On-body touch interaction using printed epidermal electrodes

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Abstract
We developed a system that enables on-body touch interaction using capacitive sensing with printed epidermal electrodes. Custom-made with commonly available ink and film, the electrodes can be easily tailored to support specific interactions on certain parts of the body. The film being placed onto the skin, somatosensory stimuli of both active touch (touching) and passive touch (being touched) can be perceived by the user, which is expected to enhance on-body touch interactions in different situations.

Author Keywords
Haptics, proprioception, eyes-free interaction, on-body interaction, epidermal electrodes

ACM Classification Keywords
H.5.2 [Information interfaces and presentation]: Input devices and strategies.

Introduction
The *body schema* plays an important part in our understanding of the world [1]. The constant update of this representation we use to plan and execute actions heavily relies on touch and proprioceptive information. Haptic perception is especially valuable when interacting with artifacts: the combination of proprioception and tactile sensations provides valuable information to

understand the ongoing phenomenon.

On-body interaction has already been explored by several researchers, e.g. [3, 4, 2], but the proposed technical solutions remain largely impracticable today as they rely on external or firmly-fixed and rigid sensing devices. Recent advances in bendable and stretchable electronic structures should soon make it easier to propose alternative solutions that conform to the soft and curvy nature of the human body[1]. Printed epidermal electrodes can already be used to prototype future on-body touch technologies and explore the design space of related interactions.

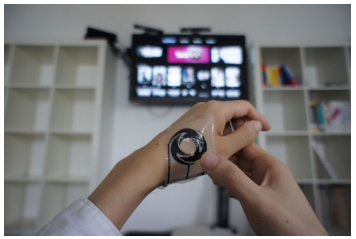

Figure 1: Prototype used for remote TV control

We take advantage of this combination of tactile and proprioceptive information by placing printed electrodes on the skin, which we hypothesize should facilitate eyes-free expert interaction. The printed shape should also help novice users correctly position their fingers when learning how to use the system. Overall, we believe printed epidermal electrodes have a great potential to effectively and efficiently support on-body touch interactions in different situations.

Implementation

Capacitive sensors must meet specific requirements in terms of thickness and conformation in order to be placed onto the skin. We made our prototypes with conductive ink[2]. The electrode patterns are printed on a thin and flexible adhesive tattoo film[3]. They are connected to a microcontroller performing basic noise reduction, gesture recognition and handling communication with an external server to trigger application-specific commands.

[1] `http://www.mc10inc.com/`
[2] `http://www.bareconductive.com/`
[3] `http://www.avery.ae/product/MD3004`

We conducted a preliminary user study based on a "remote control" scenario (Figure 1). A capacitive surface with three electrodes was designed to detect circular gestures of clockwise and counterclockwise directions on the back of the non-dominant hand. Participants were asked to perform target selection tasks without looking at the on-body sensing part.

Conclusion

We introduced a system that uses printed epidermal electrodes to support on-body touch interactions, with proprioceptive and tactile information. We are very much interested in further exploring the integration of printed electronics, epidermal electronics and conductive materials. Plans for the future include the design of interaction techniques based on the presented prototypes and their qualitative and quantitative assessment in both eyes-free and eyes-on situations.

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