basic analysis of the signals, using pressure, temporal and spatial location variables, to parse tactile qualities, which are then shared within the network.

Figure 8. Tactile Interaction Surface

Each *soft(n)* object has a custom-made fabric exterior pouch filled with soft material and embedded with a small gumstix controller that coordinates and interprets the data communication [Figure 9]. There are several small circuits that control embedded transducers – which include light array(s) and vibrating motors – that are mounted on individual circuit boards, called 'islands'. Connections that cannot be made wirelessly are made using conductive fabric 'wires' made from silk organza, a transparent directionally conductive fabric along one axis, woven through a non-conductive fabric in the other axis. The silk organza is sewn directly into the soft object tactile surface to form portions of the soft object itself.

Figure 8 illustrates a touch pad prototype, where the taxels are arranged in a grid of 4 x 5. Conductive fabric is used as a passive conductor or soft conductive cable. Figure 10 illustrates the 10 steps in the build up of the touch pad using conductive foam and silk organza as flexible passive conductive cabling. The final soft objects vary between 8 x 8 to a 10 x 10 touch array.

1. Each cell of the Touchmatrix consists of a square piece of resistive foam, in series with a Schottky diode sewn into the fabric between the row- (outputs) and column- electrodes (inputs). Schottky diodes were used for isolation between cells because of their low forward voltage. The first image illustrates one row of the diodes
2. The second image illustrates the top layer of the grid after the diodes have been inserted
3. To make better contact with the foam squares, the leads of the diodes are 'curled'.
4. The leads on the side away from the foam squares are also 'curled' for ease of connection.
5. Prior to adding the cut conductive foam squares, the top layer of diodes that make up the touch matrix are made ready for the next layer.
6. Placing in contact with the diodes, we use silk organza fabric as a conductive layer.
7. The external connection to the foam squares is made via a ribbon of silk organza, which is attached to a column of cells.
8. All four columns are connected with silk organza wires attached
9. The cells are protected from mechanical damage by a fabric layer over silk organza 'wires'.
10. The bottom of the assembly

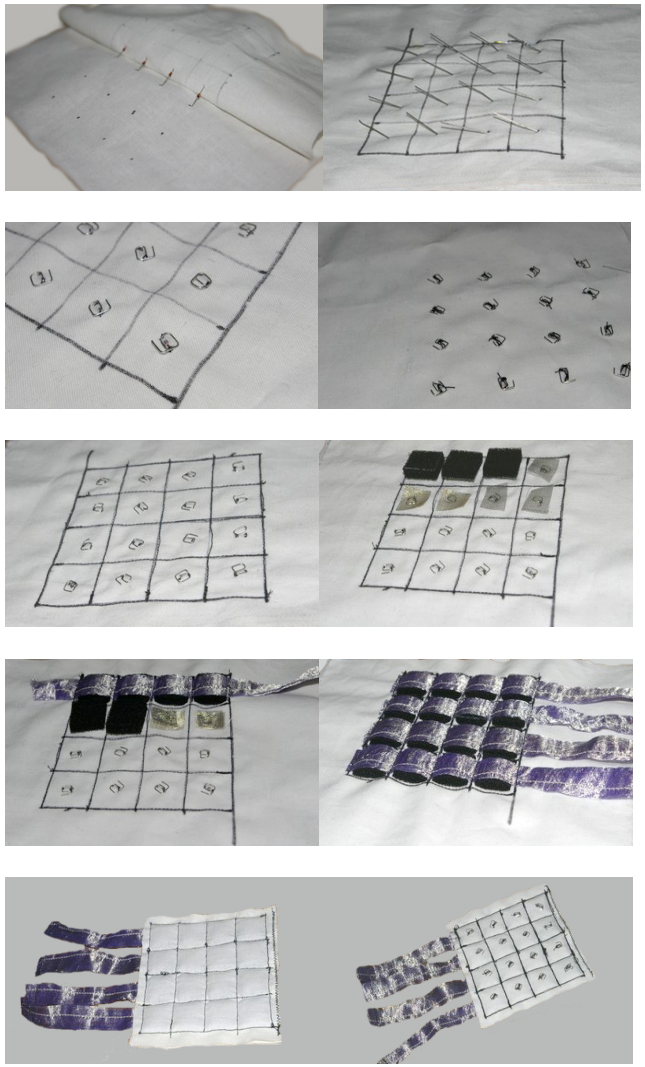

Figure 10. Illustration and Description of Build Up of Hand Sewn Conductive Multi-touch Surface

Input Touch Pad Construction and Prototyping

A touchpad is made of a grid of taxels, each composed of a cell containing conductive foam, with connecting 'wires' constructed from conductive fabric. When the foam pad is depressed through pressure (touch) the electrical resistance of the foam drops as the density of the foam increases. This behaviour allows the system to identify a point of contact or applied pressure. A single taxel is able to distinguish a single value for tactile pressure. A series of taxels can recognize the movement and quality of touch over the surface.
The fabric tactile input surface was constructed by sewing an input matrix for each soft object. The matrix dimensions varied between each soft object as each touch pad was specially designed for the single tactile co-ordinate represented by a 'taxel', or touch point, constructed by using a square of conductive foam sandwiched between two perpendicular 'wires' of silk organza fabric. [Figure 10] The parameters used to recognize the Laban 'quality' of touch includes pressure, area (size, number of tactile points), direction, speed, and length of time and is based on some of our earlier research in wearable technology [31]. The pressure-sensitive tactile pad array is connected to the gumstix controller, to provide touch-based gesture data. These touch pads are hand-sewn, pliable, flexible and soft.

4. soft(n) Semantics Of Caress

The fourth theme of the Somaesthetic Framework presented is the Semantics of Caress, which investigates how the meaning of touch can be applied to tactile interaction. In the case of soft(n) the tactile meaning is implemented following a model based in Laban Effort-Shape. Movement analysis such as Laban

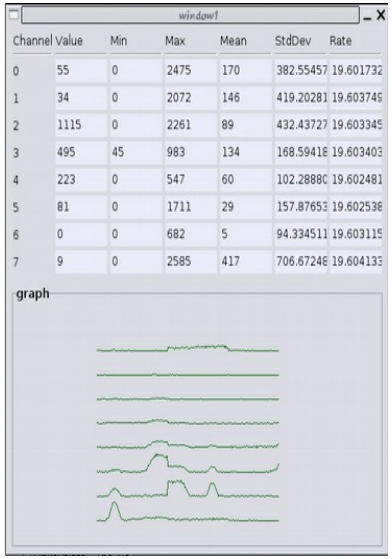

Figure 11. pressure data from a 12x12 array

Effort-Shape has a historical basis in Somatics practice [21] and has been explored in a variety of movement based systems that provide taxonomies for qualitative descriptors of movement [5]. Laban Effort/Shape can describe qualitative experience in a computationally definable form [32]. Pressure is an essential data value extracted to define a caress and its effort [Figure 11]. Touch qualities are extracted based on pressure, number, size, speed and direction of the touch data. Using a simple set of heuristics up to 12 tactile qualities can be recognized, and differentiated [31]. These tactile qualities are based on Laban's primary movement efforts. Tactile qualities remain a qualitative indicator of meaning and of the soft(n) object's state. These touch-efforts [see Table 1] can suggest soft states expressed through various mappings to actuators including vibration, sound and luminous qualities. In the soft(n) installation the touch-efforts are the basis of shared network communication between soft objects. This shared 'state data' exhibits emerging behavior between the soft(n) family as participants hold, throw, slap, jab, or stroke these soft objects. These concepts are founded on an implementation of a system that represents touch and movement as meaningful, and can network and communicate on the level of quality sharing.

Summary + Conclusion

This paper contributes to the discourse of embodiment and aesthetics of interaction within human computer interaction by introducing the concept of somaesthetics as an approach to designing for embodiment within HCI. Somaesthetics can provide a critical study of bodily experience as a focus of sensory-aesthetic appreciation and agency, and can offer a

touch-effort	Description
tap	A soft, short, small, touch, 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 is encompassing.
touch	"Touch" is a small version of "hold". An indication of comfort. 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. 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 a slightly different in shape over time. A "flick" wanders slightly more and a "jab" is more stationary.

Table 1: Touch Effort implemented onto Tactile Surface

bridging strategy between embodied practices based in somatics and the design of aesthetics of interaction within HCI. The design and implementation of soft(n) exemplifies a process of designing within a somaesthetic framework where embodied techniques are proposed within the design method (process) as well as the design outcome (goals).

As a case-study, *soft(n)* explores somatic approaches to design aesthetics that highlight the senses, body, and movement through critical physical inquiry. This approach has been used to introduce an underlying somaesthetic design framework that encompasses four themes: 1) Experience, which frames questions of cultivating embodiment, sensory perception and links to techniques of somatics; 2) Poetics of Interaction including meaning-making and open interpretation, which explores perception and cross-modal relationships between touch 3) Materiality, which emphasizes the importance of the physical body as well as the physical material, texture, shape, and form that support experience within the installation; and 4) Semantics of Caress, investigating meaning as applied to tactile interaction, particularly how tactile qualities can be applied to a computational model for interaction.

Although this case-study is unique in its concept, materials and implementation, it is intended to provide an example for the broader application of a somaesthetic framework, one that can be applied more generally to the design of experience, providing a design resource within the HCI community. As our bodily experience continues to materialize more directly through technology, the need to account for the body and its varieties of experience calls for a continuing research and exploration in practices of embodiment.

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