Extreme materials

Constellation dresses and the leeches: questions of power for electronic garments

Joanna Berzowska

Abstract

The Leech dress, constructed with stitched conductive organza stripes, functions as a soft, wearable, and reconfigurable power-distribution substrate for attaching individual silicone-coated electronic modules (the 'Leeches') that illuminate the dress. The Leeches can be attached in a variety or positions and configurations. They are held in place by magnetic snaps, which act both as mechanical and electrical connections. A single power module can be attached at the shoulder. This module can power up to ten Leeches scattered around the body. The red LEDs inside the Leeches resemble power-hungry creatures that, once attached, suck or draw power (the metaphoric 'blood') from your body and reference the potential dangers of electromagnetic fields emanating from electronic garments. The Constellation dresses are covered with twelve magnetic snaps arranged over the torso and thighs and connected in pairs through a single line of conductive thread. Light Emitting Diodes (LED) are integrated into the dresses in a design that resembles a constellation, with a cluster of stars connected to each other through short and straight lines. One set of snaps acts as a switch for the LED circuit and, when connected to the snaps from another dress, the circuit on the garment is closed and the LEDs light up. The magnetic snaps act as a mechanical and electrical connection between bodies, and their irregular placement induces wearers to create playful and compelling choreographies to connect their circuits. Rather than being complete and functional electronic pieces in themselves, these garments work as meshes on a circuit network and depend on the physical contact of the magnetic snaps to function. By bringing people together mechanically and electronically, the garments explore metaphors for building electronic or social networks. In addition, the dresses compel people to draw power from each other, hinting at a parasitic model for powering our mobile technologies.

Key Words:
electronic textiles,
reactive garments,
wearable power

Introduction

This paper describes two XS Labs projects, the Constellation Dresses and the Leeches, which raise specific questions regarding our increasing need for power – electric energy – in order to feed the electronic devices that we wear on our bodies and will soon be integrating into our electronic garments. These projects address ecological concerns through the design of garments that directly tackle issues of power consumption and sustainability through the exploration of different parasitic metaphors, where electronic modules suck power from our bodies and electronic garments suck power from each other. Central to this exploration is the question of where does power come from in a wearable context and how do we connect to various power sources?

Electronic textiles

XS Labs is a design research studio based in Montreal, where we develop electronic textiles and reactive garments. We are concerned with the exploration of simple interactions that emphasize expressive qualities of electronic circuits and of the body. We define electronic textiles as:

> …textile substrate that incorporates capabilities for sensing (biometric or external), for communication (usually wireless), power transmission, and interconnection technology to allow sensors or things such as information processing devices to be networked together within a fabric. […] An electronic textile usually contains conductive yarns that are either spun or twisted and incorporate some amount of conductive material (such as strands of silver or stainless steel) to enable electrical conductivity. Electronic textiles allow little bits of computation to occur on the body. (Berzowska, 2005)

Soft electronics

An important research direction at XS Labs tackles technical problems and looks at new construction methods for the development of textile substrates that function as soft electronic circuit boards. We construct simple electronic components using conductive threads and inks with techniques such as weaving, sewing, embroidery, printing, and tying knots. Soft electronics are important, since wearable technologies are intrinsically close to the body and need to be comfortable and even pleasurable to wear, without sharp corners and fragile circuitry. Textiles are (in many ways) naturally more reliable and durable than

traditional electronics insofar as they can be worn and physically manipulated without losing their structural integrity. We are directly inspired by traditional production methods and techniques from the textile world, which allows us to produce more interesting innovations in the field of electronic textiles. On the other hand, creating soft circuit boards also introduces many challenges and potential safety and reliability issues. Since textile materials can move and stretch as they are worn and manipulated, the electro-mechanical properties of conductive connections or components also varies over time. A new paradigm for circuit design needs to be proposed in order to adapt to these unpredictable conditions. The circuits we design must incorporate redundancy and favor simplicity.

Textiles as displays

Of particular interest to XS Labs are the many relationships between our bodies and the social and cultural context of the architectural spaces that they inhabit. Our clothing is one of the first structures, often talked about as a 'second skin', which enables an important level of interface between the human flesh and the outside world, physically and metaphorically. This is why we are concerned with active materials that can easily be integrated into textile substrates and that can be controlled through soft electronics. Since the communicative function of garments is mostly visual, we are especially interested in constructing garments that can change state over time, in the form of variable illumination, color change, shape change, or other visual animation.

Textiles as power and data transfer infrastructures

All that surrounds us was once technology. Once a technology becomes commonplace, it disappears. But what happens when we engage new bizarre forms of technology that have not yet penetrated the mainstream? We think of them as special, even when they are not. We use the term technology to refer to the things that are still rare and surprising; the things that are fragile; the things that are complex. We no longer think about weaving as a technology, but it still is. At the same time, there is much inspiration to be drawn from those older technologies, as a way to innovate in the field of electronic textiles. Textiles not only 'transfer' information and power in a metaphoric sense, in the way that meaning can be encoded in the structure and surface qualities of a textile design, but, in the case of electronic textiles,

we can use the structure and surface qualities of the design to actually transmit electricity as well as data. An embroidered stitch can replace a wire, a piece of metallic silver organza can replace a switch in a circuit. Textiles can be woven or stitched together in such a way as to integrate power and data transmission capabilities, in order to network sensors and other input devices, send data from one portion of a garment to another, send power to illuminate an LED, or connect several devices in a soft circuit.

Textiles as magical companions

Electronic textiles allow us to penetrate the world of fashion. We can focus on building enchanting garments that encourage those who wear them to enter a magical world where the laws of physics shift and play is encouraged. Through the integration of interactivity or even simple reactive electronic components into garment design, we allow people to manipulate and reshape ideas about their bodies, their histories, and their social relationships and to project their needs and their desires outwards into the world.

We assume that electronic objects need to be rational because circuits and programming are based on logic. We assume that function needs to be rational. The word 'function' does indeed imply a logical engineering process that involves needs assessment and problem solving. But do not forget that pleasure is function. Beauty is function. Poetry is function. At the same time, technology is ornament and ornament is technology. Perhaps the crucial question is: 'What does technology look like'? Maybe technology needs to look more like magic. Maybe it needs to look a lot more like art. In any case, I believe that it needs to flirt with the irrational in order to be meaningful.

Power

The developed world is becoming increasingly dense with electronic devices. This implies that our power consumption needs are also constantly increasing, particularly in the case of mobile and wearable electronic devices, and current trends indicate this will continue to be an issue in the future. Portable batteries lag behind other advances in miniaturization.

> The engine that powers the growth in batteries, especially primary and small rechargeable varieties, has been, and will continue to be, the

> proliferation of portable electronic devices, like the mobile phone. These devices demand greater performance than was available from rechargeable nickel cadmium (Ni-Cd) and alkaline primary cells. In response to this demand the nickel metal hydride (Ni-MH), lithiumion (Li-ion) and Lithium-Polymer rechargeable battery systems have been developed. (Brodd, 1999).

Since the development of alternative energy sources has not yet yielded economically viable solutions and has not kept up with the needs of our emergent and expanding markets, we are heading towards an environmental disaster (Starner & Paradiso, 2004). An important research direction is the development of energy sources that are independent from our power grids and reside on the body, collocated with the electronic devices they power. One of the approaches to this problem is to examine alternate power sources for mobile computing, such as flexible solar panels, printable photovoltaic (also called solar) cells, biobatteries, dielectric elastomers and other new materials and technologies. A second approach is to consider eco-design, power conservation, and designing for sustainability.

Parasitic power

Finally, a third direction involves looking at 'parasitic power', either harnessing energy directly from the body or generating power by the user, to alleviate design restrictions and enable new functionality. Flipsen (2005) defines human power as "power generated by human activity, e.g. bicycling, winding and general movements of the body or body parts".

Researchers such as Paradiso (2004) from the MIT Media Laboratory have studied methods to recover power (a) passively, from body heat, arm motion, typing, and walking, and (b) actively through user actions such as winding or pedaling. Human movements can be converted into electric energy using electromagnetic generators or piezoelectric elements. Researchers are increasingly exploring simple technologies for the harvesting, the conservation, and the sharing of power on flexible substrates, such as dynamos or piezoelectric materials to harvest power from walking, sweating, breathing, or body heat.

Unfortunately, current wearable power harvesting technologies are not efficient enough to satisfy demand, while the process of energy harnessing detrimentally affects the comfort of the body.

Constellation dresses

The Constellation Dresses began their life at a used clothing store. They had already been bought, worn, loved, washed, worn again, eventually hated, and discarded. We purchased the dresses in the hope that we could give them a second life by augmenting them with electronic circuitry. Through this process, the Constellation Dresses allowed us to explore several key themes in electronic textiles and reactive garments. We explored (1) the reuse of materials and the use of existing garments as material substrates that can be redesigned using soft electronics, (2) formal design questions that dealt with the integration of illumination into a simple garment, (3) interaction models that deploy wearable technologies as tools for fostering physical intimacy, (4) ways to raise awareness about energy and ecological issues associated with the proliferation of computationally-enhanced portable/wearable devices. In particular, we explored a playful yet serious model of parasitism as a metaphor for harvesting power from the body (or, more accurately, the body of another organism).

Figure 1. Each of the three Constellation Dresses has a distinct design that integrates flat square LEDs to form a decorative illuminating detail that resembles a constellation

Light Emitting Diodes (LEDs) are integrated into the three Constellation Dresses in a design that resembles a constellation, with a cluster of stars connected to each other through short and straight lines. One pair of magnetic snaps (visually distinguished by an oval embroidered pattern around them) functions as a switch for the embroidered LED circuit. The dresses are covered with additional pairs of magnetic snaps connected with conductive thread (forming a simple line between the two snaps), which act as the second half of the switch.

When the oval switch connects with a pair of snaps from another garment, the circuit is closed and the LEDs illuminate. You cannot turn

on your own dress: like a parasite, you need to use another body's power source. You are forced to "steal" the power from another dress by connecting to its power source. Because the snaps are magnetic, they will naturally be attracted to other dresses, creating unwanted connections and giving the dress agency. The dress can turn itself on by connecting with another without your consent.

Figure 2. The electronic circuit is distributed over the body of the dress. The four LEDs provide the visual output. The power source consists of a lithium polymer rechargeable battery, held in a custom-made pocket at the waist. The interactive interface consists of the pairs of snaps that act as switches and allow us to close the circuit (turn the LEDs on) by connecting to another dress

The magnetic snaps act as a mechanical and electrical connection between bodies, and their irregular placement instigates playful and compelling choreographies to connect the circuits. In addition, the awkward placement of the pairs of snaps forces people to contort and exert their bodies to connect to one another in order to turn their dresses on. This breaks down social inhibitions, merging input with communication, while providing playful feedback for physical exchange. The garments explore metaphors for building electronic or social networks. In addition, they suggest the need to physically connect in order to power oneself, which resonates on both a social level and an ecological level.

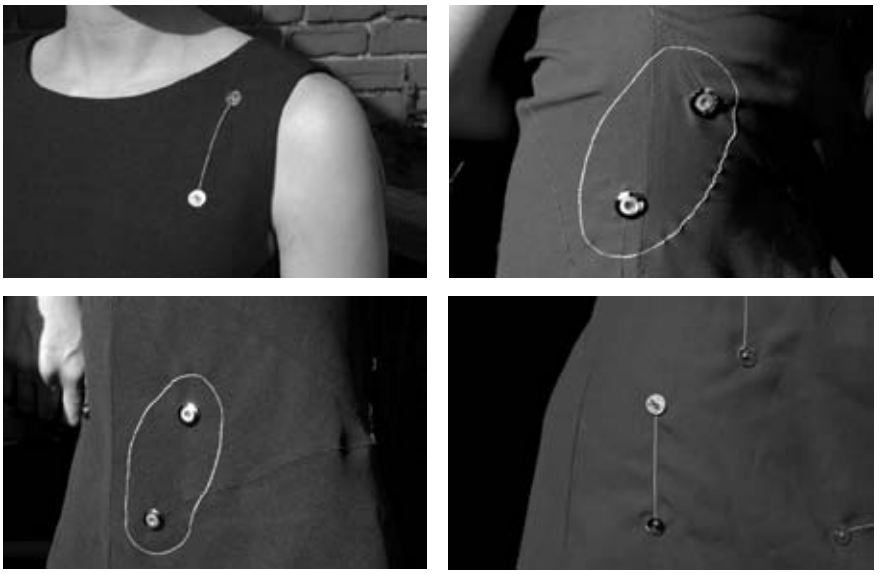

Figure 3. The open switch (in the embroidered oval) and the multiple connected pairs are distributed around the dresses. It is very difficult to connect your own circuit without literally undressing. You are strongly compelled to connect to another person

Figure 4. Connecting the dresses to one another to turn on the constellation

Rather than being complete and functional electronic pieces in themselves, these garments work as meshes on a circuit network and depend on the physical contact of the magnetic snaps to function. By bringing people together mechanically and electronically, the garments explore metaphors for building electronic or social networks. In addition, the dresses compel people to draw power from each other, hinting at a more aggressive and parasitic model for powering our mobile technologies. These sculptural wearable artifacts conceptually reference the tension between empowerment and disempowerment,

which is prevalent in the socio-economic distribution of consumer electronics and mobile technologies in the world today.

Leeches

The Leech dress explores a different kind of parasitic metaphor. Instead of individual bodies acting as parasites by sucking the energy from other nearby bodies, the parasites become the very devices that we want to power. The dress itself provides power at several different points of contact. We really wanted to create a garment that explored the concept of the body itself supplying the energy to recharge our portable electronic devices (whether cell phones or illuminated silicone appendages). The dress itself becomes the power distribution grid and the devices can grab on in many different places to suck power.

The dress is covered by alternating blue and orange stitched conductive organza strips that distribute power and ground around the body. The dress becomes a soft, wearable, and reconfigurable power-distribution substrate for attaching individual silicone-coated electronic modules (the 'Leeches') that illuminate the dress. The Leeches can be attached in a variety or positions and configurations. They are held in place by magnetic snaps, which act both as mechanical and electrical connections.

Figure 5.

In the left image, Shirley attaches a Leech on her dress. It is held in place with strong magnetic snaps. In the middle image, we see a detail of the power distribution grid, with several attachment possibilities. In the right frame, we see that a single power module can be attached at

the shoulder. In this case, we use rechargeable batteries, housed inside a silicone shell that interfaces with the dress using the same kind of magnetic snaps. In order the avoid confusion, the spacing between the snaps for the power unit is different than the spacing for the Leeches.

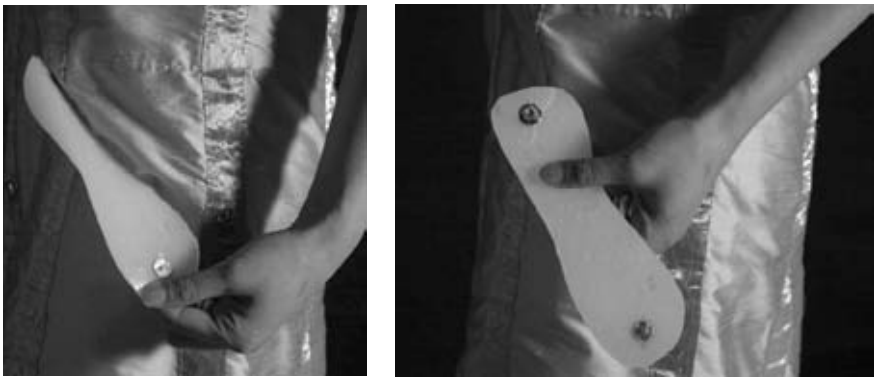

Figure 6. Removing a Leech from the power grid.

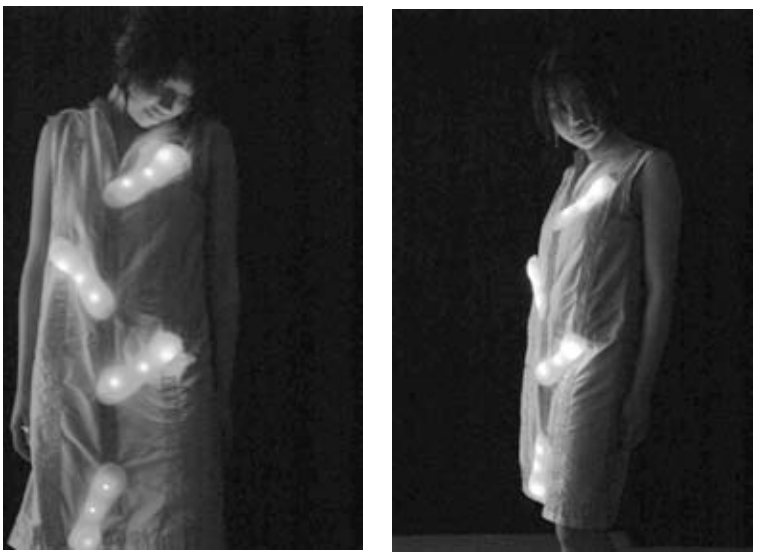

Figure 7. The illuminated Leeches can be attached to the dress in a regular, decorative pattern.

This module can power up to ten Leeches scattered around the body. The illuminated Leeches resemble actual leeches, which swell up when they fill up with blood. The red LEDs inside the Leeches hint at power-hungry creatures that, once attached, suck or draw power (the metaphoric 'blood') from your body and reference (1) more literally, the potential dangers of electromagnetic fields emanating from electronic

garments and (2) metaphorically, the violence inherent in our constant need for power and our need for energy, which can be linked to greater socio-economic issues.

Conclusion

Technological progress and increasing cultural acceptance of portable and wearable electronic devices will contribute to an explosion in the number of power-hungry devices in the coming decade. Power requirements are still relatively well satisfied by batteries, but with the increase in quantity and functionality of portable devices, comes an increase in the quantity and size of the power source. One of the crucial research questions for these coming years will be to address the developments of safe, efficient, ecological, and cheap portable power sources.

The Constellation Dresses and the Leeches offer two different but related perspectives on the upcoming portable power problem: the parasitic metaphor evident in the Constellation Dresses, where we need to – overtly or surreptitiously – steal or borrow power from each other by literally and physically connecting our bodies, and the frightening metaphor implicit in attaching a Leech module anywhere on our bodies in order to power or charge it. These garments are intended to provoke discussion not only about eco-design, power conservation, and designing for sustainability, but also encourage designers to think about the upcoming social and cultural trends that will emerge from our constantly growing need for power.

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