Fauxy the Fake Fur with Feelings

Keywords: textile / tactile / body image / homunculus / animated garment / fashion

Abstract

A taxtile is a smart fabric that integrates sensors and actuators in the same flexible material, inspired by human skin. In earlier work we explored the idea of a taxtile through a prototype in which a fabric surface 'purrs' in response to stroking. In this paper we develop a theory for the use of taxtiles in wearable information systems based on the neuroscience of body image. Bodily illusions, such as the 'shrinking waist' or the 'stretching nose' can be generated through tactile stimulation of the nerves close to the surface of the skin. These illusions demonstrate the slippage between our physical bodies and our mental awareness of our bodies. Bodily awareness is fluid and can extend to a tool in the hand, or the boundaries of a car while parking. We propose that bodily awareness could also flow into a taxtile through 'tactile nerve extensions'. The design sketch for Fauxy the Fake Fur Coat with Feelings has vibrotactile buttons sewn on the inside to connect the fabric sensor to skin sensations. We hypothesise that these prototype 'tactile nerve extensions' enable bodily awareness to flow into the coat so the wearer can feel people behind them at a distance, outside of their usual perception.

Introduction

The convergence of computing and textile technologies is marked by the inaugural conference on Smart Fabrics in Barcelona in 2005 [Smart Fabrics 2005]. Commercial products, such as the SensaTex Smart Shirt and the VivoMetrics Life Shirt are made from fabric woven with sensors that measure heartbeat, breathing, perspiration, temperature, stretch, and movement for medical, athletic and military applications. Smart fabrics, techno-textiles, and wearable computing interfaces are routinely modeled on the catwalk at the annual Siggraph Cyber Fashion Show that was first staged in 2002. In this show the movements, heartbeats and internet personas of the models are projected as augmented body images rendered in colour, sound and animation on the garments they are wearing. In 2006 Cyber Fashion became High Fashion on the runway of the Paris Fashion Show when Hussein Chalayan showed six animated garments that changed shape using embedded technology and smart wires. In the finale the model's dress folded up into her hat leaving her wearing only her own skin. It seems that beyond further spectacle there is little left to do with a Smart Fabric!

However placing the focus on the skin as a wearable information system leads to the realisation that skin is the most sophisticated Smart Fabric you could imagine! The 1.6 square metres of the skin on the human body is flexible, durable and waterproof. It protects us from disease, chemicals and radiation, regulates temperature, synthesises vitamins, repairs DNA, and heals its cuts and bruises. The skin also connects us to the world. You shiver when you jump into the cold surf, enjoy the warmth of the sun on your back, and feel the texture of grains of sand. When you purposely touch something you also feel information about it. We touch out of curiosity, to explore material, texture, shape, weight, temperature, and hardness. We touch each other to communicate, to reassure, to direct attention, to find where it hurts, and to check for a high temperature. We enjoy being stroked and touch is an important part of affection and one of our greatest pleasures.

The sensors in a Smart Fabric have thermal, mechanical, chemical and electrical characteristics that register many of the same kinds of information that skin does. Clothing also provides extra layers of protection from the environment. One day Smart Fabrics may even synthesise vitamins, repair DNA and heal physical cuts and bruises. However in current Smart Fabric designs there is a distinct gap between the sensors in the fabric and the senses in the skin. What if the sensors in the Smart Fabric were connected to the skin of the wearer to reposition the wearer from a source of 'data' to the 'smarts' in a wearable information system?

The Body in the Brain

The nerve connections between the skin and the brain are drawn as an image of the body on the associated regions of the neural cortex, as shown in Figure 1 [Penfield and Rasmussen 1950]. This 'body in the brain' with its outsized hands and lips that reflect the relatively larger number of nerves and neurons dedicated to these parts of the body, is known as the 'sensory homunculus'.

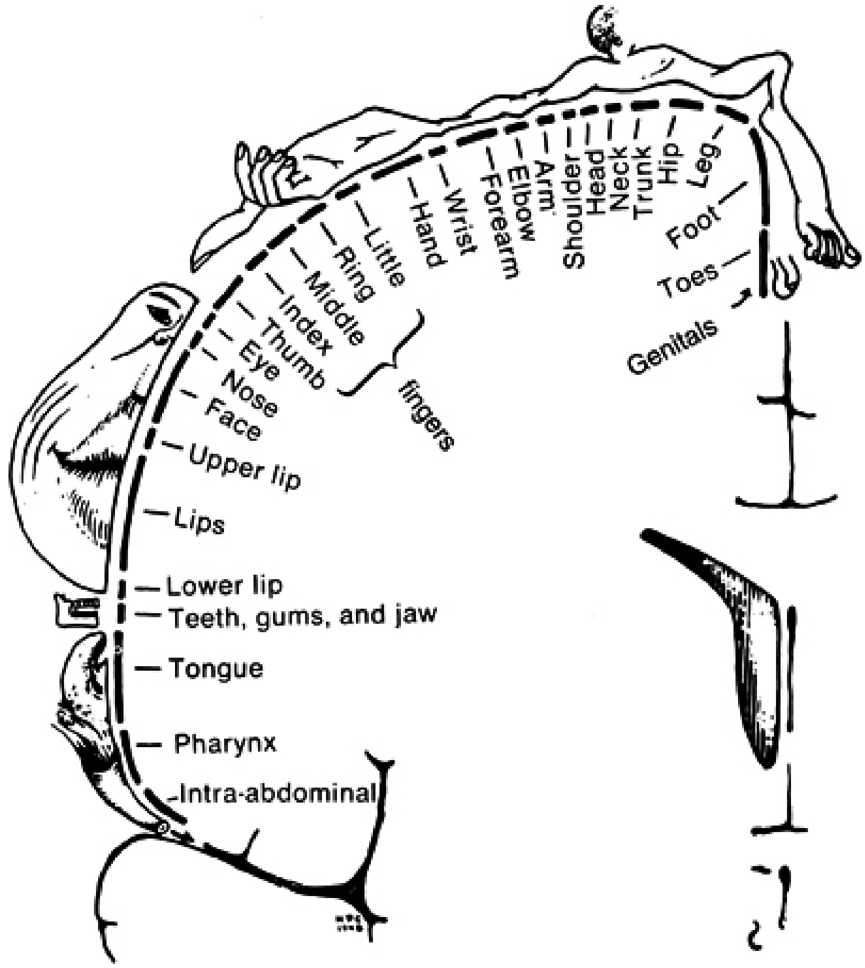

Figure 1. Mapping the skin to the brain [Penfield and Rasmussen 1950]

Not only are the proportions of the homunculus different from the physical body, but the parts of the body are re-arranged, so that the hand is adjacent to the face in the middle. Some amputees feel a phantom sensation of their missing hand when their face is touched due to crosstalk between these adjacent regions in the homunculus [Ramachandran & Blakeslee 1999]. Phantom limbs can be activated by the recruitment of neurons by adjacent regions, and can change size, configuration and behaviour over time. The homunculus is also used to explain the disappearance of body parts from conscious perception with certain types of brain damage, and distortions in the size of body parts during episodes of epilepsy or migraine.

The sensory-homunculus has a twin, known as the motor-homunculus, that maps the afferent nerves in the other direction, from the brain to the muscles and skin. The homunculus twins, shown together in Figure 2, share many features, such as the enlarged hands and lips.

However the motor homunculus differs more from one person to the next and over time, so that, for example, the motor homunculus hands of a surgeon increase in size with surgical training.

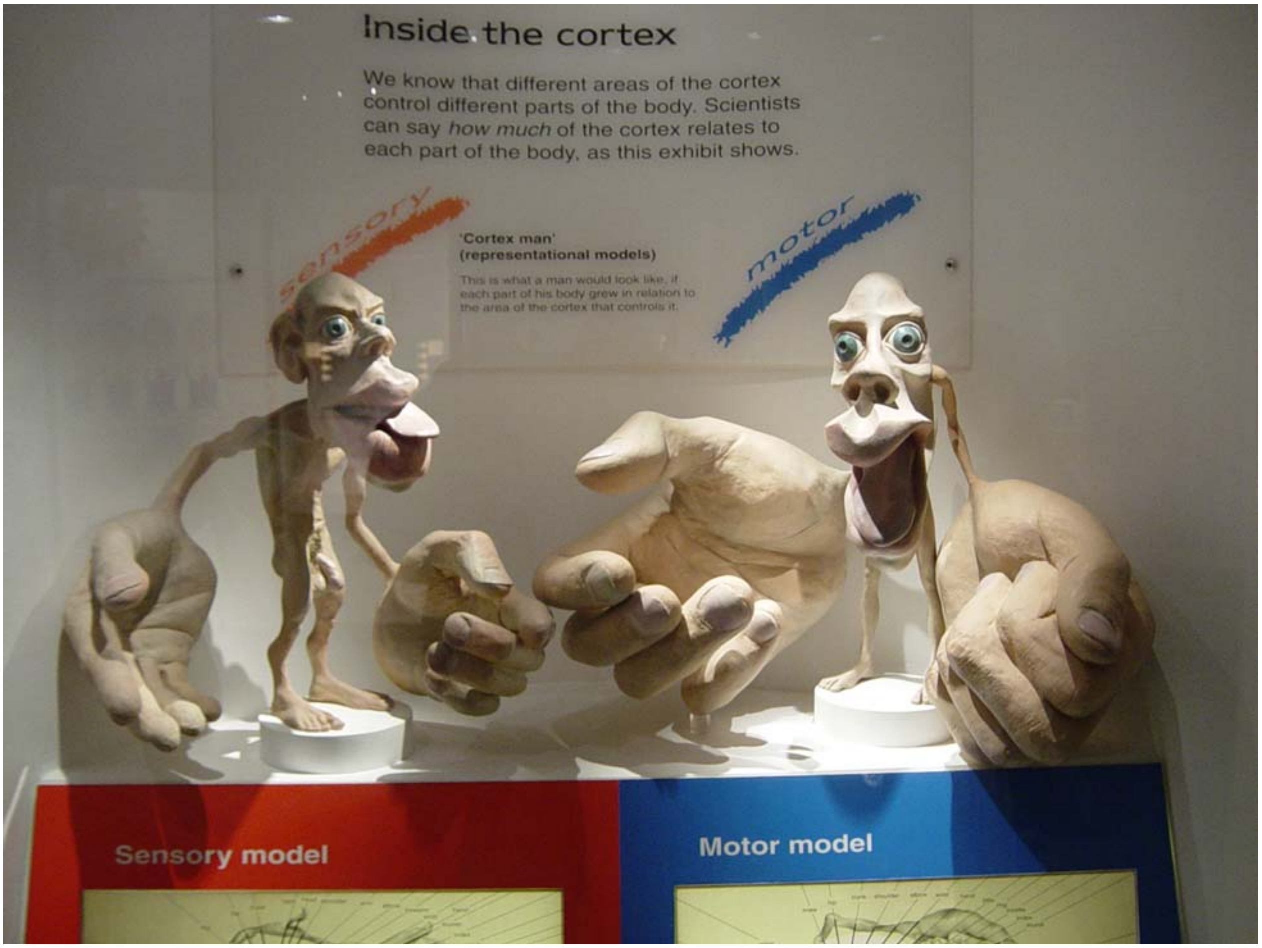

Figure 2. The Sensory and motor homunculus twins

The slippage between physical and neural bodies is demonstrated by the Pinocchio Illusion in which the nose is felt to extend up to an arms-length out from the face. The illusion can be produced by having someone hold their nose while at the same time touching a vibrator to the biceps tendon of that arm. The nerves from the fingers and nose signal they are in contact, while the vibrator stimulates nerves that signal that the bicep muscle is extending [Lackner 1988]. The person feels their nose stretch as the brain resolves the sensations by extending the neural image of the nose along with the extending arm. Physically, of course, the nose and arm are not moving at all. When the opposing triceps tendon is vibrated the nose feels like it is shrinking. The related 'shrinking-waist' illusion is produced by having someone place their hands on their hips, and then vibrating the tendons of their wrist. This illusion was repeatedly used in a brain-imaging experiment using fMRI to investigate the neural correlates of changes in the self-perception of the size of body parts [Ehrsson et. al. 2005]. The suggestion that the shrinking waist illusion could be used to treat disorders linked with distorted self-perceptions of body image points to additional cognitive issues that are key themes of fashion research.

Taxtiles

The data from sensors in Smart Fabrics is usually transmitted to a computer for analysis of aspects of the wearer's movement, or location or health. In the other direction, wearable information systems communicate data to the wearer through a head-mounted display with visual and audio interfaces. We propose that an actively tactile textile, or taxtile, can be used to create a unified sensing and communication system tightly integrated with the user's body. To demonstrate this possibility we began by inventing a Smart Fabric that can sense a hand stroking it using the 'tribo-electric effect' that occurs when electrons move between materials that rub together. Most people will be familiar with this effect from science demonstrations where a glass rod is rubbed with silk cloth so it becomes charged and can be used to pick up small pieces of paper. A Van-der-Graaf generator can build up millions of volts of charge and produce lightning like sparks through the tribo-electric process of rubbing electrons off a revolving leather belt onto a metal electrode. As it happens, human skin is at the extreme positive end of the tribo-electric scale, whilst polyester, vinyl, and plastics are at the negative end. This means that when skin rubs against synthetic fabrics there is a transfer of charge, which is why polyester shirts are 'sticky'. In tropical climates polyester can be worn more comfortably because water vapor in the humid air allows the charges that build up to dissipate. Cold air holds less water and static sparks can become frequent and irritating if you wear polyester in sub-zero temperatures.

The design sketch of a prototype taxtile, called Scruffy, uses the metaphor of the nervous system as shown in Figure 3. Scruffy consists of a square of fake fur with a 'nervous system' sewn from conductive thread, and a microprocessor for a 'brain'. Static charge built up from stroking is sensed by the afferent nerve that sends a signal to the Arduino microprocessor brain. A level of excitement is computed by the Arduino and sent through the efferent nerve to actuate fluffy vibrating appendages.

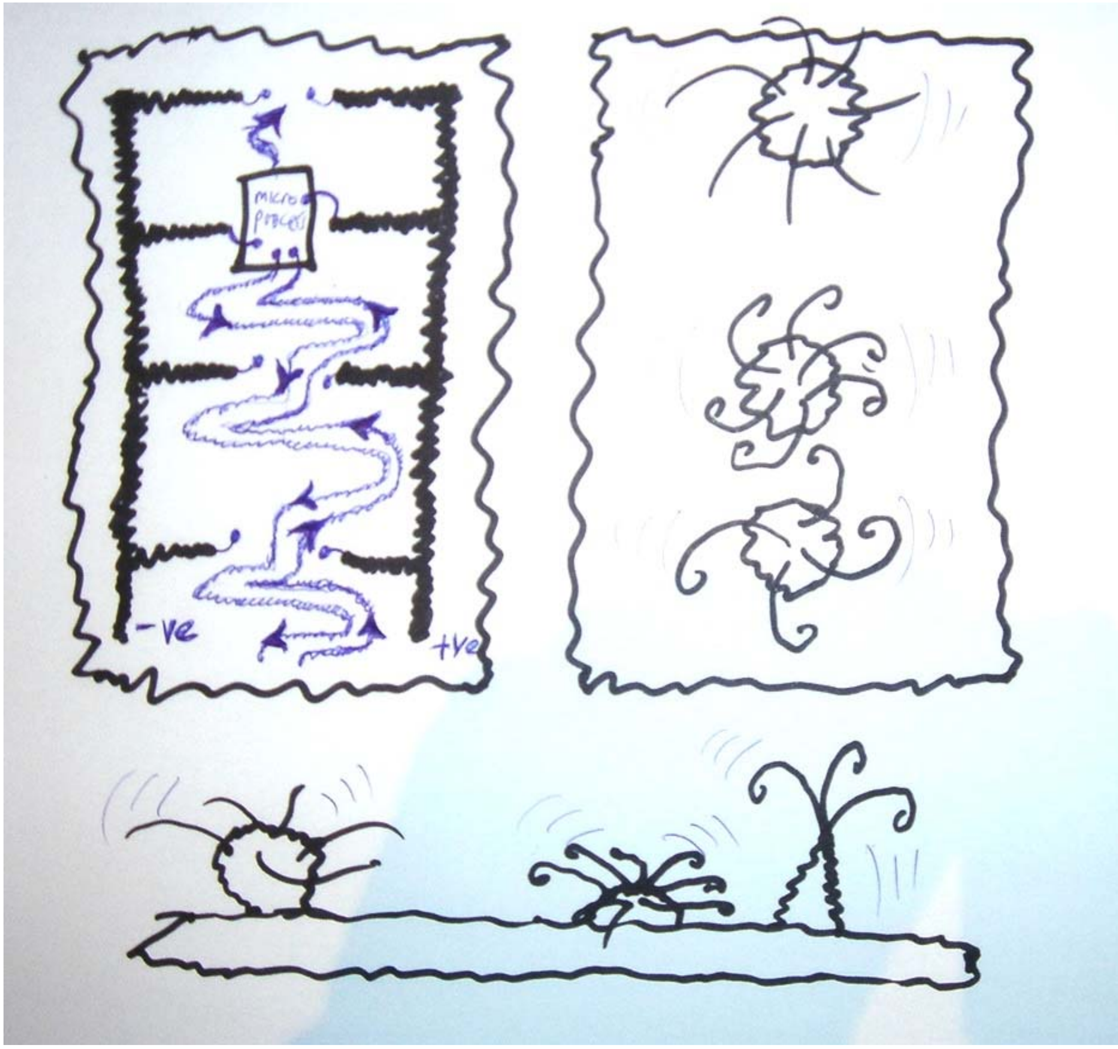

Figure 3. Design sketch for a fabric nervous system

The result is the highly-strung strangely-geometric run-over poodle-like object, shown in Figure 4. Stroking the fur causes the tail-like appendages to wag in spasmodic frenzy, and Scruffy quivers all over with what looks like joyful excitement. In colder climates or dryer weather that cause static charges to build up, Scruffy can be excited by people walking over carpet several metres away without any direct physical contact.

Figure 4. Scruffy – a prototype Taxtile

Tactile Nerve Extensions

The shrinking waist illusion demonstrates the fluidity of body image in response to tactile sensations. From our observations of Scruffy we hypothesise that a taxtile could close the gap between sensors in a smart fabric and the perceptual system of the wearer. These 'tactile nerve extensions' would allow the wearer to perceive information routed from the sensors to the brain through the skin. These augmented perceptions would position the wearer, rather than a computer, as the 'smarts' in a wearable sensing system.

The design sketch for Fauxy the Fake Fur with Feelings, shown in Figure 6, has modular 'tactile buttons' each with an independent static sensing nerve that allows localised sensing and response. These modular buttons can be sewn onto the conductive thread power supply in any arrangement, doing away with the need to custom sew efferent and afferent nerves through the fabric to each one.

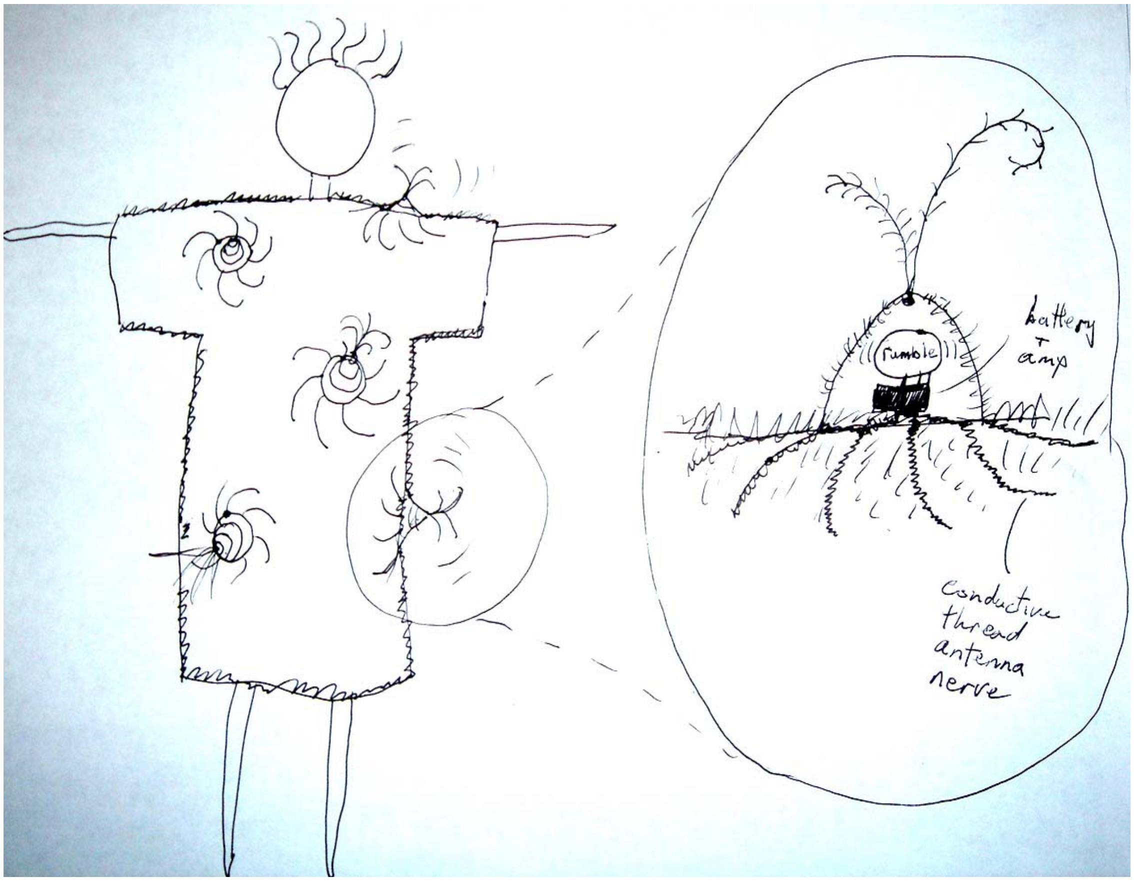

Figure 6. Sketch for Fauxy the Fur Coat with Feelings

The tactile buttons on the inside of the coat, shown in Figure 7, are prototype ‘tactile nerve extensions’ that bridge the gap between the cloth and the skin. These nerve extension buttons are designed to extend the perceptions of the wearer into the coat, augmenting their skin with the capability to feel static electricity around them.

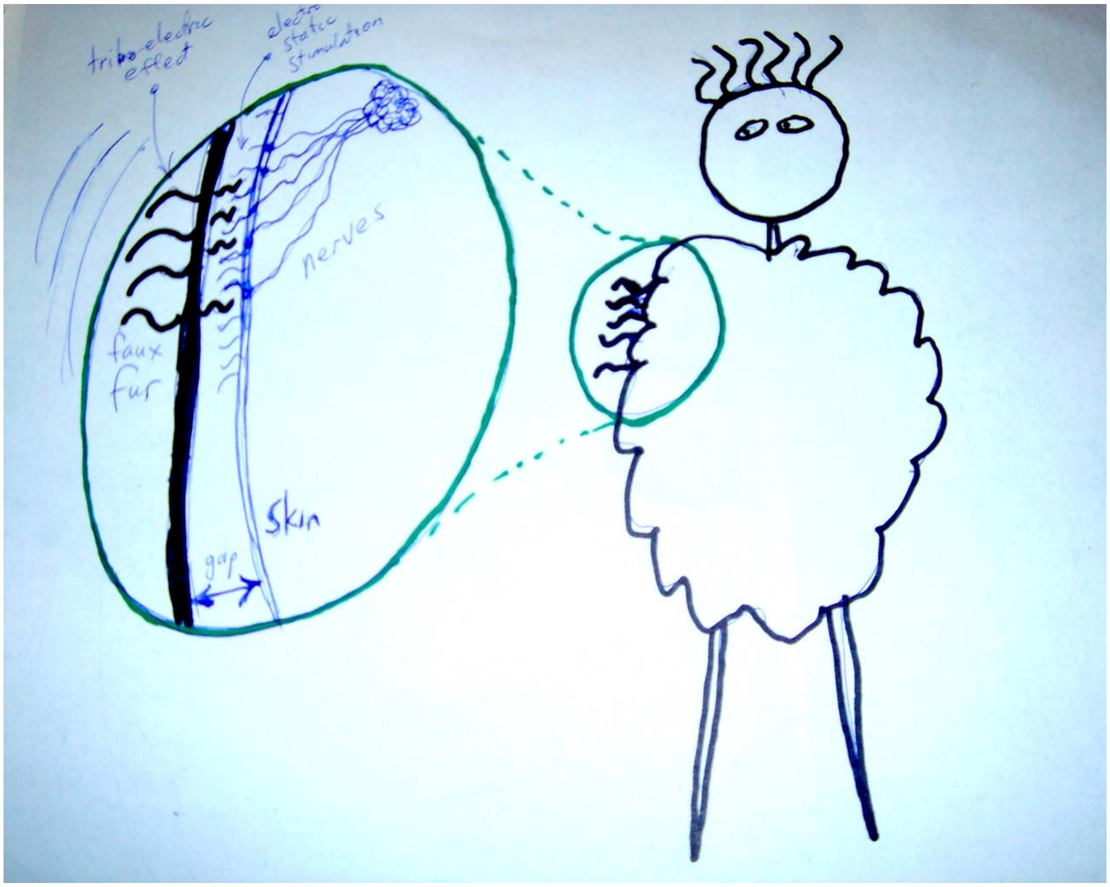

Figure 7. Concept sketch for tactile nerve extension buttons

Conclusion and Further Work

A taxtile is an actively tactile textile that co-locates sensing and response in the same flexible substrate, modeled on skin. We explored the concept of a taxtile with a prototype that responds to stroking with vibrotactile feedback. The observations from this experiment lead to the idea that a taxtile could be used to integrate sensing and communications in a wearable information system. Rather than transmitting sensor data to a computer for analysis, it could instead be communicated directly to the brain of the wearer. Bodily illusions, and the neuroscience of body image, provide a theoretical basis for the hypothesis that bodily awareness could flow into a wearable information system. We proposed the concept of 'tactile nerve extensions' that connect sensors in a Smart Fabric to the 'body in the brain' of the wearer, to allow bodily awareness to flow into the garment, and enable augmented perceptions. The design sketch for Fauxy the Fake Fur with Feelings develops the Scruffy taxtile into an immersive wearable information system. We are currently developing a modular 'tactile button' that can provide local responses and be sewn anywhere on a garment. These buttons will be sewn on the inside of Fauxy, as prototype taxtile nerve extensions. In future work we will explore the effects Fauxy has on the behaviour, sensations and body image of the wearer. Rather than using a smart fabric to project information about the wearer to the outside world, we aim to project the outside world into the mind of the wearer.

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References

Ehrsson HH, Kito T, Sadato N, Passingham RE, and Naito E. 2005, Neural Substrate of Body Size: Illusory Feeling of Shrinking of the Waist. *PLoS Biol*, Vol 3, Num. 12, e412 doi:10.1371/journal.pbio.0030412

Kirstein T, Lawrence M, and Tröster G. 2003, Functional Electrical Stimulation (FES) with Smart Textile Electrodes, in *Proceedings of Wearable Systems for e-Health Workshop*, December 11-14, Pisa, Italy.

Lackner JR. 1988, Some Proprioceptive Influences on the Perceptual Representation of Body Shape and Orientation, *Brain*, Vol. 111, pp. 281–297.

Penfield W and Rasmussen T. 1950, *The Cerebral Cortex of Man*, Macmillan, New York.

Ramachandran VS and Blakeslee S. 1999, *Phantoms in the Brain: Probing the Mysteries of the Human Mind*, Harper Perennial, 1999.

reSkin 2007, www.anat.org.au/reskin/documents/ReSkin_Prototypes_Presskit.pdf

Smart Fabrics 2005, www.intertechusa.com/smartfabrics.html