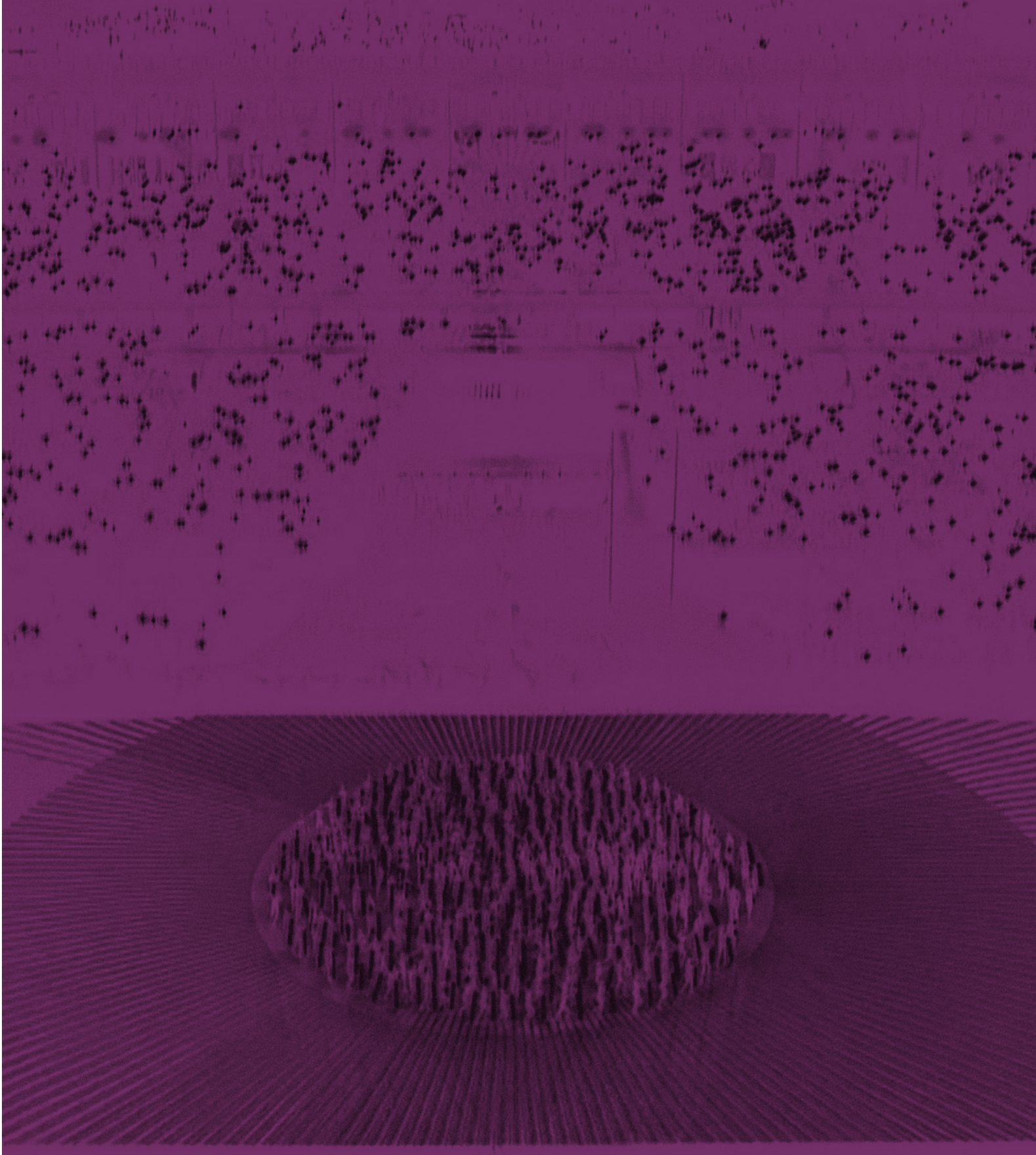
28
Computational Skins

Marcelo Coelho



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Clothing is one of our earliest technologies. It protects and shelters our bodies from the environment while expressing social, cultural, and economic aspects of our identity.[1] Today's insatiable hunger for information has been driving computers to permeate every aspect of what we wear, supplementing our wardrobes with smart phones, pedometers, electronic jewelry, head-mounted displays, and a whole host of other gadgets. This trend is in large part enabled by an increase in battery life, component miniaturization, and advances in materials science and fabrication, which have allowed electronics to be placed virtually anywhere while conforming to the curvatures and motions of the body. As computers migrate from the desktop to our skins, they will engender a new kind of interface that is primarily wireless, omnipresent, physically rich, and highly contextual. This raises an interesting challenge: how should we design wearable computers to enable a more comprehensive human experience akin to that of our clothing?

In what follows, I will outline a vision for the full integration of computation onto our bodies and describe three separate research efforts that attempt to answer this question.

SOFT MACHINES

Garments are traditionally soft, lightweight, and capable of moving and stretching with the body. Their shape is both a functional tool and a form of expression, and as they become worn their natural form changes over time. As technology improves and garments become full computational extensions of our bodies, it's only natural that they should inherit some of the properties of textiles.

One example of how this could be done is Kukkia: a shape-changing dress developed at XS Labs.[2] Decorated with three animated flowers that frame the neckline, Kukkia is essentially a soft machine that can adapt and respond by modulating its textile properties. Each flower opens and closes through the combined actuation of a custom-designed textile composite made from shape memory alloy and natural felt. While the shape memory alloy deforms the textile in one direction, the felt naturally counteracts this in the opposite direction.

Extending this work, Sprout I/O is a similar textile composite which, in addition to dynamically changing shape, can also capacitively sense when it's being touched.[3] The textile equivalent of a touch screen, this material still looks and feels like fabric, albeit with a whole new set of utilitarian and expressive functionalities.

CROWD NETWORKS

As our garments become dynamic and responsive, they will not only redefine how we access and manage information, but will also dramatically alter how we communicate and relate to each other. Alike is a wearable device that seeks to reinvent how crowds connect, relate, and collaborate when face to face. At its core, Alike is a small circuit board that can be embedded into virtually any article of clothing. It is composed of two primary components: a radio for always-on and continuous device-to-device communication, and an RGB LED that provides real-time feedback to both the wearer and others nearby.

At MIT's first Active Matter Summit, Alike functioned as a distributed and colocated display for attendees to visualize the crowd's networking activity. Embedded into a traditional conference badge, each Alike device kept track of nearby activity. When all conference attendees were stationary, such as when listening to a talk or talking to a single group of people for a long time, their devices would register a low crowd activity and light up a cool, blue color. However, as attendees moved about and interacted with more people, their devices slowly transitioned to a hot, red color. This heat map visualization not only served as a tool for wearers to visualize their behavior, but also provided the feedback and social cues necessary for people to manipulate it.

So far, we have experimented with a variety of crowd dynamics, such as games, crowd-sourced fabrication, and a large-scale performance for the Rio 2016 Paralympics ceremonies, and with a wide range of device form factors, such

Figure 28.1 (top)
Kukkia: electronic textile, a shape-changing garment.

Figure 28.2 (bottom)
Kukkia: electronic textile, a shape-changing garment.

as pendants, bracelets, carnival masks, and even drinking cups. The possibilities for designing new collective human experiences are virtually endless, since each environment and form factor signals, promotes, and precludes a different set of social behaviors. If the body is to become the computer, the relationships between bodies will become the ultimate network.

BIOCOMPOSITES

Looking ahead, it is not hard to imagine how we can go farther and ditch clothing altogether. At LogicINK we are starting to develop chemical and biological functional inks that can be applied directly to the skin to detect both physiological signals from the body and a wide range of environmental stimuli.[4]

One example is an enzyme-based ink embedded into a temporary tattoo that detects wearers' blood alcohol content through their sweat. When applied to the skin, the ink is initially transparent and conceals its design, but as the wearer drinks and their alcohol level goes up, it changes color to reveal a new image and indicate they should not be driving. This biocomposite computational approach has a series of advantages over traditional technologies: it's incredibly low-cost and disposable; its form factor is completely unobtrusive and free of battery and electronics; and since inks can be printed with all kinds of designs and patterns, it provides a completely new outlet for aesthetic expression.

The work described here is for the most part in its infancy, but future developments in biological and chemical engineering will continue to help us design, program, and fundamentally

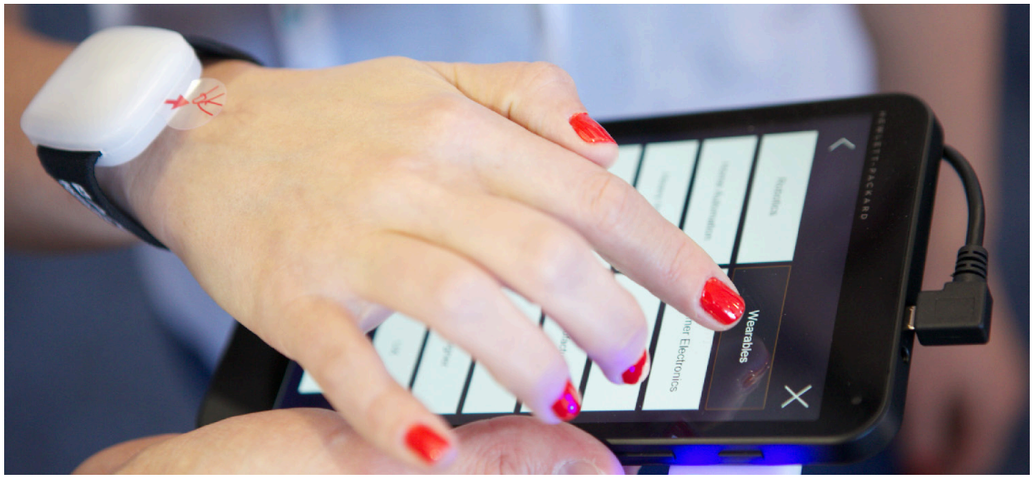


Figure 28.3 (left page, top)
Alike: custom electronics, a social networking wearable.

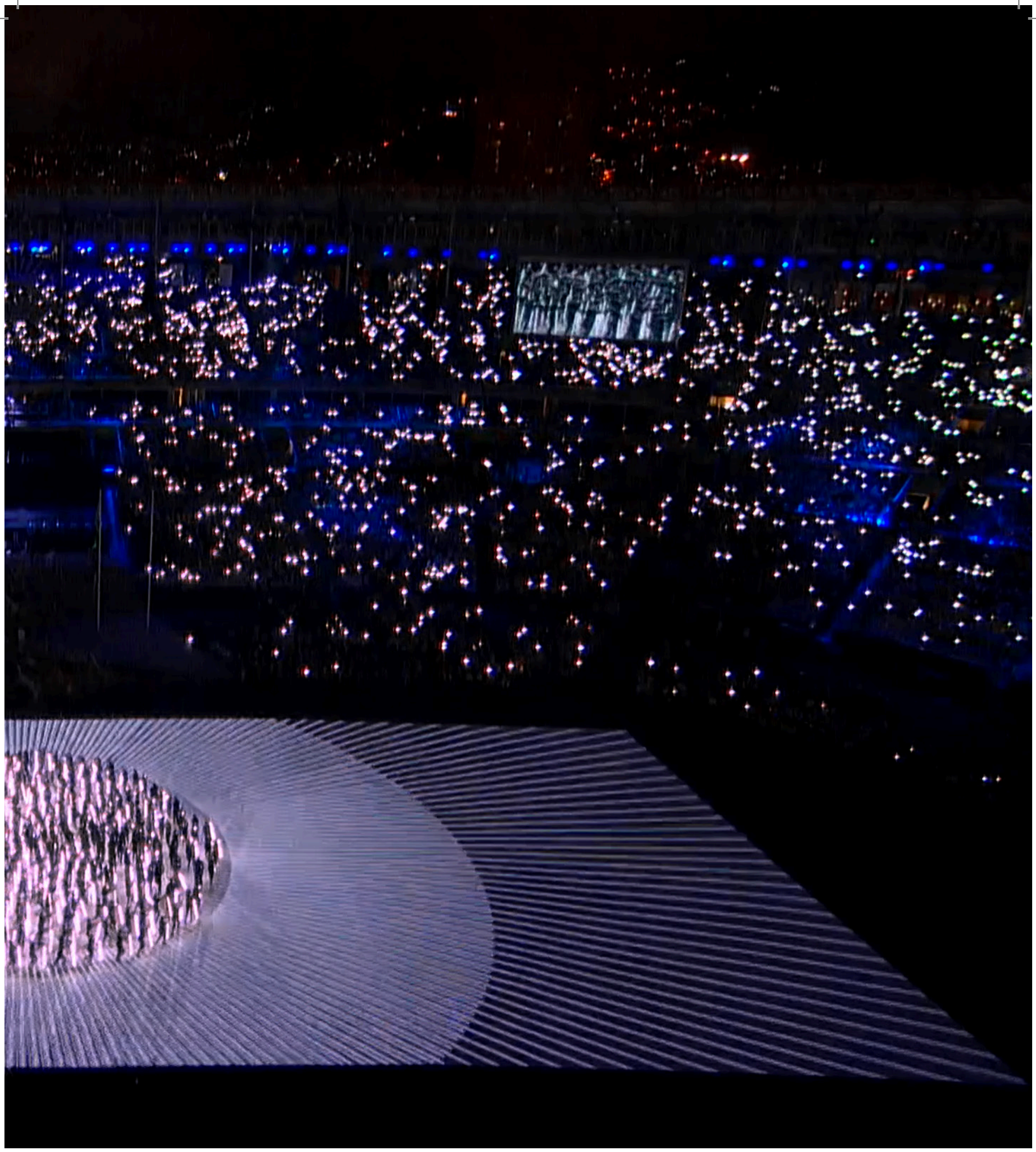
Figure 28.4 (left page,bottom)
Alike: custom electronics, a social networking wearable.

Figure 28.5 (bottom)
Alike: custom electronics, a social networking wearable.

reinvent our skin's microbiota. Working in tandem with active materials and increasingly small electronics, wearable computers may look a lot more like a sunscreen lotion or spray that we apply to our skins as we are ready to leave the house, rather than the bulky and heavy computers of yesteryear.

Figure 28.6
Beyond Vision: custom electronics, performance during the Paralympics opening ceremony.

Figure 28.7
Beyond Vision: custom electronics, performance during the Paralympics opening ceremony.



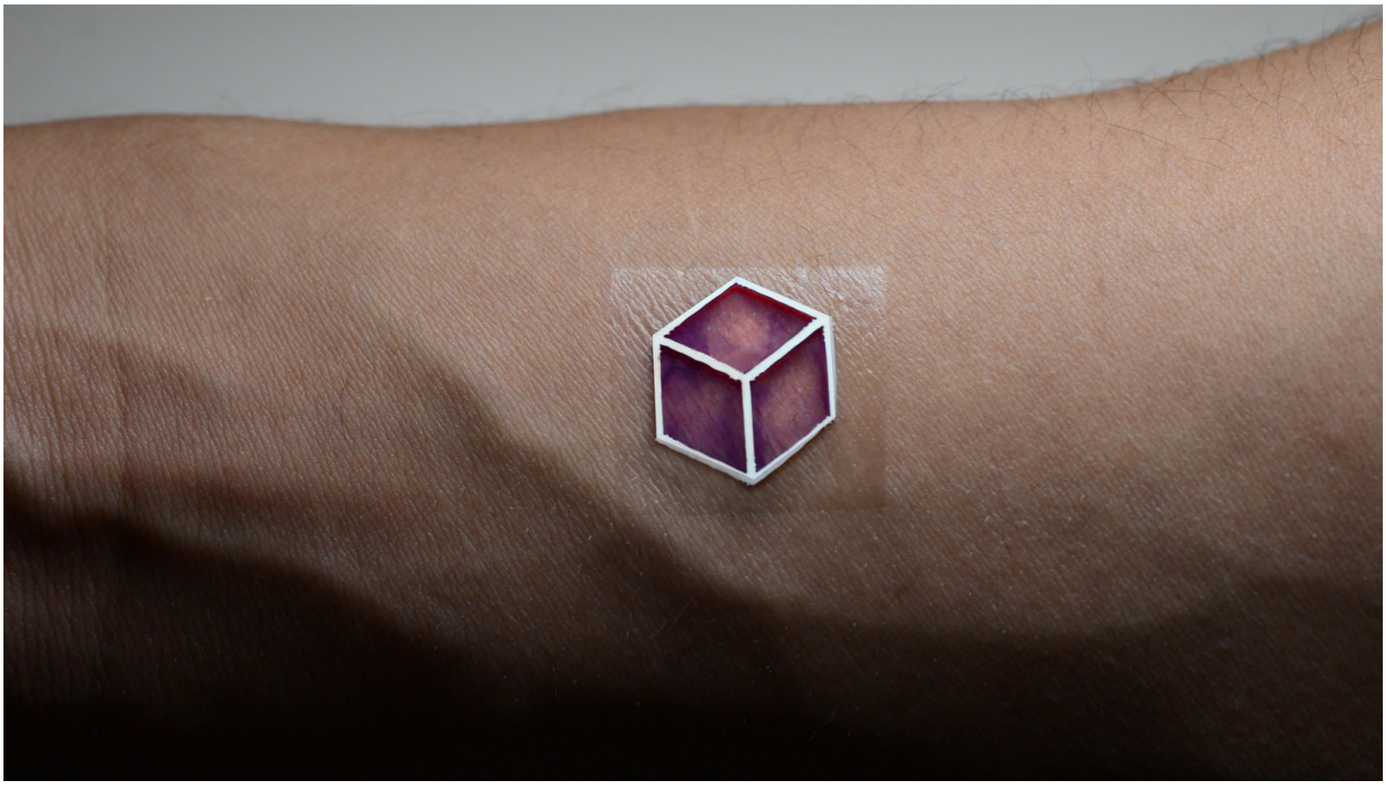


Figure 28.8
Logic INK: programmable ink, programmable temporary tattoo applied on the skin.

NOTES

1 M. Hogenboom, "We Did Not Invent Clothes Simply to Stay Warm," September 19, 2016, http://www.bbc.com/earth/story/20160919-the-real-origin-of-clothes

2 J. Berzowska and M. Coelho, "Kukkia and Vilkas: Kinetic Electronic Garments," International Symposium on Wearable Computers (ISWC'05), IEEE, 2005.

3 M. Coelho et al., "Shape-Changing Interfaces," *Personal Ubiquitous Computing* 15, no. 2 (February 2011): 161—173.

4 LogicINK, http://www.logic.ink