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An Intuitive Textile Input Controller

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Abstract

When thinking of textile interfaces, these are often imagined as being integrated into clothing. While this is the most prominent use of fabric, we present a standalone interface that builds on the natural set of interactions a piece of fabric affords, and that is feasible for industrial production. By integrating stitched patterns made of conductive thread into a square piece of fabric, we are able to sense established connections within this pattern and map these to a model how the cloth is folded. An integrated microcontroller tracks these connections and communicates them as two-dimensional continuous value changes to a host application. We present the technical construction of our prototype, a particular clip-on technique to establish the connection between fabric and electronics, and first insights into recognizing different grip gestures.

1 Introduction

Fabric interfaces have the potential to unobtrusively blend into our everyday lives. A well integrated piece of smart textile may not even be visible from the outside but still provide functionality such as sensing vital functions (Kim et al. 2008) or controlling your MP3 player (Karrer et al. 2011). Smart garments are the predominant concept of smart textiles, but since fabric is a ubiquitous part of our life, it suggests a much broader field of applications. The fabric sensors presented by Perner-Wilson et al. (Perner-Wilson et al. 2010), for example, do not need to be integrated into clothing, but can also be used standalone. We propose a square, standalone textile interface that works as two-dimensional sensor. It builds on our natural interaction with fabrics and detects how it is folded and crumpled. The relative movement of the fold is then mapped to value changes that can, for example, be used to scroll trough a menu. The interaction with the piece of fabric is thus self-contained, meaning that moving the entire piece while interacting does not result in involuntary activation, which might be helpful, e.g., for elderly users with tremor.

2 Related Work

Perner-Wilson et al. explain how to create simple textile sensors from basic materials (Perner-Wilson et al. 2010). Their large number of different sensors is accompanied by explanations for the DIY community to replicate these. These small sensors then represent the building blocks of more complex systems. *Fabritouch* is a textile touchpad integrated into a pair of trousers (Heller et al. 2014). While it also communicates continuous two-dimensional information, it is an adaptation of a touchpad, an input known from desktop and laptop computers. It is a suitable wearable input device, but it does not take advantage of the natural affordances of cloth. Schwarz et al. investigated how everyday gestures like touching, twisting, and pulling on a cord could be used as input (Schwarz et al. 2010). Their results show that gestures we perform naturally on the regular cords of our jacket can indeed be used, e.g., to navigate through a menu. *Pinstripe* (Karrer et al. 2011) uses a parallel pattern of conductive and non-conductive stripes to detect the size and displacement of a fold in a piece of cloth. This information is then mapped to a one-dimensional continuous value change. The presented use case is the integration into the sleeve of a t-shirt, for which it is an ideal interface. The drawback is that the fold needs to be picked along the stripes to be detectable, which limits its usefulness in the case of a loose piece of cloth.

So far, we found no interface that combines the naturalness of the *Pinstripe* interface with two-dimensional input.

3 Prototype

Our interface bases on the two affordances of grasping and folding a textile. We did not analyze stretching at this point since this requires a more advanced textile production process to create stretchable conductive patterns, and since it would require more complex interaction, which may be problematic for elderly users. We use a stitched pattern of conductive thread on a piece of cloth (cf. Figure 1). When folded, some of the squares get connected to each other, which the connected microcontroller stores in a connection matrix. Under ideal circumstances, the fold in the cloth is represented with the axis of symmetry of the matrix, while the maximum distance on both dimensions represents the size or torsion of the fold. If the user grabs the entire cloth firmly, a large number of connections will arise and this can be detected as a crumpling gesture.

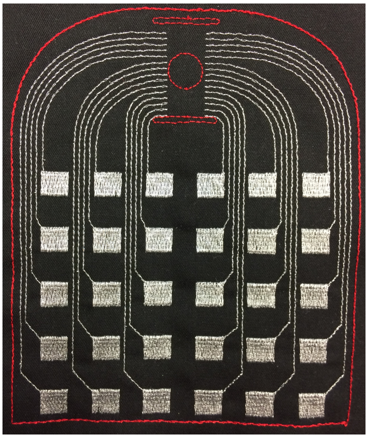
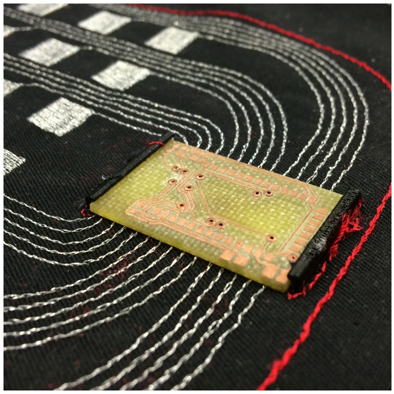


Figure 1: A prototype pattern for an interactive piece of cloth. We measure the interconnections between the patches to get an impression on how the piece is folded. The microcontroller is connected using a clipping mechanism (top).

A limitation of our current prototype is the minimum distance between the conductive traces that connect the patches to the microcontroller. The tolerances of our stitching machinery and loose fibers from the conductive thread make it difficult to go beneath 3mm distance in our current prototype, without risking involuntary connections. These traces will be isolated against the rest of the conductive materials using a stitched cover of non-conductive thread.

3.1 Electrical Connection

The electrical connection between conductive thread and a PCB holding the electronics containing the intelligence of the smart textile is of great interest to the community. The simplest way is to knot the conductive thread to the PCB, as for example with the LilyPad Arduino, but such connections are subject to wear and tear through the relative movement between yarn and PCB, and are not suitable for industrial production. Flexible PCBs can be glued or stitched in with conductive thread, resulting in a more durable connection (Linz et al., 2005). This strong integration requires the electronic components to be washable, which results in additional effort. In our prototype, we decided to use a clipping mechanism, as depicted in Figure 2. Above and blow the conductive lines are two horizontal holes to get the clip through the supporting fabric. The conductive thread is firmly pressed against conductive plates on the bottom side of the PCB by a plastic clip (Figure 2). This has the advantage that no sharp edges slowly cut into the yarn and thereby reduce its conductivity, and that the PCB can be removed before washing and clipped to another piece of fabric.



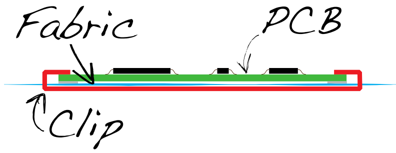


Figure 2: The connection between fabric (blue) and electronics is achieved by a clipping mechanism (red) that presses the ends of the conductive thread against conductive plates on the bottom side of the PCB (green).

3.2 Stitching Pattern

One important aspect that we want to investigate is the arrangement of the contacts used to sense the interconnections. Having them arranged as in Figure 1 is simple, but may result in unsteady sensor readings while moving, because the connections “come and go”, which would need to be filtered or interpolated in software. Using a checkerboard pattern would create more persistent connections, but it is more difficult to realize because the patches block the conductive traces to the microcontroller.

Leaving spaces between the patches to let the lines pass would result in a wide spacing because of the tolerances of our stitching machinery. Therefore we designed a hexagonal pattern that is very well suited to support moving the fold in all directions, and it does not block the connection to the microcontroller. The space between the parallel traces on the border of the patch can be higher because they do not interfere with the spacing in the interaction area.

4 Conclusion & Future Work

As part of this project, we want to investigate several production parameters to create a smooth interaction. The stitching pattern used for the conductive pads for example, needs to be such that movement in both horizontal and vertical direction is possible. So far, we only used a single direction, which results in a clunky movement orthogonal to the stitches. To solve this problem, and to reduce wear and tear, we want to try circular patterns.

Washing tests are also one of the next steps we will take. The used conductive material is known for its declining electrical conductivity after a number of washing cycles. The decline usually depends on the mechanical stress the material experiences in the washing machine. If durability of the interface has to be improved, one approach could be to use moss embroidery, a technique that enlarges the surface area. This may be sufficient to keep the conductivity on a level high enough to ensure the required signal stability.

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