ABSTRACT

This research paper focuses on the human sense of touch and how technology can further explore and embrace this realm. It is intended for students and researchers outside the discipline who seek an introduction to how we recognize touch and the evolving field of haptic technologies. This paper focuses on explaining how the skin functions as an organ and the various ways that we are able to recognize touch. It then shifts focus to explore and assess projects and technological designs which have used tactile perception in exploratory and pioneering ways.

General Terms
Performance, Design, Human Factors.

Keywords
Touch; haptic; communication; affect; technology; emotion; physical contact; tactile stimulation; subject-object awareness.

INTRODUCTION

This paper inquires into the most elusive yet, arguably, most indispensable sense; touch. I consider various landscapes of touch in order to better realize our current digital technologies and how accurately they concord with philosophical, cultural and physiological substantiations of the tangible realm.

I believe that much more work can be done to further consider our skin and tactile perception in our designs. Therefore, I hypothesize that with a greater understanding of the physiological aspect of touch and our bodies, we can better our technological advances in this field and become more informed about the issues which surround them.

I will use case studies to connect my research and ideas to historical and contemporary precedents and situate my findings within the larger discourse surrounding design and technology. I will also place these case studies in a philosophical and cultural context and consider how development of haptic design palettes alter our subject-object phenomenal experience of the world.

I divide this research paper into three main areas of focus: Skin-Scapes, Emotional Touch, Touch and Technology.

SKIN-SCAPES

This section aims to study our understanding of the physiological aspect of touch. I will explore the sensory organs, nerves, muscle cells and receptors which have enabled heat and pain sensations via the peripheral nervous system, and it also expels salts and wastes, and helps with healing wounds.

The Human Skin

Human skin is the largest organ on the body and it is “one of the organs which accounts for the largest proportion of total body weight”. (Schaefer:1) It is our barrier to the outside, located all over the surface of our bodies as a flat, pliable and tough layer between 0.5 and 4mm thick. It both gathers sensations and protects against them. In addition to other components such as fingernails, glands and hair, these elements make up an elaborate network called the integumentary system. This system’s main function is to protect the body from attack and damage from environmental insults such as disease causing microorganisms, lacerations and radiation from the sun.

Additionally, skin has the following attributes: it aids the maintenance of homeostasis, it has significant metabolic processes and has many sensory receptors to help form tactile tactual perception. Heat and pain sensations are enabled via the peripheral nervous system, and it also expels salts and wastes, and helps with healing wounds.
The Skin’s Components

The skin has a complex structure but can be broken down into two layers, the dermis and the epidermis but there is also an important underneath layer, the hypodermis. The hypodermis is subcutaneous tissue mostly composed of adipose tissue which functions as an anchor for the skin to the muscle below. It is important as it acts as a shock absorber and an insulator, also allowing the skin to move smoothly over the muscle. The dermis and epidermis contain a number of different types of cells and connective tissue that provide the form and function for the skin. There are three types of nerves in the skin: sensory nerves, motor nerves and secretory nerves. The skin's outer layer, the epidermis, is waterproof and stain resistant since keratinocytes make up around 90% of the cells in the epidermis and they produce keratin to perform this function. A robust barrier is created by intricately entwined epidermal cells to hold moisture in as well as keep unwanted water out.

On the exterior, dense, dead and shedding cells make the system more resilient. With an intelligence the military would covet, the epidermis is primed with stem cells ready to release reinforcements as needed, and pigment-producing melanocytes to deflect skin's number one enemy, the sun (Healy). Melanocytes also interact with the keratinocytes to carry out a variety of roles such as aiding the development of cells during development and maintaining the regularity of the skin.

The robust nature of the skin is also facilitated by the collagen fibers and fibroblasts, found in the dermis, and the blood circulation is made possible by the dermal microvascular and lymphatic vessels also in the dermis.

Hair Follicles

Hair follicles are located in the dermis and can sometimes reach down into the hypodermis. Each hair follicle is accompanied by arrector pili muscles which are responsible for the movements of our hairs. For example, when the hairs on our arm stand up on end when it is cold this is the action of the arrector pili muscles. There is a particular motor nerve fiber which controls this arrector pili muscle by telling it to contract or expand.

Secretary Nerve Fibers

We also have secretary nerve fibers located near the hair follicles such as sweat glands and sebaceous glands, these allow oil, salt and water to be released to keep the skin healthy and cool us down when it is hot.

The Somatonsensory System

“Somatonsensory” is a term which designates all other senses than vision, hearing, balance, taste and smell. It is a diverse sensory system which includes receptors from all over the body, rather than being situated in specific locations. There are four distinguishable modalities that make up the receptors and processing centers which tell us about objects in our external environment through: touch/tactile sensors (physical contact with skin), temperature/thermal (of the body, external objects and environment), proprioception/body position (through the stimulation of muscle and joints), and nociception/pain (also itchy and tickling stimuli).
This table (Tsuchitani) outlines the sensory modalities represented by the somatosensory systems. Since it is such a complex system this table is helpful in allowing us to see the breakdown of the modalities and sub modalities and so on. There also appears to be growing evidence for the presence of a fifth modality (McGlone:1) which is said to transfer positive/pleasant affective properties of touch, however, since this is still amid debate it is not exhibited in the table.

The sensory information which is received and processed travels along a variety of different anatomical pathways, conditional on the type of information carried. To clarify what tactile stimuli are, they are defined as “external forces in physical contact with the skin that give rise to the sensations of touch, pressure, flutter, or vibration.” (Tsuchitani: 2)

Our normal way of thinking about touch is that it displaces the skin a very little amount, although, with different types of touch, such as high pressure touch, this can actually displace the skin and underlying tissue.

**Cutaneous Receptors**

The cutaneous senses are inclusive of touch, nociception and thermal sensation which are all sensations produced by receptors in the skin. The dermis contains four different kinds of mechanoreceptors. These are sensory receptors that respond to physical pressure or distortion.

<table>
<thead>
<tr>
<th>Modality</th>
<th>Sub Modality</th>
<th>Sub-Sub Modality</th>
<th>Somatosensory Pathway (Body)</th>
<th>Somatosensory Pathway (Face)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain</td>
<td>sharp cutting pain</td>
<td></td>
<td>Neospinothalamic</td>
<td>Spinal Trigeminal</td>
</tr>
<tr>
<td></td>
<td>dull burning pain</td>
<td></td>
<td>Paleospinothalamic</td>
<td></td>
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<tr>
<td></td>
<td>deep acheing pain</td>
<td></td>
<td>Archispinothalamic</td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>warm/hot</td>
<td></td>
<td>Paleospinothalamic</td>
<td>Main Sensory Trigeminal</td>
</tr>
<tr>
<td></td>
<td>cool/cold</td>
<td></td>
<td>Neospinothalamic</td>
<td></td>
</tr>
<tr>
<td>Touch</td>
<td>itch/tickle &amp; crude touch</td>
<td>touch</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>discriminative touch</td>
<td>pressure</td>
<td></td>
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<td></td>
<td></td>
<td>flutter</td>
<td></td>
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<td></td>
<td></td>
<td>vibration</td>
<td></td>
<td></td>
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<tr>
<td>Proprioception</td>
<td>Position: Static Forces</td>
<td>muscle length</td>
<td>Medial Lemniscal</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>muscle tension</td>
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<td></td>
<td></td>
<td>joint pressure</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Movement: Dynamic Forces</td>
<td>muscle length</td>
<td></td>
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<td></td>
<td></td>
<td>muscle tension</td>
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<td></td>
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<td>joint pressure</td>
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<tr>
<td></td>
<td></td>
<td>joint angle</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: The Sensory Modalities Represented by the Somatosensory Systems

As we can see from the table, mechanoreceptors respond to stimuli categorized in the sub-sub-modality of touch: touch, pressure, flutter and vibration.

![Figure 3: The Cutaneous Mechanoreceptors.](image)

The Merkel receptors are disk shaped receptors located around the border between the epidermis and the dermis. The Meissner corpuscles are a cluster of compressed disks which can be found in the dermis just below the epidermis. The Ruffini cylinders are branched fibers inside a cylindrical module. Finally, the Pacinian corpuscles are layered capsules situated deep into the skin. (Boynton)
The temporal properties of these mechanoreceptors are as follows: The Merkel and Ruffini receptors have a continuous firing mechanism, so that when pressure is applied, the *slowly adapting fibers* (SA) keep sending signals. The Meissner and Pacinian corpuscles have instead rapidly *adapting fibers* (RA) which fire only at the onset of stimulation. The spatial properties of surface receptors (Merkel and Meissner) have a compact receptive field and react to vibrations when they are at a slow pace. The receptors located deeper into the skin (Ruffini and Pacinian) have much larger receptive fields and therefore respond to higher vibration rates.

The skin of the hand, in particular, is highly specialized to provide detailed tactile feedback (Ciesielska-Wróbel et al).

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**Table 2: Properties of Four Types of Mechanoreceptors.**

<table>
<thead>
<tr>
<th>Receptor (Fiber)</th>
<th>How Fiber Responds</th>
<th>Frequency Response</th>
<th>Perceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merkel (SA)</td>
<td>Continues (slow adapting)</td>
<td>0.3–3 Hz</td>
<td>Slow pushing</td>
</tr>
<tr>
<td>Ruffini (SA2)</td>
<td>Continues (slow adapting)</td>
<td>15–400 Hz</td>
<td>Stretching</td>
</tr>
<tr>
<td>Meissner (RA1)</td>
<td>On Off</td>
<td>3–40 Hz</td>
<td>“Flutter”</td>
</tr>
<tr>
<td>Pacinian (RA2)</td>
<td>Responds to change (rapid adapting)</td>
<td>10–500 Hz</td>
<td>Vibrating</td>
</tr>
</tbody>
</table>

Figure 4: Defining the Locations of the Surface and Deep Receptors.

The diagram I have created of the hands reveals the difference in receptive fields of the surface receptors and the deep receptors, Merkel and Meissner corpuscles (left) have small receptive fields (shaded areas) and good spacial resolution. Spacial resolution here means the number of receptors per unit length. The Ruffini and Pacinian corpuscles (right) have large receptive fields and poor spacial resolution.

The following table demonstrates the different properties of the four types of mechanoreceptors. For example, it shows us that Ruffini receptors have large receptive fields and that they respond to the stretching of skin in varying directions.

Figure 5: Representation of the Different Receptive Fields.
Pathways from Skin to Cortex

Now that we are well versed in the way in which our skin receives information, we need to understand how it transmits information to the central nervous system (CNS) located in the spinal cord and brain.

The skin is a part of the peripheral nervous system (PNS) which consists of the nerves and ganglia located near the spinal cord, but which exist outside of the CNS, in the dorsal root ganglion. The image below shows the dorsal root ganglion, which “contains the cell bodies of nerve fibers that innervate receptors on the skin, muscles, tendons, etc.” (Covey: 62)

Figure 6: The Dorsal Root Ganglion Cell.

Nerve fibers always travel in bundles and their destination is the spinal cord. The transduction in the receptors occurs if there has been a great enough depolarization of the receptor which causes the cell to produce an action potential via mechanically-gated ion channels, which is transmitted to the CNS (Covey: 59). There are separate paths which the nerves travel down depending on whether the information is pain information or touch information, they also enter the spinal cord at different locations since the spinal cord is segmented.

In Figure 7, three fibers in a peripheral nerve receive input from three different receptors in the skin’s surface. These are each sent to different areas of the spinal cord segment.

Figure 7: Diagram of the Transmission of Sensory Information.

Crossing over at opposite sides of the body, they both synapse in the thalamus and travel up to the somatosensory cortex, which is the primary sensory receptive area for sense of touch. This somatosensory cortex is located in the parietal lobe in the brain and in a similar fashion to other sensory areas, the mapping of the body occurs and is enabled by the Homunculus. This informs the brain as to which area of the body is responsible for the alert. It is interesting to note that regions of high acuity can be seen in this below image; the finger tips and lips take up larger areas on the cortex.

Figure 8: A Sensory Homunculus.
The duplex theory of tactile texture perception

While on the subject of tactile perception, it is important to know the history of advancement in this area. David Katz’s treatise *The World of Touch*, (1925/1989) was pioneering. He further developed the theory that tactile perception of the texture of object surfaces depends on a “spatial sense” for perceiving of rough textures, and a “vibration sense” for recognition of more refined textures. His view is referred to as the *Duplex theory of tactile texture perception* and is defended in recent work by Hollins and Risner in *Evidence for the duplex theory of tactile texture perception*. In this paper, the results suggest evidence against theories that attribute perception of all textures to a single mechanism (Hollins & Risner: 704). They state that two mechanisms, one which is sensitive to movement, and the other not, are necessary to explain tactile perception across the full range of discriminable textures which they investigated. These findings then support evidence for the Merkel receptors being responsible for the *spatial cues* which are determined by the size, shape, and distribution of surface elements. Also, that the Pacinian receptors are responsible for the *temporal cues*, since they determine the rate of vibration as skin is moved across finely textured surfaces. (Boynton:Week 10)

Research of Highly Specialized Species

The Star Nosed Mole (*Condylura cristata*) resides in burrows in low wetlands of North America and it is known for its incredibly sensitive nose.

Being almost blind, instead of visual perception, these animals guide themselves around the earth using their snout surrounded by 22 fleshy and mobile protrusions. They are able to touch 13 different points at the same time.

Figure 9: Star Nosed Mole.

The Star Nosed Mole possesses the highest density of nerve endings known in any mammalian skin, with over 100,000 fibers in an area less than a half inch in diameter, researchers have been able to determine that these nerve endings are specifically geared to detect *light touch* (McStravick). Catania (1999) notes that there are many “surprising parallels between the somatosensory system of the mole, and the visual systems of other mammals.” this suggests “...a convergent and perhaps common organization for highly developed sensory systems.” (Catania:367) By studying these kinds of animals we can begin to understand and compare the way our own human receptors are arranged and what we can sense, with the capabilities of other animals. With this greater understanding, we could create more interesting and developed haptic devices. For example, Catania suggests that by further exploration of *Eimer Organs* of which the star nosed mole has plenty, we could apprehend perception of textures which are not in our capacity to perceive, since we simply do not have as advanced tactile capabilities.

Figure 10: A Star Nosed Mole’s Snout.
Figure 11: A Star Nosed Mole’s Eimer’s Organ.

EMOTIONAL TOUCH

Touch is the most developed sensory modality at birth, providing cognitive, brain and socioemotional development throughout infancy and childhood (Field, 2001; Hertenstein, 2002; Stack, 2001). When designing our technological objects which, no doubt, will encompass in some way tapping into our tactile sensations, it is important to realize the sensation our object gives to the user. The touch is an intimate sensation. Dr Watson, an American behaviorist, illustrated this by investigating into the emotions of children. He tested what deep emotions could be conditioned into a subject through our tactile sensations.

“Try this on your bambino. While you let baby touch a rabbit’s fur, give out a load “Booh!” Repeat if necessary. The child will in a short space develop a positive terror of furred objects.” (Shledon & Arens: 427)

He notes that many adults have had some sort of experience like this when they were younger and still harbor a certain reaction to certain textures. It is a type of conditioning, which occurs in our daily lives, whether we are aware of it or not.

This point just highlights how important touch is, and how we must consider emotional responses to the textures we use when creating objects. The deciding factor on buying an object may well come down to the way it sits in your hand, the way it feels, do you feel comfortable holding it? If you do, there is likely to be some sort of emotional attachment to this item – it reminds you of something, or the texture and weight and perhaps even temperature give us a pleasurable sensation.

Our designed objects, the knobs on our cooker, our soaps which fit into the palm of our hands, our hats which fit around our heads, all of these things have been designed with touch in mind, carefully constructed to optimize our pleasure and productivity in daily lives. If we observe our actions carefully enough, it becomes more apparent how the way things feel affect our lives. We may have a sweater in the closet which we never wear and it may turn out to be the case that it gives you a tickling sensation on the arm. Although some people may be very aware of their unconscious actions, others will not. Touch is very influential and, therefore, important to analyze.

Touch and its Ability to Communicate Distinct Emotions

In many cultures, adults have various ways of touching other humans which can be pinpointed, such as flirting, expressing power, soothing, playing, and maintaining proximity between child and caretaker. (Eibl-Eibesfeld) Non-human primates have additional ways of touching, such as grooming, reconciling after aggressive encounters, (de Waal) and so on.

Popular studies show that a touch communicates the hedonic tone of emotion. (Hertenstein & Campos, 2001; Jones & Yarbrough, 1985; Knapp & Hall, 1997) This means that touch communicates either a positive valence; warm, intimate emotion, or a negative valence; cold, uncomfortable.

However, very recent studies by Hertenstein et al. (2006), claim that touch can communicate more than just the hedonic tone and intensity of emotions. (Hertenstein et al.:532) Hertenstein et al. found that results from participants in their test showed a higher than chance possibility that the participant detected a particular emotion from a touch. Moreover, compared with studies on emotion with facial displays and vocal communication which are considered to be successful in detecting emotions, the accuracy rates are similar. Hertenstein et al. discovered six different emotions that tactile modality can signal: anger, fear, disgust, love, gratitude and sympathy, and, furthermore, they identified specific tactile behaviors used by participants to communicate distinct emotions,
exhibiting the richness of the physical properties of touch. (Hertenstein, 2002)

Hertenstein et al. note that there are possible alternative reasons other than emotional reasons which might explain the results. One of these is that the participants were communicating intent rather than emotion. Fridlund (1997) has argued that facial displays communicate intentions rather than emotion, so the same could be the case with the investigation of tactile signals.

Other information from the study showed that not only can we receive emotion from a touch, we can pick up the emotion of a touch from watching another person being touched. A possible explanation for this might be due to mirror neurons which fire not only when we complete an act, but also when we observe another executing a motor act. Since our neurons copy the motor act another person is completing, the emotions or intention of that action could be picked up by us simply understanding this action via re-enacting it. Hertenstein et al. envision further research on this topic to answer the question of “whether decoding accuracy would be enhanced, or diminished when touch is both seen and felt.” (Hertenstein et al: 532)

This research is interesting since it shows that there are uncertainties about how much emotion is exchanged within a touch, and that there is opportunity for further research. This research could certainly aid the work of haptic technologies.

**TOUCH AND TECHNOLOGY**

**Haptic Technologies**

The following section presents encounters, reflections and production of artworks and haptic technologies which focus on embodied experience.

Derived from the Greek *haptesthai*, “of, pertaining to, or relating to the sense of touch or tactile sensation” haptics is the study of touch and an investigation into the different ways we interface with the world via this sensory mode. From phones that vibrate, to touch face interfaces and game controllers, haptic technologies are all around us.

Designing and crafting actual objects, haptic technologies have been undergoing major advancement. In the 1990’s with the rise of digital technology, certain criticisms were raised, such as Malcolm McCullough critical question: “What good are computers, except perhaps for mundane documentation, if you cannot even touch your work? The fact that traditional craft endures at all is because it satisfies some deep need for direct experience- and most computers and not yet providing that experience.” (McCullough:25)

This notion is dated now however, since haptic technologies have been discreetly proliferating, enabling more active explorations of the mechanistic medium between computer and user. They have found uses in multiple areas such as surgical procedures, military exercises, clearing mines, internet sex, interplanetary exploration, undersea exploration and video games. (Hannaford 2000; Stone 2000; Arthur 2002)

**PHANTOM**

An example of this is PHANTOM and its software program FreeForm, designed and built by SensAble Technologies. Tomas Massie and the physicist Kenneth Salisbury invented this device in 1993 at the Massachusetts Institute of Technology (MIT). Known as computer aided design, it allows the process of creating technical drawing with the use of computer software, encompassing simulations of 3D shapes, textures and clay. (Paterson:224)

![PHANTOM](image)

**Figure 12: PHANTOM.**

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1 The acronym PHANTOM stands for Personal HApetic iNTerface Mechanism
PHANTOM is designed with a pen with a mobile arm connected to the interface. As one uses the stylus, feedback (resistance) is given by the electronic motors so that one can actually feel the shape of the image on the screen. In this way, the user is inclined to become more present since they are not just passively clicking and viewing a screen and there is a more immediate relationship with the digital objects. Therefore, there is a sense of being “immersed, of being engaged with the task at hand.” (Paterson:223) The potter feels no separation between the task at hand and the clay.

On the other hand, it can be argued that the “aura” of the artwork has somewhat been altered and, since the object is digital, despite its digital tangibility, this cannot emanate the character, mood, and energy around a distinct physical object. In the case of haptic devices over distance, where tangible presences are re-created through artificial means and, therefore, reproduced the virtual objects give the “illusion of being immediately present, literally manipulable or graspable.” (Paterson:434)

Paterson argues that Walter Benjamin’s notion that only the original artwork has an aura, never its reproductions, is rendered obsolete in this new age of haptic technology since now the original object and its copy literally feel the same. (Paterson:434) However, I tend to disagree with this view. If a computer can accurately re-produce my mother’s every characteristic, and I can give her a hug in my New York apartment enabled by haptic technology, I feel that something would be missing. Since her actual presence and body would remain at home in England, there would be a difference between her aura in England- her actual self, and the aura of herself here- her replicated self. If her body could be momentary teleported here, and this was her actual self wholly in my presence, then this would feel right! It has something to do with sense of being in the presence of other people (an actual person). The philosopher Hubert Dreyfus (borrowing a term from Merleau-Ponty) calls this the sense of “inter-corporeality” and suggests that “even the most sophisticated forms of telepresence may well seem remote and abstract if they are not in some way connected with our sense of the warm, embodied nearness of a flesh-and-blood human being.” (Dreyfus:14)

The take home point here is that haptics and force-feedback do a better job of bringing objects to life than digital representations on a screen, as we have seen by products such as PHANTOM. However, the intimacy of touch, the aura of an artwork and the inter-corporeality of being in the presence of other humans, bring us interesting ideas and questions for the advancements in haptic technology. This might be a problem of the type which Professor Horst Rittel coined “wicked problem” for tele-present platforms.

**Technology and Isolation**

In the 1920s E.M. Forster had an interesting view of the destiny of the human race. He conceived of a future where people contacted each other only using electronic equipment. He pictured people remaining in their rooms all their lives, talking, seeing and even experiencing medical care from remote automated machines, and so on. Needless to say, this way of life caused humans to have pale skin, stout, flabby bodies (which they despised) and when an uncommon situation ensued whereby a person met another face to face, “it was considered a great faux pas to touch or be touched by another person.” (Dreyfus:1)

It seems we might be moving towards this future Forster envisioned, although not quite as drastic as not leaving our homes ever, nonetheless, we can do almost anything in the comfort of our own bedroom; we can order food, speak to friends, keep up with the latest events, conduct research, meet people (online date), play games and also control remote robots without leaving our room. If the reader is not sure whether we can, in fact, control robots yet, then they should draw their attention to “The Telegarden.” (Goldber et al., 1994)

This is was exhibited in the Ars Electronica Museum in Austria in 2004, where visitors to the website could log in from terminals all over the world and could control the direction of the camera, plant seeds and water the plants. It began in 1996 and remained online for the next 7 years. The activity was recorded in logs so that the cooperative could be self-governing (Goldberg), and the idea was to encourage participation, return visits and user supervision.
Telepresence

“Art has always concerned itself with presence: of gods in religious art, heroes in classical art, the artist in romantic art; of presence itself in abstract art. In telematic art, our telepresence is distributed throughout the Internet. We are both here and there, out-of-body and re-embodied, de-materialized and re-configured at on and the same time”. (Ascott 1996: 382)

Telepresence is an emerging technology which gives us a new relationship to technology, others, and our surrounding world, and since it is becoming one of the core intermediaries in connecting to others, and is primarily visual, its interesting to note how our sense of touch can come into play.

As part of the exhibition of contemporary art in central Amsterdam called *I + the Other: Dignity for All, Reflections on Humanity*, *Telematic Dreaming* (1992) by Paul Sermon is a prime example of a mix of analogue and digital which explores the many levels of virtuality of the body. By looking at Suzan Kozel’s interaction with this installation, we can gain some insight into the implications of the telepresence technology, its affect on tactile sensations and the negotiation between public and private experience.

*Telematic Dreaming* was set up in two separate rooms, one upstairs and one downstairs. For four weeks, Kozel, a dancer, lay in the room upstairs on a bed in an illuminated space, this became her performance space. There was a video camera on the ceiling above the bed which recorded Kozel’s movements. This image of Kozel was projected in real time onto a bed in a room below. In this room below, the space was blacked out so that the projection of the bed in the above room could be seen. Visitors were invited to join Kozel on the bed and interact with her. There was also a video camera set above the bed in the room below which was shown on two monitors in the upstairs room.

Since visual connection is normally the central point in telepresence, *Telematic Dreaming* involves vision and touch in a very thought provoking way. Though essentially visual, it brings about a surprisingly real sense of touch that is amplified by the context of the bed (private space) and a sharp shift of senses in the telematic space. The interaction with Kozel and the other viewers involved a logic of images. Using only vision only to direct movement towards the other
person, Jütte describes the interaction between the spectators as “we see their eyes meet and their hands reach out in search of each other, exactly as though they were together in a real space” (Jütte:325).

Kozel, herself talks of the strong physicality of the piece, noting that the mechanization of human experience is for the most part thought of as diminishing the physical and emotional sides of life, however, this piece elevated these by taking them away in the normal sense that we experience them. She notes how she became more aware of her own body, its digestion, breathing, pains and cramps. (Kozel) Perhaps because her body expected to feel another person, she became more aware of own self, as if it were also the other.

**Your Skin, My Skin**

*Your skin, My Skin* is a project which assumes the former premise, but challenges the latter premise:

1. the skin is a physical container for our body,
2. we cannot extend ourselves physically beyond this container.

Similar to Telematic Dreaming, *Your Skin, My Skin* is gives the user an experience of extending the body, not losing or substituting it. In an attempt to provide the self with another dimension, this provides an extension of touch in the physical realm.

The confrontation with P2 is established by introducing a “second skin” on the wearer. This second skin replicates the feeling of someone else being touched. In this way, this project aims to extend our bodies beyond our own skin’s container and into a new container, one which allows us to more fully understand and experience what it might be like to be in another’s skin in a very literal way.

The two garments are connected wirelessly and communicate using two XBee shields, two arduino fios. Capacitive sensing is used to sense the touch on the first garment, and once touched, this simultaneously blows up an air bag in the other suit, via an air pump, air valves and tubing, in the same place on the body where the first person was touched. The two people can choose to be in view of each other or out of view, since the technology supports them being in different locations.

What is most interesting about this project is being the wearer of the suit which inflates, you can choose to look at the other person and have the expectation of feeling the touch, or you can choose to not look, and feel the surprise of the air bag inflating. You feel a touch, but you don’t know who is touching you (you do not know who is touching the other person).

It makes touch very de-personalized, since no person is actually touching you, you cannot tell what kind of touch the other person is getting, for example, whether it’s delicate, sympathetic, or even painful. You are confined to the feeling of the other person of generated by the pressure on your skin from the air.

Figure: 15 Your Skin, My Skin. The model on the left wears the garment which actuate the touch, and the model on the right wears the capitative sensor garment.

**Creating Soft, Dynamic Textures**

By understanding the way the skin receives information from other surfaces, it allows us to think more deeply about the type of touch we generate with garments. At the moment, the majority of technological tools which integrate haptic technologies do this with vibration motors. Our phones vibrate, our game controllers do, so do our massage machines. Innovative haptic technologies are being explored by MIT Media Lab researchers. In their paper which has just this year been released, *PneUI: Pneumatically Actuated Soft Composite Materials for Shape Changing Interfaces* they experiment with various materials to create dynamic texture change.

Two approaches of particular interest are their tests to create dynamic textures on soft surfaces.

The picture on the next page illustrates the method these researchers implemented. They fabricated silicon with air bubbles to make different channels. To
create a tactile output they inflated air into each of the air channels so that when holding the mould, one would be able to feel each of the air bubbles either inflated or deflated.

Figure 16: (a, b) Structure of the composite material. (c, d, e) Fabrication process. (c) Pouring pre-mixture of silicon into a mold with threads of beads suspended in the mid-air. (d) Thermally curing the silicon and peeling it off the mold. (e) Pulling the beads out of the silicon for the final sample. (Yao et al.:6)

The density, frequency and sequence of the texture can be altered by pumping and vacuuming the air into the separate columns at different times (Yao et al. :6) Using this method, bigger air bags could be used, and bigger holes made, so that the scale of this application could work on both micro and macro levels.

Applications of this kind of technology could be to enhance gaming or mapping technologies- giving you directional signals and speed, and also 3D modeling textures and patterns, similar to what we saw earlier with PHANTOM.

The second approach to create the dynamic texture was creating a composite material which utilized cut stretch fabric to create the texture. As the air pressure inside the surface increased, the texture was able to be seen on the surface of the silicone, from “global to local region” (Yao et al.:6)

Figure 17: a) Structure of composite material. (b) Fabric constraints of deformation in local areas of surface.

Figure 18: As the air pressure increases the surfaces deform.

Figure 19: Different textures generated due to different cutting patterns.

Perhaps using this type of testing and manufacturing of compositing materials could be an interesting step for the garments from *Your Skin, My Skin*. Different types of touch could actuate different textures on the garment which receives air actuated touch. These could represent different emotions or intentions and/or different textures.

CONCLUSION

Skin is a complex, multilayered organ which detects and responds to the outside environment. It enables us to move about the world confidently, knowing that we have a defense mechanism which will notify us if we are coming into contact with harmful outside objects. By breaking down the various characteristics of our skin, we come closer to understanding how this incredible system does its job. In this paper I claimed that by looking towards nature and likening ourselves to other creatures and their sensory systems, we can discover the limits and bounds of our own systems, and how we might enhance them using technology. Without using our knowledge of how our skin functions, haptic technologies will suffer.

Our advancements in technology should “take by the horns” what we already know about our body systems, and use that as a stepping stone to further enhance our interaction with the world. In doing this we can then have a deeper comprehension of the world, and transform our perceptions through altering our sense capacities. Whether our altered apprehension of the world gives us a more “real” perception of the world than before is a question for the thoughtful metaphysician. However, what I do
know is that we have an ability to alter our perceptions to open up new realms, and we should embrace these opportunities if only to learn more about ourselves and what unknown possibilities there are for advancement of the human species.

Haptic technologies are on the rise and, in this paper, I described a diverse range of projects, designs and installations which have innovated this field. Though each project differed highly in concept and, indeed, technology, each one involved altering our interaction in the world via a technology that discernibly gave our tactile senses authority. PHANTOM, Your Skin My Skin and research by the MIT Media Lab researchers all activated our tactile senses in an obvious way (via increasing our tactile capabilities). However, what is remarkable about Telematic Dreaming is that this installation managed to do this by completely diminishing the persons tactile relationship to another person. Taking Suzan Kozel as an example, her experience of the installation actually enhanced her proprioceptive senses, thereby intensifying her own sense of presence and self-embodiment. By taking us out of the ordinary, explorations like Telematic Dreaming help us learn more about how our bodies react in certain situations and pin point its charm and fascination.

What we really stand to gain from advancement in this field is knowledge about who and what we are. We can understand how objects interact with our skin and our nervous system, and how emotion might be involved in this interaction. Furthermore, we know that there are always more questions to be answered and more to learn about ourselves and our surroundings.

I hypothesized that with a greater understanding of the physiological aspect of touch and our bodies we can better our technological advances in this field. My research has not contested this statement. I believe that by taking the two hand in hand; studying our physiology with science, and exploring different situations and circumstances with our bodies using art and design, our haptic technology possibilities are boundless! New technologies in telepresence, haptic interfaces and virtual reality can augment our relationship with the world and amplify our sense of presence and potential for action. Also, in exploring and continuing to be inquisitive, we can simultaneously further our scientific practice, our creative practice, and our individual sense of place and being. In the words of Andy Clark, “In success and in failure, these tools help us to know ourselves.”

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