Second Skin: An Exploration of eTextile Stretch Circuits on the Body

Figure 1: Testing the elasticity of a stretch circuit panel. The LED and button are inserted into tiny unbonded pockets, through tiny slits the back of the fabric, and secured with conductive thread. Please refer to our video figure to see the sample being stretched.

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Abstract
Second Skin is a stretch electronic textile (eTextile) garment that adapts to the shape of the body. It is designed as both a provocative outer shell and a functioning undergarment, or foundation garment. Using elastic materials and building on techniques from cutting edge sportswear manufacturing, it facilitates wearable electronics which can recede from the users attention. We consider Second Skin as a platform that other researchers can use to add functionality of their own. In our exhibit, people can interact with a prototype version of Second Skin as well as with material samples to gain a better understanding of its look, feel and material capabilities.

Author Keywords
Wearable electronics; prototyping; electronic textiles; materials development; manufacturing; soft circuits

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous. J.5 Arts and humanities: Arts, fine and performing.

Video Figure
https://youtu.be/vd2GedFZLIs

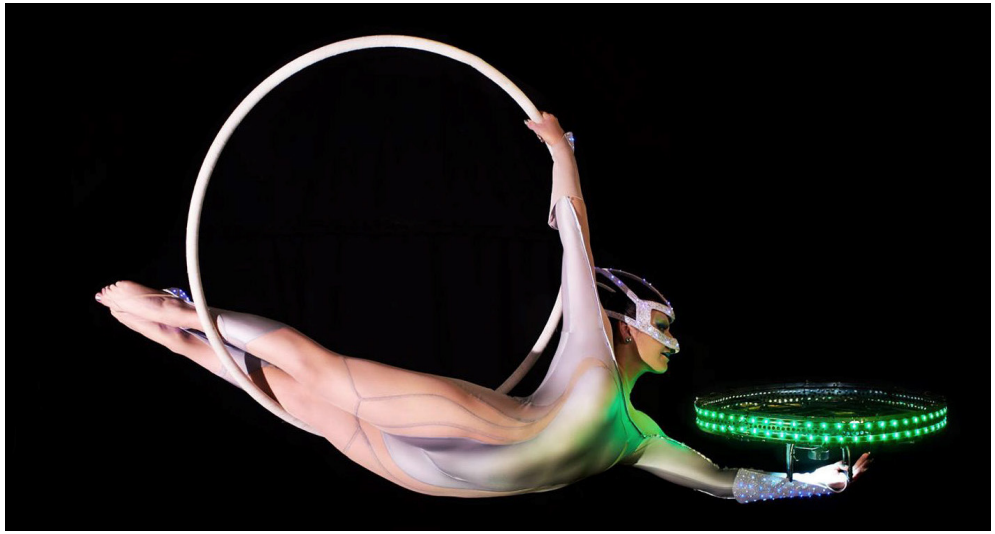

Figure 2 - Empress Stah performs a show choreographed with a drone. She is wearing a prototype Second Skin suit, testing seam lines on the body for placement and strain relief. Headpiece and cuffs incorporate eTextiles. The intent is to have a fully addressable eTextile suit which can be synced with the drone. Photo © Empress Stah www.zerocentral.london

Introduction

The growing field of wearable garments is theatrical in the sense that electronics often require heightened physical awareness. Second Skin seeks to address the issue of how electronic fragility may compromise functionality in the context of a garment. Hard surfaces and brittle materials mean we must adapt our behaviour to be sensitive to devices which are supposedly designed to serve us. Elastic eTextiles (Figure 1) have the potential to minimise such limitations: allowing electronic elements to disappear from tactile perception, giving more freedom to the wearer.

We present Second Skin, an evolving eTextile prototyping suit designed as a platform for experimentation of electronics on the body. Using conductive and resistive materials, special bonding adhesives and films, it is a practical solution to integrate stretch circuitry into garment technology.

Second Skin is designed with physical performers in mind. It is currently in development with an aerialist (Figure 2) and a sonic artist who uses dancers and acrobatic performers in her installation work. Wearables for physical performance should not constrain the performers' freedom of movement in any way. To support full body movement, the eTextile garments and electronics must be able to stretch and deform with the body. The project addresses issues such as strain relief and circuitry on joints, offering ways to bridge gaps where cables and wires would make electrical connections impractical. They must be able to withstand pressure and high velocity movement while having an absolutely flat profile so as to allow the performer to freely glide over silks, ropes and hoops.

This provides Second Skin with the ultimate durability test. Once Second Skin can support demanding physical performances, it will be more than capable to overcome the theatrical nature of our current generation of wearables and can be applied in other areas of garment technology.

Related Work

There is a long tradition of designing wearable technologies that are integrated in fashion, rather than added to the body as external devices. Joanna Berzowska designed ‘Second Skins’ that were used to externalize the wearers history of intimate encounters [1]. Like with our Second Skin, Berzowska decided to use the functional circuit as an ornamental element of the clothing. Explorations in wearable fashion have become commonplace in TEI, exemplified by the 2011

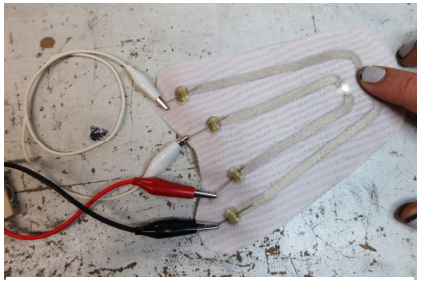

Figure 3 - Testing a stretch circuit panel. Pads of conductive lycra are left exposed to attach power. The LED and button are inserted into unbonded pockets, through tiny slits the back of the fabric, and secured with conductive thread

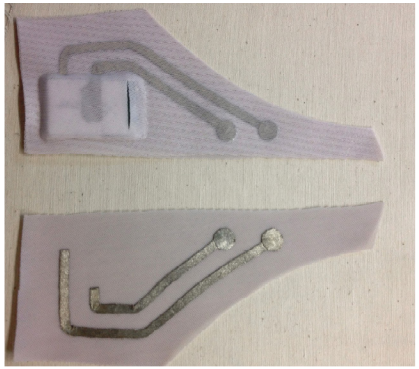

Figure 4 - eTextile battery pouch detail

design challenge in which students presented self-made superhero outfits. An exploration that not only merges electronics with clothing, but additionally blends the clothing with the body is Monarch by Kate Hartman [3]. She uses EMG signals to actuate her garments, providing users with additional expressive modalities.

The garment we present uses textiles as conductors, much like a large, soft, elastic circuit board. However, this type of textile can also be appropriated for active components. An introduction to such methods was published by Hannah Perner-Wilson and Leah Buechley [4]. Together with Mika Satomi, Perner-Wilson maintains an archive of DIY soft sensors [2].

Project Jacquard [5] presented a method of creating conductive materials that can be woven on industrial scale. Unlike Second Skin they do not focus on performance materials: the conductive circuits of project Jacquard are not elastic and therefore less robust, suited to less physically demanding applications.

Implementation

To accommodate the constraints set by designing for physical performers, Rachel opted to develop techniques established for high performance sports fabric. All textiles used in Second Skin are chosen for their low profile and their ability to stretch equally in all directions. Conductive stretch fabric (e.g. Shieldex Technik-Tex P-130 silver plated lycra – Figure 3) is used for creating electrical connections. The conductive material is sandwiched between layers of powernet (mesh) and lycra/elastine (microknit) stretch textiles to electrically insulate them (Figure 3 & 4).

Figure 5 Toile #2:Second Skin pattern piece layout showing assembled eTextile panels and laser cut ladders to house tubing for cables

The materials are fused to each other using heat-reactive precision bonding films (Bemis Sewfree fusing) designed for stretch and recovery in sportswear and lingerie. Using bonding films as part of the circuit design selectively allows the garment to conduct or insulate. Consequently multi-layered stretch circuitry can be created.

Whilst these films must be used with extreme precision in both pressure and timing to create bonds suitable for manufacture and sale, select products exist that have a melting point low enough to be used with domestic irons, allowing for DIY and handmade sampling,

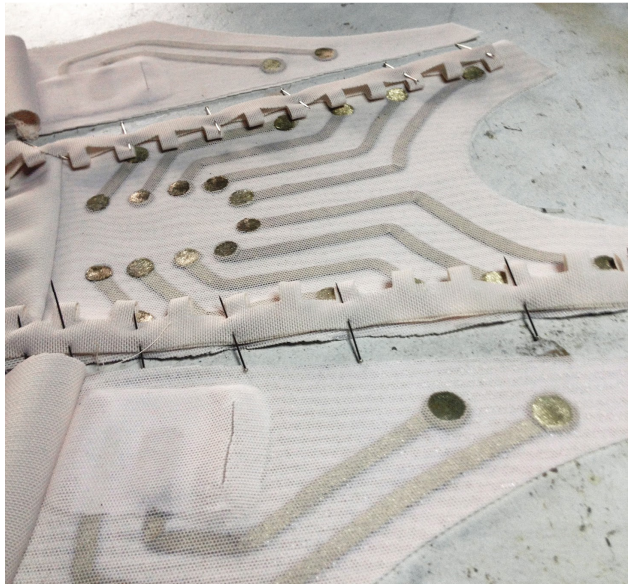

Figure 6 - Work in progress. Detail of Toile #2, sewing the eTextile panels into the garment

prototyping and garment production. Figures 4 & 5 show the process of combining individual pieces of fabric with conductive traces into a larger garment.

Motivation

This work is centred around the body, focused on intricacy, detail and craftsmanship and the power evoked by the richness of texture and the complexity of process. It is the places where the lines blur between design, craftsmanship, vocation and function.

Working in the emerging field of wearable technology means there is opportunity to shape how we attribute value to materials and technology in this newly established field. As wearables become more integrated into our lives we are entering a new era of craftsmanship and have the opportunity to devise systems which can be manufactured simultaneously on both a personal and industrial scale, while representing the values and design choices important to us.

Clothing should amplify a person, not create one. It should also come with an awareness of its environmental and sociological impact, as all design choices made directly influence the way we act and are perceived in the world. Every object has a story to tell, and these stories have a powerful impact on our lives and surroundings.

It is easy to forget that wearables exist in the real world rather than the controlled environment of the stage or a research lab. Clothing is meant to be lived in and serve a purpose, whether it is aesthetically focused to empower the wearer or exists to be completely practical and functional. The ideal garment will be both.

This project exists to serve fellow researchers as a platform to expand upon. Second Skin is designed with an eye-catching aesthetic intended for both functionality and discussion. Due to Rachel's background as a fashion and material designer, she uses the style of documentation and promotion found in fashion branding as well as high quality products suitable for sale and distribution. This helps researchers and hobbyists who wish to transfer their creations from the lab or workshop to a more public stage. The project aims to create and present a format which allows both DIY makers and large scale manufacturers to work with the same materials and a comparable toolkit, creating the potential for design which can scale according to the size of production.

Figure 7- Fabric concept for eTextile mi.mu glove which inspired the second skin project http://mimugloves.com/

Second Skin does not have inherent uses in and of itself, but instead is looking for design functions to be added to the structure to test it's theory and application.

History

Second Skin began as a part of the mi.mu gloves project to make a super comfortable and wearable eTextile glove (Figure 7). It was created as an extension of the existing mi.mu glove which uses bend sensors and traditional electronics housed in high performance stretch textiles. The current state of the project however still requires development work in order to scale to the small size and high complexity of such a product.

Limitations & Future work

This work has an Alice in Wonderland aesthetic: it is currently constrained by scale, which gives a wonderful narrative, but limits functionality. Existing industrial machinery can be adapted to manufacture and improve the functionality of Second Skin, but currently there is no incentive for manufacturers to do so.

The next step for personal manufacturing is to experiment with laser cutting more complex shapes, exploring how much the idea can be scaled down to house more complex design ideas and how this will in turn restrict the material qualities of the garments. Finding the balance between intricacy of the electronic connections and quality of the garments will give a starting point for the direction to approach material and machine manufacturers in creating textiles and equipment to develop bonded eTextiles for multiple uses.

Presentation

The art piece will consist of an exhibit of the first prototype Second Skin (Figure 8 & 9). To facilitate interaction with the audience and exploration of the materials we will also exhibit test elements, such as a sleeve, as well as selected small samples of circuitry and garment test pieces (toiles) available for people to touch and interact with.

The full garment will be displayed on a mannequin and will have basic interactive functions to demonstrate how it conducts electricity. Viewers will be encouraged to simultaneously stretch and interact with the material to experience the extent to which it can deform and adapt to the shape of the body. To demonstrate how Second Sking can connect to existing platforms, we will enable interactivity by connecting the circuitry of Second Skin to a Twiz by Cedric Honnet [6].

Presenting the Second Skin at the Art Exhibit will allow questions and create a discussion about the chosen aesthetics of the work. This is integral to understand how people view and accept a piece of clothing. All feedback will be documented – we consider feedback to the project from an engaged audience to be a valuable addition to the project as a whole.

Conclusion

Second Skin is an exploration of eTextile stretch circuits and their implementation in a functioning full body garment as a rapid prototyping shell. Combining repurposed housing for traditional electronics and using developing materials and techniques in sportswear technology, this open source project will create and demonstrate techniques to develop stretch eTextiles. Second Skin is replicable in both a DIY and industrial

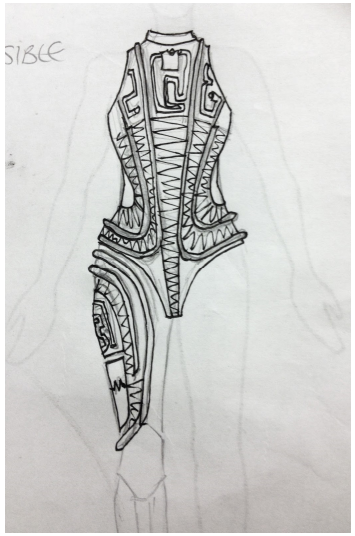

Figure 8 - Initial sketch of second skin design, imagining how to place cable housing and eTextile panels on the body. Aesthetic inspired by high altitude flight suits and pressure suits

Figure 9 - Toile #1: First toile to test shape of garment, how tubing will work in stretch fabrics, and to test strain relief. Photo © Allan Amato. Model: Logan Browning

manufacturing context. Inspiring and facilitating designers to explore new directions in bonding and stretch materials has the potential for further innovation in a new area of material development which can be scaled in an accessible way from boutique production to large scale manufacture. The aim is to bridge the often frustrating disconnect between prototyping, making and manufacture in the textile industry and create viable, provocative examples of garments on both a design and material level. Aesthetics, functionality, comfort and ubiquity play equal roles in our acceptance of technology as an extension of the self. eTextiles serve as an exciting tactile and understandable way to integrate wearables

References

1. Joanna Berzowska. 2005. Memory rich clothing: second skins that communicate physical memory. *Proceedings of the 5th conference on Creativity and Cognition*: 32–40. https://doi.org/10.1145/1056224.1056231

2. Hannah Perner-Wilson and Mika Satomi. HOW TO GET WHAT YOU WANT. Retrieved from http://www.kobakant.at/DIY/

3. Kate Hartman, Jackson McConnell, Boris Kourtoukov, Hillary Predko, and Izzie Colpitts-Campbell. 2015. Monarch: Self-Expression Through Wearable Kinetic Textiles. *Proc. TEI '16*: 413–414. https://doi.org/10.1145/2677199.2690875

4. Hannah Perner-Wilson and Leah Buechley. 2010. Making textile sensors from scratch. *Proc. TEI '10*: 349. https://doi.org/10.1145/1709886.1709972

5. Ivan Poupyrev, Nan-Wei Gong, Shiho Fukuhara, Mustafa Emre Karagozler, Carsten Schwesig, and Karen E. Robinson. 2016. Project Jacquard. In *Proc. CHI '16*, https://doi.org/10.1145/2858036.2858176

6. Andreas Schlegel and Cedric Honnet. 2016. Movement of Things: Exploring Inertial Motion Sensing When Autonomous, Tiny and Wireless. In *Proc. MOCO '16*, 1–2. https://doi.org/10.1145/2948910.2948916