Fabric Computing Interfaces

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ABSTRACT
This paper presents a series of physical computer interfaces and computational devices that are constructed from electronic fabrics and conducting threads. We introduce two types of textile keyboards, a piecework switch matrix and a capacitive embroidered keypad. We discuss these fabric sensors in a variety of applications. We give examples of computational clothing using this technology. This clothing shows how digital technology can be imbedded into the world around us. We argue that creating computational devices with new and unexpected materials gives designers the creative freedom to radically change the appearance and "feeling" of such devices.

Keywords
Physical Interface, Smart Materials, Wearable Computing, Industrial Design

INTRODUCTION
Designers of computer interfaces have not only dreamed of changing the software inside computers, but also of changing the physical form and place of computers in the world [1] [2]. Usually, such design practice has been limited to reshaping and coloring a plastic shell. But for computers to truly move off of the desktop out into the world, designers of computational objects must (as architects do with buildings) control, understand, and influence the materials from which computers and their peripheral devices are constructed. This project is a collaboration between researchers who in spite their different fields of expertise, (i.e., art and science), came together to with a common goal. We wanted to change the physical properties and place of computers and computational devices in the world around us.

FABRIC COMPUTING DEVICES
Designing with unusual materials can create new user attitudes towards computing devices [3]. Fabric has many physical properties that make it an unexpected physical interface for technology. It feels soft to the touch, and is made to be worn against the body in the most intimate of ways. Materially, it is both strong and flexible, allowing it to create malleable and durable sensing devices. Constructing computers and computational devices from fabric also suggests new forms for existing computer peripherals, like keyboards, and new types of computing devices, like jackets and hats.

Fig. 1 Embroidered Keypad

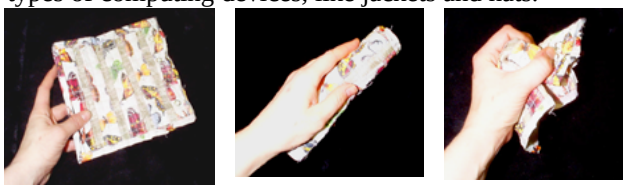
Fig. 2 Quilted Fabric Keypad, Flat, Folded and Rolled

Sensitive Fabric Surfaces
Creating sensors that are soft and malleable and that conform to a variety of physical forms will greatly change the way computing devices appear and feel. Currently, creating beautiful and unusual computational objects, like keyboards and digital musical instruments, is a difficult problem [3],[4]. Keyboards today are made from electric contacts printed on plastic backing. These contacts are triggered by mechanical switches and buttons. Digital musical instruments rely on film sensors, like piezoelectric and resistive strips. All these sensors require rigid physical substrates to prevent de-lamination, and the mechanical incorporation of bulky switches. This drastically limits the physical form, size and tactile properties of objects using these sensors, [5].

Two Fabric Keypads
Our fabric keypads offer far greater physical flexibility and softness than existing flexible keyboards. Unlike fabric sensing of the past, these keyboards offer the precision and repeatability necessary to create reliable sensing devices [6]. These keypads can be used to interface with

everything from a desktop computer, to a pager and an interactive dress.

Quilted Switch Matrix Keypad (Figure 2.)
This row and column switch matrix is sewn from strips of conducting metallic fabric, (the electrical switch contacts), and non-conducting cotton and nylon tulle, (the insulating layers) [7]. Because no plastics or non-textile materials were used in this keypad, this quilted computer keyboard is soft, can be scrunched into a small ball, folded up and wrapped around an object of any shape, with no damage. This keypad is highly responsive, so users can rest their fingers on the sensing areas and press lightly to get a response on the computer screen.

Embroidered Capacitive Key Pad (Figure 1.)
This keypad is embroidered from a resistive kevlar and stainless steel thread, and uses a capacitive sensing technique to recognize touch [7]. Each embroidered number registers a key press when touched. These sensors can be easily made on a computer controlled embroidery machine. Using this entirely new method, sensors can take on any size or shape and conform to any surface. These sensors can easily be made to look like butterflies as well as calculator pads.

Smart Fashions, Sewn Circuits, and Fabric Computers


Fig. 3 Musical Jacket

For the MIT Media Lab's "Wearable Computing Fashion Show" (10/14/97), we created a series of "smart fashions" that incorporated fabric sensors, busses, ground planes, power planes and electrodes.

Musical Jacket (Figure 3.)
The Musical Jacket incorporates an embroidered fabric keypad, a sewn conducting fabric bus, a battery pack, a pair of commercial speakers and a miniature MIDI synthesizer [8]. When the fabric keypad is touched, it communicates through the fabric bus to the MIDI synthesizer, which generates notes. The synthesizer sends audio to the speakers over the fabric bus as well. Power from the batteries is also distributed over the fabric bus. The embroidered keypad and fabric bus allow the elimination of most of the wires, connectors and plastic insets that would make the jacket stiff, heavy and uncomfortable.

Firefly Dress and Necklace (Figure 4.)
The Firefly dress and necklace uses conductive fabric to distribute power throughout the dress [9]. As the wearer moves, LED's (small lights) to which we attached fuzzy conductive pads (the electrical contacts), brush lightly against the fabric power and ground layers, creating a dynamic lighting effect. The necklace, (having no power supply of its own), creates dynamic light effects when its conducting beads and tassels brush against the surface of the dress. These "opportunistic" connections allow power to be distributed without hard and fast connectors and wires. The dresses design is reminiscent of the 1920's and suggests a level of detail and romance rarely associated with technology.


Fig. 4 Firefly Dress

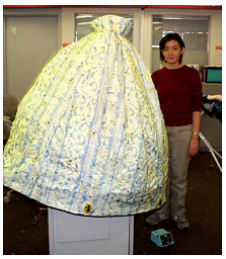
Fig.5 Electronic Gown

Electronic New Year's Eve Ball Gown
Patterned after a 17th century French gown, this Electronic Ball Gown uses floral conducting embroidery to connect lights and embroidered sensors on the skirt to PIC microprocessors, [10]. The PICs control how the lights flash. By touching the flower sensors, the dress can be turned off or on, or made to flash in different ways.

CONCLUSION

Using sewn fabric sensors and circuits allowed us to eliminate uncomfortable and heavy wires, connectors and electronics. It also allowed us to create computing clothes that hung, moved and felt like normal clothing. Moreover, these garments demonstrate that designers can gain creative freedom through new materials for computational devices.

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