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New Technologies for Dynamic Tattoo Art

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ABSTRACT
With the development of new technologies, new dynamic epithelial artifacts (*new tattoos*) are designed, enabling new types of situated and embodied multimodal communication. *New tattoos* (NTs) turn the skin into a source of dynamic and reversible inscription, possibly responsive to fine-grained organic variations, and dependent on oriented local perturbation. As new aesthetic-cognitive artifacts, NTs alter the operational and semiotic dimension of the skin, transforming it into a new frame of interactive interface. This paper aims at introducing some epithelial prostheses based on new biocompatible materials and technologies.

Author Keywords
Dynamic tattoo, design, biotechnology, cognitive extension.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design

INTRODUCTION
The design and application of new tattoo technologies has not changed dramatically since its origins. But things have altered recently. With the development of new technologies, new dynamic epithelial devices and artifacts are designed, enabling new types of multimodal situated and embodied communication. By "dynamic epithelial devices" we mean any dynamic (potentially changing in time) artifact intentionally inscribed or attached to the skin. There are projects associated with the use of new bio-technological devices, as well as with new synthesis of materials and new techno-scientific applications. These artifacts will convert the almost static aesthetic-technologic tattoo field into a new domain of experimental design of interfaces, improving on a new collection of non-verbal communication, and creating new forms of situated and embodied communication.

STATIC NATURE?
Any approach on the development of dynamic tattoos, based on new techno-scientific methods and models, should initiate on its own support -- the skin -- and the new available biologically compatible technologies. In a simplified form, tattoo is an invasive plastic inscription performed on the skin. The pigment is introduced in the dermis (second layer of the skin) (Figure 1), through micro-incisions made in different ways. Although the skin intensely renews itself because of the constant cells replacement, it does not absorb the pigments because they are in the dermis within the fibroblasts. Each fibroblast is surrounded by a conjunctive tissue prominent network that holds and immobilizes the cell. The elimination of the pigments particles is prevented due to the basal intact membrane restoration [3, 15]. (Many evidences indicate that in the very beginning, reverse attempts to the tattoo process were practiced. Even very old mummies have traces of attempts to remove the pigment inserted into the skin).

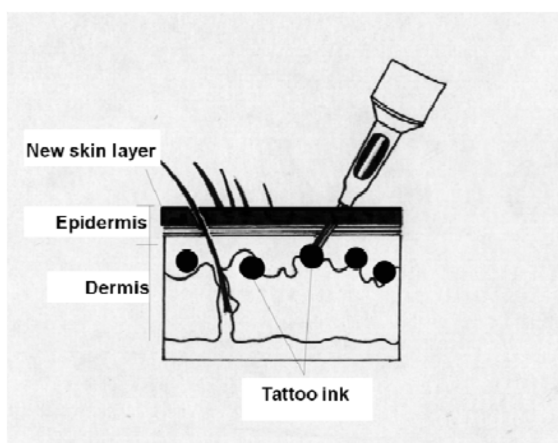

Figure 1. Tattoo Process.

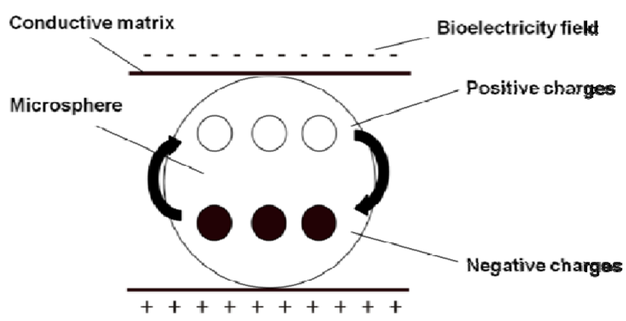

Figure 2. Electronic-ink, adapted from [13].

DIGITAL INK

E-ink, digital ink and electronic ink, are flexible matrix of pixels which are introduced in the skin. Through small surgery, encapsulated microspheres are embedded in the skin. The charge contained in these spheres is thrown in response to organic changes [5, 13]. As the body is both an electricity producer and a conductor, the charges can be attracted or repelled by the bioelectricity field, generating the images in the skin. The microspheres are between two conductive matrixes of bioelectricity; within them there are suspended charges in a translucent liquid [13, 22]. When the bioelectric field is generated and conducted to the matrixes through the body, it can attract or repel the spheres' charges and produce the images. The energy consumption of these inks is very low, and it should be possible to keep these artifacts in operation solely on the bioelectricity of the body [5] (Figure 2).

Companies are developing researches to design new tattoo forms based on digital inks. The pioneer was Philips Design, which included a new tattoo concept in its Design Probes [20]. The company develops a tattoo which is emotion and mechano-responsive (reagent to touch on the skin). The proposal is presented in the video "Electronic Tattoo" available on the company's website [20] (Figure 2). The video shows the dynamic displacement of a tattoo under the skin, based on positive feedback between two young people. When the girl's hand slips on the skin surface of her companion, images are produced. These tattoos should be able to respond not only to touch, but also by neural and endocrinal variations, perhaps even contextual-environmental.

LED TATTOOS

A recent paper at MIT Technology Review [10] describes a new type of ultrathin silicon transistor that can be incorporated into a soluble biomaterial film based in silk. The material has biocompatibility, elasticity and various resistance taxes. Researchers are developing ultrathin LEDs (light-emitting diodes) onto soluble water and biocompatible silk substrates that might act as photonic tattoos [10, 12]. These tattoos show blood-sugar readings, allowing the mapping of a great range of physiological functions. Medical applications of these transistors has been developed by researchers at Beckman Institute, at the University of Illinois and Tufts University [10].

The research has applications in controlling the Parkinson's symptoms. The applied electrodes allow deep neural stimuli due to the possibility of deep access to the nervous tissue layers. Experiments are successfully conducted with animal models (mice). Much like electronic tattoos, LED tattoos can be programmed with an external device enabling the design of complex visual patterns.

DATTOOS

The designer Hartmuth Esslinger created the "Dattoo" concept [7]. This is a tattoo that enables the host DNA reading to be activated. Dattoo's goal is to be performed both by minimally invasive methods as with recyclable materials. Only the sensors are inserted under the skin. The interface is printed as an interactive adhesive that enables both its easy application and removal. The display is prototyped (printed) on an adhesive surface that can be aggregated to the skin for a specified period of time, which allows the subject to have it removed or not.

OTHER TECHNOLOGIES

Researches focused on printing silicon transistors on flexible materials allow great advances in the design of new extremely thin and flexible displays. In the same way, researches of biocompatible devices for application in health and engineering, like biosensors and nanotransistors enables the development of technological artifacts (flexible displays, transistors and sensors based on biomaterials) that can be inserted and applied to the human body without harming the health.

Researchers at the Beckman Institute and Tufts University, have developed studies on ultrathin devices over flexible silk substrates [10]. The aim of these researches is the development of biodegradable circuits to enable better neural interfaces with transistors and LED tattoos to provide dynamic epithelial devices. Other possibilities to make these interactive displays are in progress. Several investigations have been developed, such as the production of extremely thin and flexible displays.

Researchers at HP Labs created, through silicon transistors printed on top of plastic, a flexible color display which could appear in future color e-readers and tablet computers [1]. HP is scaling up a process for making silicon electronics on rolls of plastic through silicon transistors, which can switch on and off pixels on the display [11]. In the same way, researchers at Samsung and Sungkyunkwan University develop flexible touch screens made with printed graphene [2, 8]. This flexible graphene sheet with silver electrodes printed that can be used as a touch screen when connected to control software on a computer. This research can also results in sheets of atom-thick carbon made displays that are extremely fast. Scientists from Empa and the Max Planck Institute for Polymer Research also developed researches with graphene transistors, corroborating the fact that graphene ribbons are considered to be strong candidates for future electronics applications [17].

Researchers at MIT are developing multifunctional fibers that act as sensors carrying light and sensing pressure to be used for medical imaging and structural monitoring [8]. Nicholas Kotov (University of Michigan) develops textiles coated with carbon nanotubes which form electronic sensors that look and feel like ordinary cotton [18]. Babak Parviz (University of Washington) develops piezoelectric materials, which produce an electric current when subjected to mechanical pressure [6]. Embedded technology promises not only to provide data wherever and whenever we need it but to transmit real-time data about ourselves [6]. The vast amount of research and development with promising initial results enables the future development of a new dynamic and interactive tattoo.

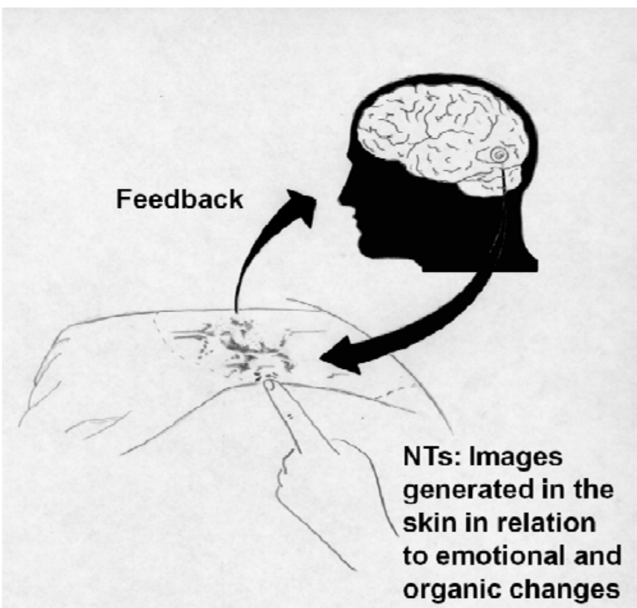

Figure 3. NTs: Image reacting to neural and endocrinal variations.

TECHNO TATTOOS

What we call here NTs (Figure 3) (dynamic and interactive images generated on the skin) can be developed from technological adhesives, (i.e., displays that can be aggregated to the skin without invasive procedures). These adhesives contain tiny sensors that allow the uptake of organic and environmental variations. The technology is already in development [1, 8, 9, 11]. Sensors detect organic variations and send data making use of wireless and body area network (BAN) for technological devices [4, 13, 19, 21]. Through skin bio-conductivity, organic variations patterns are established. A way to measure these values is through Galvanic Skin Response (GSR): small variations in the skin's bio-electricity caused by the sympathetic nervous system are captured between the electrodes inserted into the skin and are, thus, calculated; emotional changes can be identified [16] and translated into dynamic images generated on the skin.

The sensors in these devices capture changes such as temperature (bodily and environmental), pressure, brightness, movement variations, and so on. This data is captured as inputs and, in response, outputs are generated in the form of interactive images on the skin.

CONCLUSION

The skin is open to a new collection of interface design. It's a reasonable assumption that new forms of interpersonal relations will be established due to the creation of new patterns of communication associated with new ways of reading the organic states (neural, endocrinal systems) through interfaces based on quasi-automatic feedback. The development of a new collection of prostheses and aesthetic-cognitive artifacts should enable new interaction modes with the environment and its components. By aesthetic-cognitive prostheses and artifacts we mean any devices that extend some cognitive ability related to aesthetic fruition. The impact of developing technologies for the conception of "new" forms of organic interventions will have ramifications in unpublished areas, allowing the use of new interactive epithelial prostheses (*responsive dynamic tattoos*), and creating new paths for embodied communication. Such artifacts should not be analyzed separately, but in dense interaction with subject and complex environment. In subsequent works, we will analyze possible simulations of these technologies, developing alternatives and results for practical researches that have already begun exploring ethic considerations and its future context of use in terms of communication, design and arts. Our main purpose here is to present a preliminary approach of some of the materials and technologies to be used in the near future to design and produce new epithelial prostheses.

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