SoftShare:

A Wearable Surveillance Tool

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SoftShare is a trench coat that features embedded e-textile and wearable technology. The coat has a soft circuit and sensors built into the design facilitating an interaction that explores interrelationships between surveillance and embodied experience. Following a set of simple instructions, the person wearing this garment is capable of creating a short sensorial travel diary. The coat is an expressive surveillance tool that allows the user to play with interpreting and experiencing the place where they are. When the user manipulates two of the sensors, the data from other sensors and a GPS are recorded to the memory of the micro-controller. The information that is gathered from the user's body by different sensors is combined with the responses that are contributed by the user to certain elements in the place that she is in. The user may only control a portion of the information that is recorded. The wearable is a trench coat because this is the costume of a private investigator and the user playing the game is participating in a type of surveillance. The interactive components in the design of the coat enable the user to react to the presence of surveillance with tactile and embodied responses. These actions of responding and recording "out in the field" of the urban environment are a method of examining surveillance as a multi-faceted dynamic involving embodied perceptions of space.

Can surveillance of others and the self-revelation that is facilitated via our constant connectivity contribute to the user having agency and reversing the power dynamics of surveillance? How do new surveillance technologies shape our perceptions of physical space? The first section of this paper will provide a brief overview of surveillance practices that are now being implemented at the present time and examine some of the implications of these new methods of monitoring on embodied experience. The second section introduces physical computing and the LilyPad and Arduino software environment. The third section describes examples of wearable and locative media art works that investigate surveillance as a theme and address issues of resistance to surveillance practices. The fourth section outlines the interaction design of *SoftShare* and includes documentation of the process of building the project. In my conclusion I will reflect on the design and research process and discuss avenues for future research.

Surveillance can be understood as a method of gathering information about where someone is and what that individual is doing, whether this might be in the physical or the virtual world, during a certain time frame (Castells et al 119). Surveillance and locative communication media record information about physical actions of individuals and the practice of tracking human activities can also impact spatial perceptions of areas and regions (Curry Phillips 144). Surveillance is becoming increasingly spatially oriented as new locative surveillance technologies are being developed and implemented (Lyon 113). The translation of physical and material presence into digital information enables different ways of understanding embodiment and the "rise of the virtual body has its roots in the interconnection between new technologies and new directions in surveillance" (Conrad 381).

Surveillance fragments and reduces to data the actions of individuals being monitored. What Lyon and other theorists have labeled "the phenetic fix" is a drive towards creating abstract categories based on patterns of conduct that is generated by data collected about the physical actions of human individuals. This data is organized into categories of income, education, physical attributes, preferences and other characteristics that are often utilized to manage and influence populations. Lyon suggests that this "social sorting" is enabled through the implementation of new information technologies such as biometrics, 'smart' ID systems, and CCTV with facial recognition capabilities (Lyon 3). For Lyon, "bodies are disappearing" as everyday tasks are done at a distance, and this has created a need for greater surveillance. Human activities are controlled through surveillance systems that are owned by corporation and state institutions and "these agencies use surveillance practices as a means of making visible that which is being lost from their sight; our bodies and the bodies of those with whom we relate" (Lyon 200). Location technologies link to these other methods of gathering information. Geo-demographic systems that have been developed in the United States, Canada and Europe over the past thirty or forty years have allowed for greater access to data about locations and the people who live in these places (Curry, Phillips 144). In some municipalities in the United States, cell phone data is utilized as a tool to monitor traffic flow. This kind of monitoring exploits the fact that cell phones actively search for nearby cells to connect to and link from tower to tower as they move. Municipal traffic monitoring programs utilize a surveillance infrastructure that has the capability to track citizen's movements (Andrejevic 100).

"Dataveillance" is a term that describes the gathering of information through search engines for target marketing. This process of monitoring is often utilized in place of visual and audio surveillance practices for different purposes (Lyon 200). Surveillance is a mainstay of new methods of market research and wearable computing will inevitably aid corporations in their quest for detailed information about consumer's habits. This new type of surveillance of consumers is called m-commerce (the m stands for mobile) and what has been labeled "customer relationship management" is a growing area of business. This new industry plays a role in organizing the vast amounts of information about consumer's individual preferences that are communicated through the interpretation of their movements (Lyon 43).

Smart clothes will also contain biometrics that will be linked to demographic databases that gather information for marketing purposes (Andrejevic 113). Wearable technology functions as a mobile interface and is often designed to protect the user from information overload. Wearable technology is potentially, "a site of a struggle over power, information and control as clothes are programmed by the manufacturers (Andrejevic 114). Researchers at MIT that are presently working on the RFID tag-based Auto-ID project, "pitch it as an individualized form of real time demographic data gathering" (Andrejevic 114). Wearables being built today can incorporate sensors that gather different categories of data including "acoustic, biological, optical and environmental [data] and measure the position, force, shape displacement of a subject in space and his/her heart rate, body temperature neural activity, voice pitch and also surrounding environmental conditions such as temperature, humidity and light"(Viseu 3). The data that is collected may be relayed to the user or a computer to aid in tasks such as communication or navigation (Viseu 3). Medical applications of wearables are presently being experimented with in order to facilitate the monitoring of patients.

At what point do wearable computers stop being tools and become ‘technological companions’ extensions of the self or a ‘second skin’? Andrejevic predicts that, “clothes which have long served as a visible signifying system and an interface between public and private may be delegated the additional task of providing an interactive second skin that allows users to navigate the information rich world of the digital enclosure” (115). Andrejevic employs the term “digital enclosure” to describe the web of information being collected via these new interconnected systems of surveillance (212). A recent wearable computing project at MIT has been nicknamed “MIThril,” in reference to the elvish armor that Frodo wears in Tolkien’s Lord of the Rings trilogy and the potential protective function of ‘smart’ clothes or wearable technologies (Andrejevic 112). For many researchers and designers, wearables are intended to be ubiquitous and protect the user from the barrage of information that is facilitated by networked communication. Wearables are being developed to serve as mediators for the user who will be blissfully unaware of the conversations between various networked devices that will help them to get through the day (Andrejevic 112). Wearable technology will facilitate the creation of, “a ubiquitous computing system [that] is spread throughout the environment, thus enabling mobility; and does not require conscious grasping of its mechanism, thus endorsing seamless interaction; and is networked, thereby facilitating communication among the various actors/elements/participants”(Viseu 1). Modern communication technologies are pervasive and contribute to a sense of blurring relationships between the user and the technology. In some instances it is difficult to distinguish between the individuals involved in the interactions and the technology being used, especially when the technology is becoming increasingly more ubiquitous (Tully 445). Wearable technologies become extensions of the body, augmenting the senses, and enable the expressive usage of new communication technologies. These technologies act as an interface between public and private and facilitate new methods of surveillance.

Wearable computers augment a user’s personal space with new capabilities and appear to enable empowerment. While surveillance is generally perceived to be negative, this attitude towards surveillance is contradicted by individuals often enthusiastically participating in surveillance and the sharing of the intimate details of their lives. Koskela observes that a growing acceptance and enjoyment of self-revelation of intimate personal details, through home web-cameras or Facebook profiles is a kind of “empowered exhibitionism” that results in counter surveillance (Koskela 199). In her view this production and circulation of images and information by individuals has the effect of shifting the power dynamics of surveillance and it becomes “more radical to reveal than to hide” (Koskela 199). Surveillance as a theme is a source of entertainment and the popularity of reality television shows reflects the mass audience’s fascination with surveillance.

There are several examples of popular online and “mixed reality” games that combine game play with surveillance technologies and locative media. The fact that these games “focus on fun is evident from the fact that surveillance as a theme is seldom, if at all, addressed, discussed or problematized in the game’s descriptions and instructions (Albrechtslund, Dubbeid 219). The game, “Monopoly Live” began as a method of promoting a new version of the board game, and takes place online and in the city of London utilizing city landmarks. The popularity of the game caused the company Hasbro Games to prolong the highly successful marketing campaign (Albrecthtslund, Dubbeid 219). A new application called OntheRoad.To was recently made available for free download to the iPhone. The application allows travelers to keep in touch with friends and family while on a journey, and using GPS it tracks location, speed, as well as the distance traveled. Your loved ones can recommend sites to visit while they chart your location on a map from home. It includes a privacy feature that can control who can see the details of your trip and allows the user to share observations and photographs through links to Twitter and Facebook. (Globe and Mail, July 16). A form of travel diary that maps every step taken, this new feature expands the expressive and functional use of the mobile phone and furthers a spatial element to online sharing and interaction. The pleasure we derive from surveillance is evidenced by the popularity of games and entertainment media that use surveillance as a theme and the access to “sharing” that social networking sites allow.

Physical computing is an area of experience design that widens the scope of possibilities of interaction between the human body and technology (Noble 245). A physical computing interactive artwork creates a situation in which physical action is transformed into an abstraction through communication. Data is sent from the physical world into a digital environment and feedback is generated in response to the users actions. Art that incorporates physical computing exploits the fact that “touch delivers invasive ‘unbounded data’ whereas the eye supplies images that are contained in a frame”(Sennett 152). Interaction designers must take into account the user’s kinetic reactions to the system they are creating. An ongoing challenge for interaction designers of games and other types of interactive artworks and computer environments is devising systems that respond effectively to the user’s input (Noble 246). Interactive art creates experiences that facilitate participation by the user, and the “object” of this type of art becomes the interaction between the user and the situation the artist has created (Noble14). Video-game designer and writer Chris Crawford describes interaction in this context as “an iterative process of listening, thinking and speaking between two or more actors” (Noble 7). The connection to performance and performativity that Crawford makes is interesting because the expressive potential within these types of interactions is linked to the technology or tool becoming an extension of the person who is using it. The user’s tacit knowledge is a fundamental source of the creative experience of an interaction. The philosopher Michael Polanyi describes the concept of “focal awareness” as a sensation of extension that we feel when performing an action with a tool:

> When we bring down the hammer we do not feel that it’s handle has struck our palm but that its head has struck the nail…. I have a subsidiary awareness of the feeling in the palm of my hand, which is merged into my focal awareness of driving in the nail (Sennett 174).

This kind of tacit body knowledge is also essential to take into account when analyzing the effects of wearable computing on embodied experience. Wearable computing and games that utilize networked technologies open up possibilities for new ways of learning, because our bodies hold on to memories linked to movement and action. The user who is wearing the coat and responding to what they see and hear through manipulation of the sensors is recording information by touching the tangible media built into the coat. This is a very different experience from writing down a description of what they have seen or a sound that they heard during that time. Sennett comments on the nature of the interplay between self-conscious critique and tacit knowledge, when he states that “embedding stands for a process essential to all skills, the conversion of information and practices into tacit knowledge” (50).

The LilyPad Arduino micro-controller used in this project was developed for use with fabrics. An embedded micro-controller allows for a subtler brand of user participation, which is appropriate for a surveillance project. Another advantage of using the LilyPad is that the clothing or accessory that the LilyPad is attached to takes the shape of the users body when worn and the device becomes more connected to the user’s body. It is small in size, (about 5cm in diameter and 2mm thick) and can be easily sewn into garments. The LilyPad is washable and powered by a 3.7V rechargeable lithium battery. The LilyPad board is based on the ATmega168V and can be programmed using the Arduino Development Environment. I have used a LiPower board battery supply for the LilyPad and this is connected to a 3.7V rechargeable lithium battery.

The LilyPad was originally conceived of as being a kind of e-textile version of the Lego MindStorms kit, a simple construction kit that would be user-friendly and accessible to users that have no previous electronic experience (Buechley 1). The first LilyPad soft circuit was developed by Leah Buechley as part of a project by the Craft Technology Group based at the University of Colorado. The project’s ambition was to create an easy to use, sew-able micro-controller that would allow programming novices to fabricate their own wearables. The principal aim of the developers of the LilyPad was to stimulate creativity and encourage young people (especially young women) to engage with electronic technology and create original embedded technology designs. The developers of the LilyPad decided to use the Arduino Programming Environment because users of the LilyPad would be able to have access to a vibrant on-line open-source community (Buechley 2). The Craft Technology Group is presently researching ways to widen the scope of children’s craft education by developing craft techniques that merge simple craft and tactile activities with electronics and computer technology. The first incarnation of the LilyPad was introduced in a workshop setting with teenagers in 2006. Buechley makes a distinction between e-textile technology research and wearable technology, describing e-textiles as textiles that incorporate embedded technologies in the fabric itself while wearable technology involves attaching devices to clothes (Buechley 1).

Fashion designers and companies such as London based CuteCircuit are now producing beautiful e-textile garments. The *Galexy Dress* that was created last year by CuteCircuit incorporated 24, 000 LED lights and a scaled down version of this design was worn by singer Katy Perry at the Metropolitan Museum of Art's Met Costume Institute Gala in May 2010 (<talk2myshirt's Zine>). A new initiative entitled PLACE-IT (Platform for Large Area Conformable Electronics by InTegration, has been organized by a group of companies interested in developing an integration platform of foil, elastic and fabric optoelectronic technologies. This project may soon put illuminated fabric that can "bend light" within reach of fashion designers (<talk2myshirt's Zine>). Leah Buechley's e-textile wearable pieces combine an interest with traditional craft techniques with her research work about embedded technologies. Leah Buechley's LED bracelet is a beautiful demonstration of fusing craft and wearable technology. The LED beads are woven on a traditional beading loom. The accelerometer and array of LED lights incorporated into the design are wirelessly connected to the Internet with a Bluetooth module. These garments and accessories often incorporate innovative usage of communication medias with decorative patterned light displays and demonstrate that these media, craft and aesthetics are now intertwined.

Wearable interactive art works and games that utilize locative media and physical computing provide feedback to physical actions that cause a convergence between place and data. Robinson identifies a need for contemporary artistic responses and creative work that address new and emerging themes present in surveillance practices at this time. She states that "sensory knowledge other than, (or in addition to the visual) might offer a way to examine the impact of the surveillant gaze upon the embodied subjects caught in a society under increasing watch/fullness" (Robinson 25).

An interactive wearable artwork entitled *Urban Sonar* by Kate Hartman, Kati London and Sai Sriskandarajah addresses issues of surveillance and location. The wearable is a jacket that contains four ultrasonic sensors, two pulse sensors and a microcontroller. The micro-controller communicates through a Bluetooth connection in order to measure a kind of "personal space bubble" that is created by the sensor data and a simple graph is created that visually represents the changing data. This data is then sent via a mobile phone to the Internet (Igoe 218). The participant's response to their environment is translated into abstract data and a visual portrait is created on a computer screen. This project uses sensor data to create a visual representation of surveillance and the user/viewer might be given another way of envisioning what effects surveillance might have on physical experience.

Bio-Mapping an interactive project created in 2006 by British artist Christian Nold, is a wearable system that combines the technologies of GPS and "finger cuffs" that are used in lie-detector tests to measure the sweat-levels of the skin. The system effectively takes a reading of the wearer's emotional responses to different environments. Nold calls this process "emotional mapping" and the system he has devised allows people to connect their emotional state to the place they are in.

City Sneak is a game that was invented by Boombox Games in 2005 as a method of researching the implications of surveillance practices and pervasive computing in urban spaces (Sweeny and Patton 209). Players are equipped with GPS equipped cell-phones and warned of surveillance cameras that are positioned in a certain area of the city. The object is to move through the space without being filmed by the cameras and get to the designated finish line. If the players are "seen" their phone immediately notifies them and the game is over. There are three levels to the game mapping, sneaking and scoring. The mapping of the space is a way to learn about where cameras are located in the environment, and information is shared with the general game community. The kind of embodied learning that happens in this game serves as "a vehicle for the analysis of voyeurism and social control in public spaces"(Sweeney and Patton 213).

Since the 1970s, the artist Steve Mann has experimented with augmenting embodied experience with wearables. Mann describes three fundamental characteristics of wearable computers: constancy, augmentation and mediation (Beloff 5). Constancy refers to the fact that the computer doesn't require logging on or off (boundaries are more fluid), augmentation means that the computer or device aids the user to accomplish other tasks at the same time, or it aids the user to multi-task, and the last, mediation, is the fact that the user is enabled to control the information coming in (for privacy) and the information flowing out (also for privacy) (Beloff 5). Steve Mann and his collective The Surveillance Camera Players participate in surveillance practices that call into question the surveillance that official state and governments oversee (Andrejevic 67). Steve Mann has labeled the process of reversing the power dynamic of surveillance "sousveillance" and creates projects that have a sort of "fight fire with fire" attitude. The performance and video work created by Steve Mann, Bill Brown and The Surveillance Camera Players "is involved in recapturing the gaze and, as often as not, of resituating it in a series of prosthetic eyes-cameras, glasses and lenses that attempt to return the gaze to an empowered viewer" (Robinson 25). The projects that Mann and his group participate in comment on a concept of surveillance that has much in common with the totalitarian concept of Big Brother, Orwell's metaphor for a surveillance state that is concerned with invasive control of its citizen's activities (Lyon 32). The projects of The Surveillance Camera Players, "in their aiming of cameras at cameras, seek to draw attention to the ability of an ephemeral controlling power to see, invade, record, and make use of footage for political ends" (Robinson 25). Mann and his group are involved in a kind of empowered surveillance that asserts the individual citizen's right to engage in surveillance and "watch the watchers". Steve Mann also explores intimacy as embodied knowledge through the creation of such gadgets as the eye-tap device, which allows two people to each see what the other sees through the eye-tap when it is connected (Berzowska in Moore interview 5).

Joey Berzowska's art and research work is primarily focused on the expressive and communicative potential of e-textiles and wearables (Moore 2005). Berzowska is a professor of Design Art and Digital Image and Sound at Concordia University and a member of Hexagram, Institut de Recherché et Creation Médiatiques in Montréal. Her approach to wearables or what she terms "shware" (playful soft interfaces), differs from other incarnations of wearable technology that were pioneered by artists such as Steve Mann though the clothing and soft interfaces she creates also confront issues of surveillance in culture (Moore 2). Berzowska notes, "He (Steve Mann), talks about his wearable computing as a building built for one inhabitant, which is a very political thing and a very protective structure kind of thing"(Berzowska in Moore interview 2). In place of focusing on augmenting or extending the senses, for Berzowska, wearables represent, “expressive aspects of what we put on our bodies, …that these wearable technologies are not these exoskeletons or these buildings that protect us, but tools for communication (Berzowska in Moore interview 2). Bezowska’s work discovers new ways of interacting with communication technologies through her playful approach to experimenting with e-textiles. As Berzowsa says, “I talk a lot about the outfits I make as intimate and playful technologies, which is something Anne Galloway talks a lot about when discussing mobile technologies, ways of creating space for intimacy and playfulness” (Berzowska interview 3).

Finger Dress is a wearable Berzowska created that displays what she terms “intimacy events”, a visual impression of where the dress has been touched. This project reveals what has been invisible before. She describes the impact of the visual traces on the garment that occurs during interactions with the *Finger Dress*:

When you have a cell phone and you’re told that every call can be tracked and is stored in a database and maybe someone can have access to it, you don’t see it visually so you’re like, whatever who cares, when you see a skirt that changes colour in the places where it has been groped, suddenly it takes a whole different meaning (Berzowska interview 5).

Berzowska utilizes tangible media to express ambivalence about the invasive effects of surveillance and loss of privacy.

The wearable artwork *SoundSleeves* by Joanna Berzowska and Vincent Leclerc utilizes multiple digital inputs. The sleeves are covered with strips of conductive metallic organza that act as individual switches. When these strips are combined they create a large flex-sensor that makes sounds when the wearer moves in different ways. When the wearer’s arms are crossed for example, the pitch of sounds is set at a higher frequency communicating an atmosphere of anxiety and stress. The sleeves of the garment function as a non-verbal communication device that is influenced by the movement of the person wearing the piece.

These artworks all explore interactions that include sensory responses to surveillance and many use e-textile and wearable technologies in order to facilitate interactive experiences for the user. The more recent projects explore concepts of new technologies of surveillance as having something “in common with the lawn weed creeping Charlie with its star-shaped roots or the Google web search engine” (Lyon 4). The projects address changing dynamics of surveillance practices and allow for investigations into the sensory effects of surveillance.

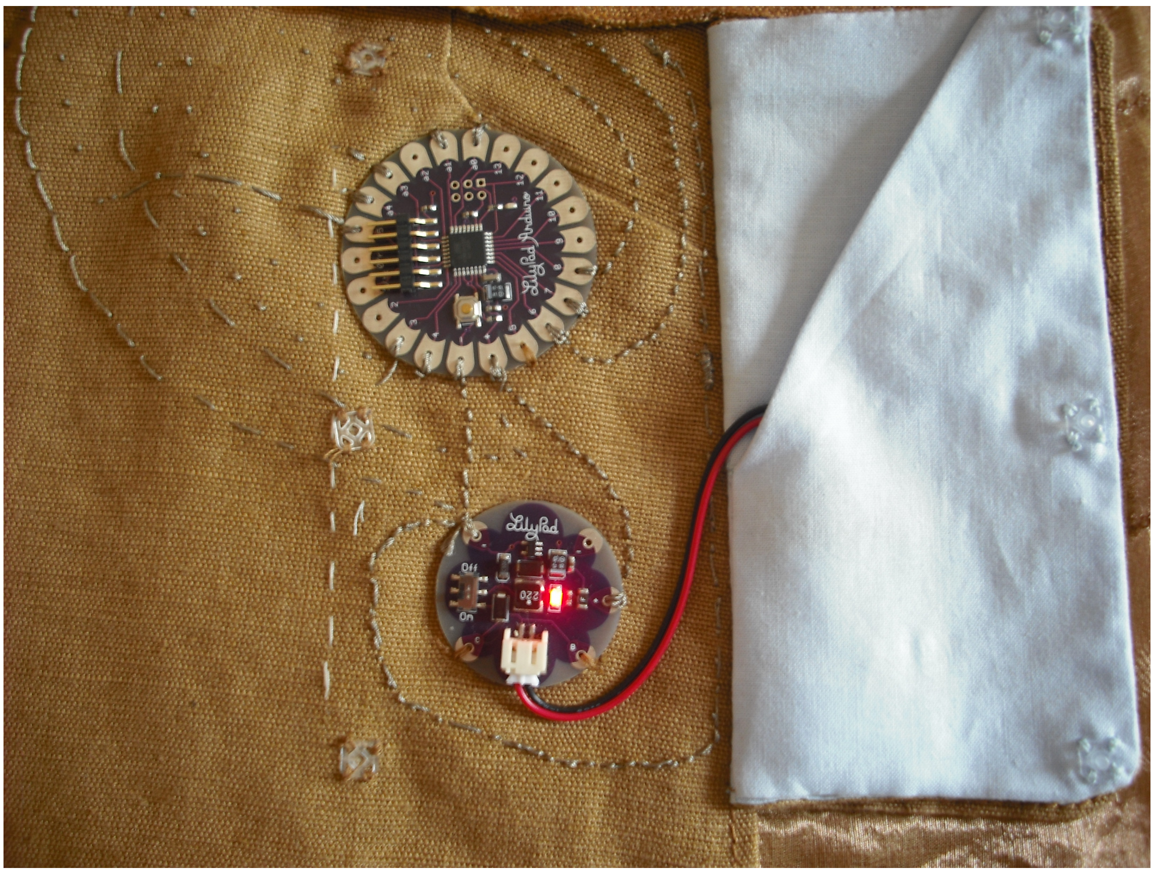

Figure 1. The LilyPad micro-controller sewn into the coat: I used a LiPower attachment that is connected to the – and + pins of the LilyPad and the 3.7 V rechargeable battery is tucked away in the blue pocket. The LiPower has an off and on switch which is useful and saves wearing out the battery. I used clear plastic snaps (no danger of plastic causing a short in the circuit) and the pocket snaps in place and protects the LilyPad and its power supply.

CONSTRUCTION AND INTERACTION DESIGN:

The person wearing the *SoftShare* device is encouraged to watch for signs of surveillance, clues that the area is monitored or the presence of security cameras. If they discover the presence of surveillance systems in the environment they can register this by rubbing an embroidered sensor. There are two embroidered sensors in the coat and these are sewn onto the top pockets. A set of instructions for the user is outlined in Appendix B of this document. The sensor on the right top pocket forms the word WATCH.

Figure 2. The soft circuit of the embroidered sensor is connected with conductive thread. In this photograph each letter of the word WATCH is connected to form the connections to an area that is designated the "power" part of the sensor. I used a small patch of neoprene to insulate the circuit path so that the ground circuit path could be sewn underneath it.

The WATCH sensor is made of conductive yarn and the embroidered motif that forms the soft sensor was machine embroidered on the pocket. Figure 2 (above) documents a part of the process of making this sensor. To start recording data (to note that surveillance has been observed) the user touches a conductive pom-pom that is attached to the coat. I made the pom-pom from a mix of conductive yarn and wool (Figure 4). The conductive yarn is wrapped with steel and this allows the thread to conduct electricity. The conductive thread was purchased from Statex Productions and is very fine. I used the wool yarn to create a bulkier pom-pom. I was able to model the embroidered sensor and pom-pom on descriptions of these sensors that I discovered on a DIY website How to Get What You (http://www.kobakant.at/DIY/?page_id=318). The content of this website is provided by Mika Satomi and Hannah Perner-Wilson. At the time of writing, Wilson is a graduate student at the MIT Media Lab's High-Low Tech research group.

When the pom-pom is rubbed on the word WATCH the conductive thread acts as an electrical "wiper" between the embroidered word and the border around it (also sewn with conductive thread). This type of sensor functions as an unpredictable variable resistor. The schematic of the circuit is included in Appendix C of this document. When pressure is applied to the pom-pom (it is pressed down or flattened on the embroidered circuit) the LilyPad micro-controller records a higher voltage reading than if the pom-pom is touched lightly to the surface of the embroidery. When the sensor's data is graphed with a Processing program a visual representation of these changes in pressure is displayed (see Figure 3).

The other embroidered sensor that I incorporated into the coat forms the word LISTEN and this sensor is used for registering reactions to sounds that are heard while on the walk. This sensor is constructed in exactly the same manner as the WATCH sensor. If the user hears a sound that is beautiful, music or birdsong then they can "record" this experience by responding in a tactile way. Sounds that the user encounters in the environment are an element that evades visual surveillance. Sound is often absent in visual footage of camera surveillance. If sound is included, what is heard in the videotaped recording often happens outside of the frame of the camera and is disconnected from the source. In video or film surveillance technology "there is a discontinuity between sound and representation. The soundtrack to the surveillance camera is usually disconnected from the images; audio surveillance becomes coded word and the words are not attached to actions" (McGrath 49). A disconnect between the sound and the images allows for the possibility of new interpretations of the recorded sounds.

Figure 3.   A graphed representation of the embroidered sensor values.

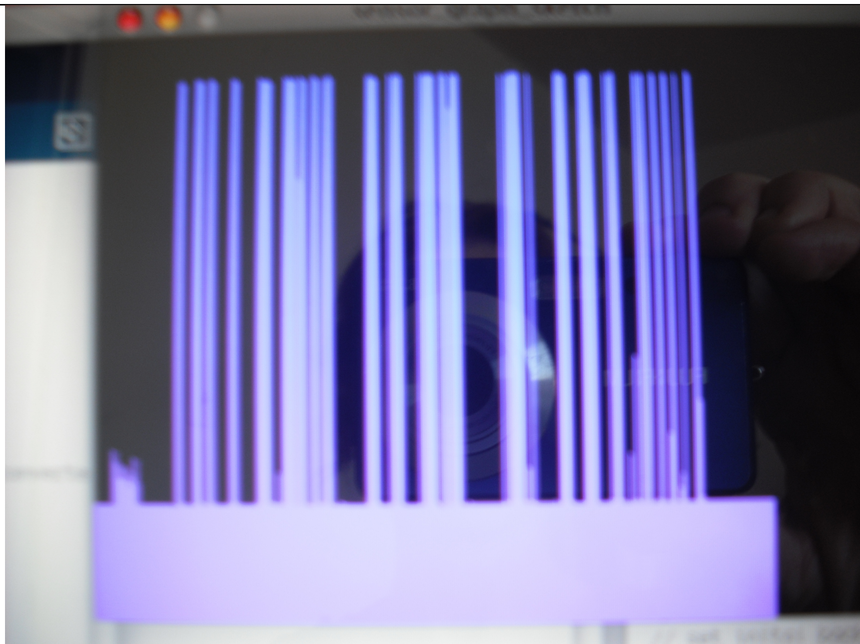

Figure 4. One of the conductive pom-poms I made. The thin silver thread is conductive.

Janet Cardiff is a sound installation artist whose work addresses themes of surveillance. She describes her audio- performance art works entitled *Sound Walks* and elaborates on the disconnect that often happens as a by-product of mediated experience:

> I think many people long for a more synesthetic relationship to the world… I do think that unconsciously the walking pieces are a strange attempt to join our separate worlds through a mediated one, to create a symbiotic relationship between the participant and my voice and body, but also to heighten the senses so that you can experience or be part of the environment in which you're walking (Cardiff qtd. Robinson 37)

The user of *Soft Share* is instructed to respond to sounds and while the sensors are manipulated the locational data from the GPS is combined with the set of readings that are taken from the users physical actions. The sensors, with the exception of the temperature sensor, are fabricated from conductive fibers and fabric. The only "hard" components are resistors, the LilyPad micro-controller, the GPS and the separate battery sources. The GPS is connected to a perf board that I cut to size and soldered the RX and TX connections to, as well as the power and ground connections to the battery pack. The RX and TX of the GPS are connected to digital pins of the LilyPad configured to act as a software serial interface (Figure 4 and Figure 5 document the GPS installed in the coat). I experimented with making the sensors solely from the conductive fabric, threads and yarns and zippers. The connections between the sensors and parts of this circuit are hand-embroidered and sewn with conductive thread. I have used traditional methods of embroidery and hand-stitching techniques to connect the circuit paths. Figure 7 shows the recording of data to the EEPROM memory using the conductive pom-pom on the sensor. The Arduino code that is used for this project is included in Appendix A of this document.

Figure 5. The EM-406-The perf board is sewn onto the coat and the snaps fold things away in the pocket.

Figure 6. The battery pack with the 4 AAA batteries is in the blue pocket and has an on/off switch.

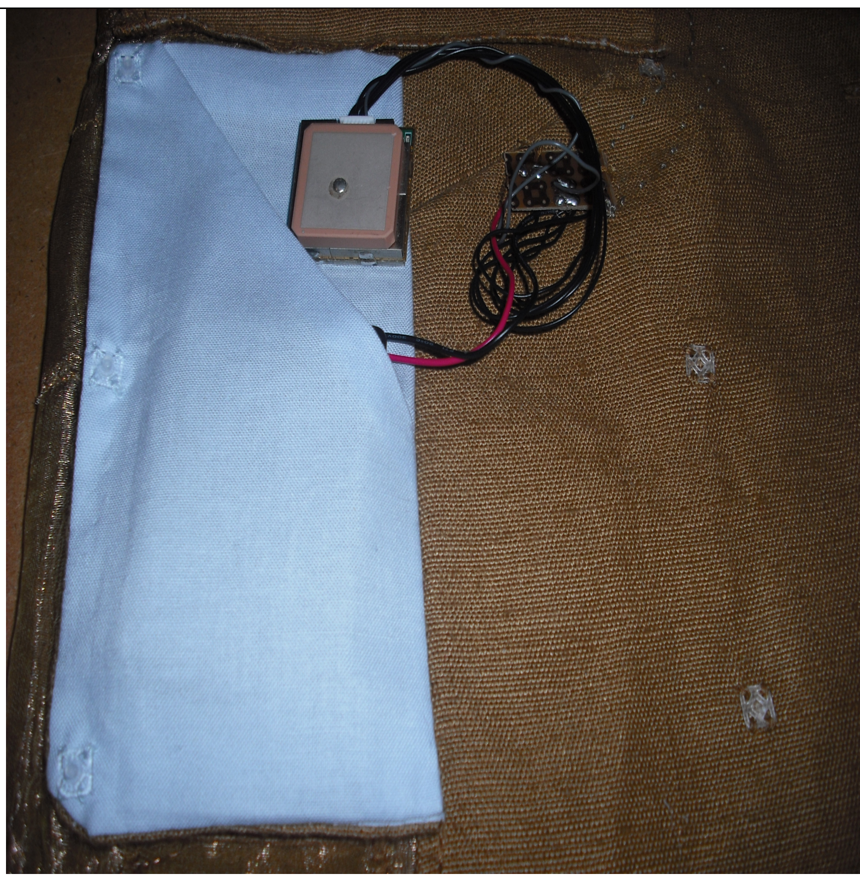

Figure 7. Experimenting with the sensor and recording sensor reading to EEPROM.

Figure 8. The embroidered sensor and a section of the sleeve sensor.

The side pattern pieces of the coat are made of sheer silk organza. The sides are transparent and the front and back of the coat are made of linen. Linen was chosen because it is a textile that is appropriate for embroidery work and is a natural fiber (this is not a trench coat that you would want to wear on a wet day). The sides of the coat are sheer and this element of the design is reflective of the fact that boundaries of self-disclosure are an aspect of this work. These sections of the coat are constructed of a metallic silk organza and are conductive. The fabric is woven from natural silk and very hair-fine copper wire. I experimented with the silk organza and modeled the sleeve sensors on a zipper sensor that I had experimented with in an independent study course in Physical Computing. The strips of silk organza on the under sleeves are divided by strips of linen and three 220 Ohm resistors on each sleeve divide the connections between the positive voltage source and ground. A stitched connection for each sleeve sensor in sewn from the side panels of the coat and is connected to an analog pin on the micro-controller.

Instead of the zipper slider or fastener creating the connection between the positive voltage source and ground, the circuit is completed when the conductive fabrics brush against each other. The temperature sensor is sewn to the back of the collar so it will be in contact with the skin of the users neck. This sensor will gather a reading of the user's body temperature. The sensor is connected to the positive voltage source and ground and an analog pin on the LilyPad micro-controller. Figure 1 shows the LilyPad and LiPower supply sewn into the coat.

I established where all the connections were going to be sewn into the garment and sewed the circuit with conductive thread. After I had sewn the circuit, I used a puffy acrylic fabric paint to insulate the circuit threads. This paint prevents short circuits, which could easily happen if the positive voltage supply and ground lines were to brush up against each other. The photographs below show this process (Figures 9 and 10).

Figure 9. Starting to cover the soft circuit with the fabric paint.

Figure 10. The inside of one side of the coat with the gold puffy fabric paint covering the circuit paths.

The data that is being collected is recorded and stored in the EEPROM memory of the LilyPad micro-controller. EEPROM memory, or Electrically Erasable Programmable Read-Only Memory is a type of memory that is used in computers and other electronic devices to keep small amounts of data that need to be saved when the power is removed (Noble 575). This type of memory is useful for writing values to and recovering them later. I chose to use the EPPROM memory to store the recorded sensor values (as opposed to wireless alternatives such as Bluetooth or X-bee radio) because it allows the wearer of *SoftShare* to go to places that might not be accessible to a wireless network. The EEPROM memory is restricted to 512 bytes and this can be stored when the power is turned off. After the walk, the information can be uploaded to a computer and displayed on the serial monitor of the Arduino programming environment. A portion of this information is contributed voluntarily because the participant makes decisions and judges and rates the experience. The data from the GPS, temperature sensor and sleeve sensors are recorded when the embroidered sensors are touched and all of the data is captured together in the EEPROM memory. While the user is recording the data to the EEPROM by touching the embroidery with the pom-pom the LED (light-emitting diode) that is above the left bottom pocket blinks. When the user stops recording the light goes off. When all of the EEPROM memory has been used, the LED above the pocket is turned on to let the user know that no more data can be recorded until the program is uploaded to a computer. There is the option of erasing the memory and starting over while out in the street. If the user wishes to clear the memory and erase the previous data collected, then they can simply push the small button on the coat that is located beside the LED. The button must be pushed for 5 seconds. When the memory is cleared then the green light (digital pin 13) on the LilyPad micro-controller turns on, there is a five second delay and then the user is able to record data again. When the user returns home and wishes to display the data on the serial monitor, the micro-controller is attached to a USB cord and the button is pushed once to change to playback mode (Figure 11 below).

Figure 11. The button, (on the right) and the LED light.

Wearables and e-textile technologies augment and influence our senses and enable a constant connectivity to new technologies for communication. These technologies allow for new methods of surveillance practices that are able to collect information about people's physical location and activities. There is enthusiastic participation in self-revelation, the sharing and recording details of our daily lives through these media and as new social spaces are created, there is an element of surveillance within these new places. *SoftShare* utilizes locative media and physical computing and the user provides feedback in the form of data related to physical actions that cause a convergence between place and data. When the sensors are recording data, the GPS string is parsed by the Arduino code to note the course and speed during this time. The collection of this information adds an element to the interaction that allows for an exploration into the possible implications on embodied experience of networked media and surveillance technologies that are linked to location. The GPS that is built in the trench coat records the place in which the user's responses take place linking the material and actual place to something that is abstract, a representation or interpretation- an abstract system of numbers and mapped co-ordinates.

Inhabiting for a time what is essentially an electronic device allows the user to participate in monitoring a space within which, because of the pervasiveness of surveillance in urban spaces, they are also being monitored. The person who participates in the work is given agency to participate in surveillance and link that surveillance with data that details information about their actions. The user, who is instructed to watch for surveillance and listen with heightened awareness, is enabled to share this experience through data that is created by touch and manipulation of conductive textiles. This project draws the user's attention to surveillance spaces that are a product of surveillance practices in culture and happen within "spaces of performed interactive communication" (Wilkins 102). The interaction in the design allows the user to be an agent of surveillance by enabling tactile reactions to be recorded.

SoftShare enables the user to manipulate sensors that are soft and tactile, and this alters the experience of using electronic devices. These tactile interfaces serve to lesson disconnect between the digital and physical worlds by emphasizing other senses besides sight.

There are many potential avenues for investigating new ways to communicate through the use of soft wearable circuits. A future wearable or e-textile project could involve various possibilities for display and expression, such as a shirt that enables the user to connect to a Facebook account and can give the user a chance to signal his or her popularity to others with a dynamic display of lights that are sewn to the garment.

SoftShare allows the user to play a game with surveillance and allows for an opportunity to interpret and respond to their particular unique experience through touch: but at the same time the user cannot contribute their responses without including information that they cannot easily control. In the end it is their choice to save the data to EEPROM and have a record of their walk and what they have discovered on the way, but they are not able to have this agency without contributing other information, the data that is collected about where they are and details about their physicality. It is this aspect of the project that addresses an attitude of ambivalence surrounding surveillance practices at this time. It is necessary to participate and communicate, but when we do this we are creating a trail of data that exists somewhere in digital form. The data files that contain information about us are “alternate representations that circulate like extra bodies with their own lives and histories” (McGrath 159). The use of new communication technologies impacts embodied experience and perceptions of social spaces because within these new spaces for communication there is always an element of surveillance.

Bibliography

1. Albrechtslund, A. and Dubbeld, L. (2005). “The Plays and Arts of Surveillance: Studying Surveillance as Entertainment.” Surveillance in Society, 3(2/3):216-221.

2. Andrejevic, M. (2007). iSpy: Surveillance and Power in the Interactive Era. Lawrence, Kansas: University Press of Kansas.

3. Arduino Home Page<http://www.arduino.cc/ >last accessed August 18, 2010.

4. Beloff, L., (2006). Overview on Wearables <www.realitydisfunction.org/papers/basic**Overview**_07.pdf>last accessed August 29, 2010.

5. Buechley, L.(2006). A Construction Kit for Electronic Textiles <web.media.mit.edu/~leah/publications/**buechley**_ISWC_06.pdf>last accessed August 29, 2010.

6. Castells, M., Fernandez-Ardevol, M., Qiu, J. and Sey, A. (2007). Mobile Communciation and Society: A Global Perspective. New Haven, United States: MIT Press.

7. Conrad, K. (2009). “Surveillance, Gender, and the Virtual Body in the Information Age.” Surveillance in Society, 6(4): 380-387.

8. Curry, M. and Phillips, D. (2003). “Privacy and the Phenetic Urge.” Surveillance as Social Sorting: Privacy, Risk and Digital Discrimination. Ed. David Lyon. New York: Routledge. 137-152.

9. Eric<talk2myShirt.Zine> Last accessed August 26, 2010.

10. Fernadez, L. and Huey, L. (2009). "Editorial: Is Resistance Futile? Thoughts on Resisting Surveillance". Surveillance in Society. 6(3): 198-202.

11. Igoe, Tom. (2007). Making Things Talk. Sebastopol CA: Make Books.

12. Lyon, D. (2007). Surveillance Studies: An Overview. Cambridge, UK: Polity Press.

13. Lyon, D. (2002). "Editorial. Surveillance Studies: Understanding Visibility, Mobility and The Phonetic Fix". Surveillance and Society, 1(1): 1-7.

14. Koskela, H. (2004). "Webcams, TV Shows and Mobile Phones: Empowering Exbitionism." Surveillance and Society. 2(2/3): 199-215.

15. McGrath, J.E. (2004). Loving Big Brother: performance, privacy and surveillance space. London, New York: Routledge.

16. Moore, J. In the Shadow of the Cyborg: Interview with Joey Berzowska <http://dpi.studioxx.org/index.php?id=49 >last accessed August 18, 2010.

17. Noble, J. (2009). Programming Interactivity: A Designer's Guide to Processing, Arduino, and OpenFrameworks. Sebastopol CA: O'Reilly Media Inc.

18. Perner-Wilson H. and Satomi M. How to Get What You Want< http://www.kobakant.at/DIY/?page_id=318 >last accessed August 18, 2010.

19. Robertson, K. (2008) "Try to Walk with the Sound of My Footsteps": The Surveillant Body in Contemporary Art". The Communication Review, 11: 24-41.

20. Sennett, R. (2008). The Craftsman. London and New Haven: Yale University Press.

21. Sweeny, R. W. and Patton, R. M (2009). "Play, Pedagogy, and Surveillance." Digital Cityscapes: merging digital and urban play spaces. Ed. de Souza e Silva, A. and Sutko D.M. NewYork: 204-216.

22. Van der Ploeg, I. (2003). "Biometrics and the body as Information: Normative issues of the sociotechnical coding of the body." Surveillance as Social Sorting: Privacy, Risk and Digital Discrimination. Ed. David Lyon. New York: Routledge. 57-73.

23. Viseu, A. Social Dimensions of Wearable Computers: An Overview <www.yorku.ca/a**viseu**/pdf%20files/socwear.pdf >last accessed August 29, 2010.

24. Wasik, B. My Crowd, Or Phase 5 <http://www.harpers.org/archive/2006/03/00809631>last accessed August 18, 2010

25. Wilkins, Craig (2007). The Aesthetics of Equity:Notes on Race, Space, Architecture and Music. Minneapolis, United States: University of Minnesota Press.

APPENDIX A: ARDUINO CODE

```
#include <EEPROM.h
#include <NewSoftSerial.h>
#include<WString.h>
String silly1(64);
String silly2(64);
String silly3(64);
String silly4(64);
String silly5(64);
String silly6(64);
String spd(64);
String c1(64);                          // these strings have a maximum length of 64 bytes/chars
NewSoftSerial GPS = NewSoftSerial(4,3);
#define TEMPSENSOR 5                    //temp sensor
#define SLEEVE1 0                       //silk sleeve 1
#define SLEEVE2 4                       //silk sleeve 2
#define POCKET1 1                       //embroidery on pocket 1
#define POCKET2 3                       //embroidery on pocket 2
#define BUTTON  8                       // button
#define LED1 6
#define LED2 13
 index = 0;
int sensval[]={0,1,2,3,4};
byte value = 0;
int state = 0;
void setup(){
  GPS.begin(4800);
  Serial.begin(4800);
  pinMode(6, OUTPUT);
  pinMode(13,OUTPUT);
  pinMode(8,INPUT);
}
  void waitForGPRMC(void) {
     String s(1024);
     s.clear();
     while(! s.contains("$GPRMC,")) {
     if(GPS.available()) {
       char c = GPS.read();
       s.append(c);
         }
     }
 }
// this function collects characters from the (hardware) serial port
void collect(String& s) {
  char c = 0;
  s.clear();
  while ( c != ',' ) {
   if(GPS.available()) {
      c = GPS.read();
      if( c != ',') s.append(c);
    }
  }
}
//function to parse the gps.
void parse(void) {
  waitForGPRMC();
  collect(silly1);
  collect(silly2);
```

```
  collect(silly3);
  collect(silly4);
  collect(silly5);
  collect(silly6);
  collect(spd);
  collect(c1);
}
//function to write sensor reading to the EEPROM.
void writetoEEPROM(void) {
   char* c;
   if(index < 507 ){
   for(int x=0; x<5; x++)EEPROM.write(index+x,sensval[x]);
   c = spd.getChars();
   for(int x=0;x<4;x++)EEPROM.write(index+x+5,c[x]);    // write 5 positions in to current EEPROM record
   c = c1.getChars();
   for(int x=0;x<4;x++)EEPROM.write(index+x+9,c[x]);    // write 9 positions in to current EEPROM record
   index += 13;
 }
}
// read the sensors in the array
void readSensors(void) {
  sensval[0] = analogRead(5)/4;
  sensval[1] = analogRead(0)/4;
  sensval[2] = analogRead(4)/4;
  sensval[3] = analogRead(1)/4;
  sensval[4] = analogRead(3)/4;
}
//this function determines what happens when the data is being recorded.
//the EEPROM should record all sensor readings from temp and sleeves etc. + gps if the embroidered
potentiometers are touched with the pom-pom.
void walkmode(void) {
   if (analogRead(1)>30 || analogRead(4)>30) {
     digitalWrite(6, HIGH);                        //blink LED when writing to EEPROM.
     delay(100);
     digitalWrite(6,LOW);
     readSensors();
     parse();
     writetoEEPROM();
     if (index == 507){
        digitalWrite(6, HIGH);                      //if the EEPROM is full then keep LED1 on.
     }
   }
 }
//read the sensor and gps data and print the results in the serial monitor.
 void homemode(void) {
      for (byte x = 0; x<5; x++) {
      Serial.print(" ");
      Serial.print(EEPROM.read(index+x),DEC);
      delay(500);
      Serial.print("");
}
   Serial.print(" ");
      for (byte x=0; x<4; x++) Serial.print(EEPROM.read(index+x+5),BYTE);
      Serial.print("/");
      delay(500);
      for (byte x=0; x<4; x++) Serial.print(EEPROM.read(index+x+9),BYTE);
       Serial.print(" ");
       Serial.println(" ");
       delay(500);
       index += 13;
       if(index == 507) index=0;             //clear the data from the EEPROM.
 }
```

```
 void clearEEPROM(void) {
   for (int i = 0; i < 507; i++)
       EEPROM.write(i, 0);
}
//function that determines how long the button is pressed.
int buttonLong(void){
  int x = 0;
  while(digitalRead(BUTTON)) {
  x++;
  delay(50);
}
if (x>200) return true ;
   else return false;
}
//changes the state depending on whether the button is presses and for how long.
void determineState (void) {
  if (digitalRead(8)==HIGH) {                          // if switch pressed, state will change
  if(buttonLong()==true) state=2;                      // if the button is pressed long, change to state 2
     else {
      index = 0;                                       // otherwise, toggle between state 0 and 1
   if(state==0)state=1;
     else if(state==1)state=0;
   }
  }
}
//this function calls other functions, walkmode, homemode and clearEEPROM depending on the state.
void expressState(void) {
  if (state==0)walkmode();
  if (state==1)homemode();
     index = 0;
  if (state==2) {
     digitalWrite(13,HIGH);
     clearEEPROM();
     state = 0;
     delay(5000);
     digitalWrite(13,LOW);
  }
}
void loop () {
  determineState();
  expressState();
}
```

APPENDIX B: INSTRUCTIONS FOR THE USER OF SoftShare

Put on the coat and take a walk.

Pay attention to your surroundings and watch for signs that you are being watched.

If you are aware of surveillance then rub the WATCH sensor.

If you hear something that makes you happy then rub the LISTEN sensor.

When you get home look at the information you collected and wonder what to do with it.

APPENDIX C: SCHEMATIC OF ELECTRICAL CIRCUIT