Sensing Touch Curtain: Soft Architecture

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Abstract: *The Sensing Touch prototype demonstrates one type of sensing that can be woven into soft building components. It is a computational textile that senses the nearness of a person or people and registers absolute touch on fabric through capacitive sensing. Capacitive sensing measures position and distance between the textile and a target object by sending forth electric signals. The methods of construction, method of electronic weaving will be discussed in the paper. The Sensing Touch project frames an expanded role for soft architecture enclosures.*

Palabras clave: Computational Textile, Soft Architecture, Capacitive Sensing, E-Textile, Flexible Composite Materials

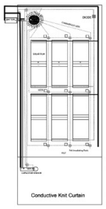
The practice of using soft textiles to make building enclosures such as tents and is an ancient practice, which has great relevance to the architectural discipline in a literally unstable, changeable environment. One has only to look in the past year to the earthquakes in Haiti, Chile, Australia and most recently Japan to see that the earth is in an active cycle, causing great distress to resident populations. If entire buildings are constructed of lightweight, soft materials in a variety of ways using fabric in both in compression and tension, so that one might construct many kinds types of building systems in addition to tents, then it is possible to spin electrical capacity and other energy/data bearing threads into the fibers of those soft components. If this can be done, then work may be initiated to construct an intelligent soft architecture that can communicate information to people about its environment and change in relationship to information received from the environment. This project prototype integrates techniques of textile fabrication, programming and electronics to develop a new idea of composite soft building systems.

The Sensing Touch prototype is a computational textile that senses the nearness of a person or people and registers absolute touch on fabric through capacitive sensing. Capacitive sensing measures position and distance between the textile and a target object by sending forth electric signals. Absolute touch is when there is no measured distance between the textile sensor and a person. The fabric serves both as a receiver of information and outputs this information via a series of led's that stand in for other forms of output. For example instead of lighting led's the output could be to heat the textile to a particular temperature, depending upon the distance of a person to the fabric. The textile is a composite material constructed of several layers including felted fibers, knitted conductive threads. The project uses an electronic weaving technique as a method to receive information from the sensor to communicate the different states of nearness or touch to the led panel. The paper will present the methods of construction, method of electronic weaving and show video demonstrations of the fabric.

The Sensing Touch project demonstrates a method of electronic weaving and using soft conductive material to make a new soft composite material capable of communicating variable states in its environment to people.

Introduction_ Soft Architecture

The concept of Soft Architecture is increasingly relevant on a planet that is currently in a very active phase of making new land and changing its shape. Earthquakes this previous year in Haiti, Chile, Australia, Japan and most recently on the East Coast of the U.S., attest to this and have caused much discussion about what are best ways to build on a very changeable earth crust. Many of these countries have long developed methods of building in earthquake zones, using building components that fail in ways that allow occupants a better chance of escaping unharmed, to methods of constructing that are more flexible and built to sway with the ground like trees. Soft Architecture proposes developing these strategies another step and proposes using soft materials, such as manufactured threads like carbon fiber and other spun threads to create composite materials as both bearing materials in compression and tension like beams and columns, and that are lighter, stronger and have greater elasticity to withstand the forces of earthquakes. There are really two critical components to consider in developing a soft architecture, the first is the structural capacity of the material, which is not treated in this paper. The second concept, is integrating other building systems or infrastructures such as electricity, water, heated and cooled air into or with the soft materials, which is the focus in this paper. If soft materials are used to develop building components, then it is possible to intertwine other functions into those soft components making a sentient, active building that can communicate the state of its environment or its state to people. This paper is about combining these other functions with soft building materials. Many of these experiments are ongoing in the field of wearable computing, using spinning, knitting and weaving to construct multilayered composite materials that not only cover and protect but also can perform some communicative function. The Sensing Touch Curtain project integrates many of these techniques with architecture and communicates information about its environment through the act of touch. [Please see Figure 1].



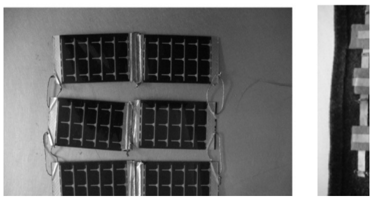


Figure 1. Curtain Panel Open (right) Panel Closed (left)

RelatedWork_TextileBuildingandWearableComputing
There are some architectural firms that have begun to look at the potential for making architecture from responsive soft components; some salient examples are Kennedy and Violich's Zip Wall, contains lighting, soft electrical outlets, soft digital plugs housed within a soft wall. The zip wall provides a soft wall that makes a space of enclosure, its flexibility and sensuous softness changes the relationship between the human body and its environment. A second project, a development of the Zip Wall by Kennedy and Violich's, called Convia Smart Building Infrastructure developed for the Herman Miller Corp. uses a soft curtain system that hangs from a track in the ceiling of a building. [Please See Figure 2.] This track provides solid state lighting, telecom, wireless and other network wiring. Lastly Kennedy and Violich's Soft House, uses large energy harvesting Photovoltaic curtains to collect solar energy to generate up to 16,000 watt hours of power or more than half the average daily energy consumption for an American home today. [Please See Figure 2.]

Other examples that show how textiles could be used to transform the environment come from the apparel industry such as this cooling suit that contains heating elements to provide warmth or this astronaut's suit that provides cooling coils within its shelter. [Please See Figure 2, (lower left).]

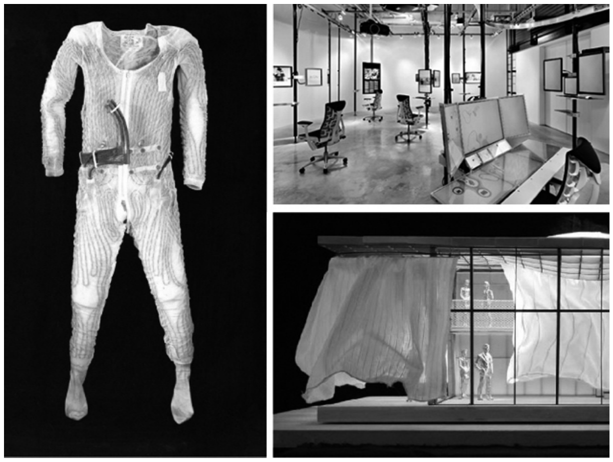


Fig 2. Kennedy and Violich's Convia Smart Building Infrastructure (upper left) and Soft House (upper right), Apollo Liquid Cooling Suit (lower left).

Materials and Construction

The Sensing Touch Curtain is a multilayered nonwoven fabric panel that provides its own power through solar film strips on the cover of the curtain panel. The curtain itself is made of machine knitted conductive thread, which is connected to a capacitive sensor that can read human nearness and touch. As a way to read this nearness or touch, led's are programmed to be active at different values read by the sensor. These values were set to read, close by, at 4 inches, close at 1/4 inch and touching. Certainly other communicating devices could be substituted for led's, such as providing heating or cooling elements in the textile that operated on touch for example.

Solar Film Array_First Circuit

The curtain is made active by three circuits, which are insulated from each other by two layers of felt, and conductive threads sewn in between the thickness of the felt. The first circuit is the solar circuit with diode to direct the juice gathered from the solar film to the battery. The diode prevents the gathered energy from flowing back into the solar film. The solar film was sewn with conductive threads between the plastic film and the metal strip that is the conductor. First two solar strips were sewn as a series, plus to minus. Then these series were sewn as parallel clusters. This array yielded 8 volts of power out of doors in sunlight. [Please see Figure 3 (upper left) for circuitry and Fig. 3 (lower left) for solar film]

Electronic Weaving_Second Circuit

The second circuit is the Chalieplexed circuitry, or electronic weaving circuitry made to output the three different values for the sensor. This is the gridded circuit you see in the Figure 1 with the panel open. This circuit was made with a conductive fabric that was ironed onto fabric glue, and then laser cut to reduce the number of frayed threads. Additionally, the conductive fabric was treated with acrylic nail polish to ensure tiny fraying threads would not short the circuit. This circuit is powered through the microprocessor in the Lilypad to the Chalieplexed conductive fabric grid. An Arduino program was used to take readings from the sensor, and turn on and off the lights on the woven circuit. The electronic weaving made it possible for the curtain to output many more kinds of states of nearness because it expanded the nodes on the Lilypad processor where N^2 –N led's would be possible, where N is the number of connecting nodes on the Lilypad. After the conductive fabric grid was completed the positive legs of the led's were sewn to horizontal bars, and the ground leg was sewn to the vertical strips. [Please see Figure 3 (upper right) for circuitry of Charlieplex and Figure 3 (lower right) for fabric circuit.]

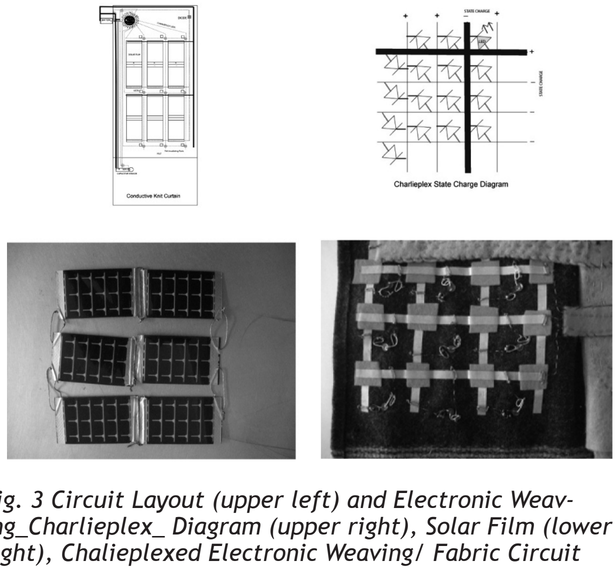


Fig. 3 Circuit Layout (upper left) and Electronic Weaving_Charlieplex_ Diagram (upper right), Solar Film (lower right), Chalieplexed Electronic Weaving/ Fabric Circuit (lower right).

The Arduino program could then select a specific led(s) to power and turn all the others off by making them the opposite charge of the led we wanted to light up. The pins on the Lilypad sewn to the horizontal bands of conductive fabric were set to HIGH and the vertical pins set to LOW. To turn on a particular led(s) its horizontal bar was called at HIGH and its vertical bar was called at LOW, all other led's received the opposite charges.

Capacitive Sensing and the Conductive Curtain Third Circuit

The last circuit is for the sensor it is a Capacitive Sensor AD 7746. The sensor is also controlled through a Lilypad 328 and is connected by one channel, to the conductive knit curtain. The curtain was knitted with the 14ohm/foot, silver plated 4ply thread.

The capacitive sensor uses the curtain as an expanded field through which it measures the distance between it and a human hand. A change in the distance between the curtain and human skin changes the capacitance. Or:

Capacitance = (Dielectric *Area)/ Distance Apart.

Each new environment has a different capacitance, because that environment is made up of many types of surfaces that carry various amounts of charge, so that the Sensing Touch curtain must be recalibrated in Arduino for each new environment it is placed within.

Computational Touch and Soft Construction

What is critical is to develop a framework and suitable representational models, and then applications that use computational touch in soft building components. Intelligence embedded in human touch offers a staring point for a model, with many possible representations.

If the scenario of the Sensing Touch Curtain is reversed, then in addition to a person responding and learning about the environment through his or her sense of touch, the curtain or a soft building component could take in a sense of what is touching it, where it is touched and learns from that, to provide heat or cooling or electrical power to an area, depending upon the kind of touch.

As a technical phenomenon, the electronic weaving described in this project could stand in as a metaphor for the prevailing techniques that have been used by the engineering sciences since the 1950's to connect an expanding network of devices that carry information and knowledge for the human mind. This interwoven constructional method is provisional and easily adapted, changed and updated. A smart building in the future may not only connect but incorporate many of these devices through wireless technologies and miniaturized or nano scale components that can be knitted, woven and plated into sinewy textile surfaces that can carry electricity, insulate us and provide structural capacity. The fibers that can be used for these soft walls can be designed structurally at the nano scale to provide desired characteristics for carrying electricity, insulation, and structural loads. The walls of such a building could be soft, malleable to the touch, moveable, and lightweight.

Contributions of Sensing Touch Curtain

In the case of the Sensing Touch curtain, the project makes a step towards understanding the problems embedded when designing soft empathetic or two way response architectures. The project frames an expanded role for soft architecture enclosures; not only can these woven and knitted enclosures bring electricity and other services to people through soft materials without using wiring, they can also respond to the environment through the human touch. The project demonstrates how soft walls could operate as an infrastructure capable of *both* input and output. The project demonstrates a method of electronic weaving and using soft conductive material to make a new soft composite material capable of communicating variable states in its environment to people. The project shows how human touch can be used through capacitive sensing to communicate with soft enclosures radically changing the idea of shelter and enclosure for the human body.

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