Piezing

A Garment Harvesting Energy from the Natural Motion of the Human Body

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ABSTRACT
Piezing is a garment which harnesses energy from the natural gestures of the human body in motion. Around the joints of the elbows and hips, the garment is embedded with piezoelectric material elements which generate an electric potential in response to applied mechanical stress. The electric potential is then stored as voltage in a centralized small battery and later can be discharged into a device. As a concept, Piezing explores a decentralized and self-reliant energy model for embedded interaction, pushing forward possibilities for mobility.

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Embedded Interface, Gestural Interface, Wearable, Fashion

ACM Classification Keywords:
J.9.e Wearable computers and body area networks

INTRODUCTION
In the increasingly mobile nature of contemporary life, the devices we carry and the garments we wear are converging into a 'secondary skin' which functions as an extension of ourselves, in both ability and perception. Mobility engenders a form of self-reliance, and yet our societal constructs of energy generation and supply remain centralized and tied 'to the grid.' Several new interface devices, such as the Sony Odo system [4] are exploring sustainability ideas with a new type of interaction engagement powered by kinetic energy, using your body to generate energy as you play with them. Piezing looks to further explore how the human body can itself be considered a generator of energy, when objects and methods are designed to convert the mechanical movement of the body to electrical energy. Piezing offers a wearable garment which can be used to power external devices, acting as a self-reliant and decentralized source of energy for mobile interactions.

Figure 1. Piezing shown at the Seamless: Computational Couture Runway Show at the Boston Museum of Science, 2008

SYSTEM DESIGN
The design process for Piezing began with an investigation of various ways in which the body can generate energy through mechanical motion. We were intrigued by thinking of the body as mechanically deconstructed into joint segments, creating what Oskar Schlemmer of the Bauhaus coined a 'technical organism' [fig. 1] [1]. Schlemmer's diagrams revealed how a seemingly simple and constrained set of mechanisms, our joints, can yield complex and diverse motion capabilities in three dimensional space. This led us to capitalize on the varied motion of the joints- in this version of Piezing we have focused on the motion of the hips and elbows, however the garment could be extended to capitalize of movements of the knees, shoulders, or waist, for example.

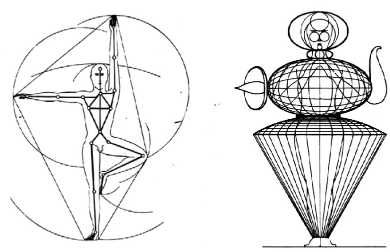

Figure 2. Oskar Schlemmer, The laws of motion of the human body in space with the various aspects of rotation, direction, and intersection of space resulting in a technical organism.

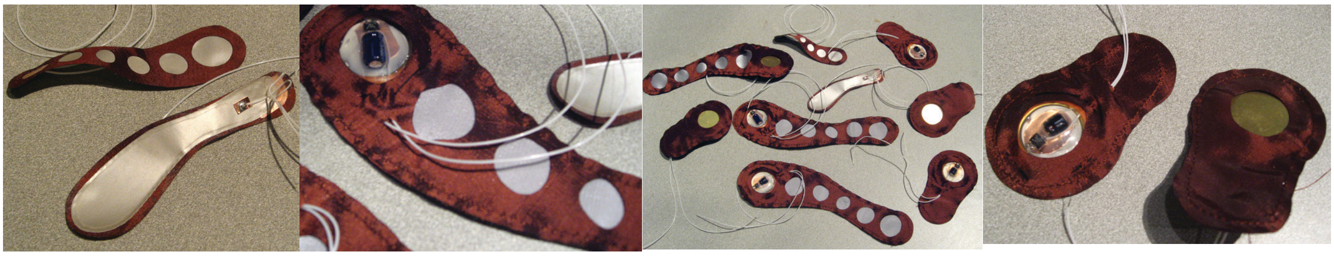

Figure 3. a) front and back of piezo film embedded in fabric b)piezo disc, film and circuitry combined into a single element c) piezo elements (film and discs) prepared and ready to be sewn into the garment d) front and back of gold piezo disc and circuitry

New technological advances have produced piezoelectric materials which are lightweight and flexible, appropriate for wearable applications [5,6]. Piezing uses an innovative combination of piezo discs and piezo film. The discs are more rigid in nature and featured directly over the joints to maximize mechanical strain, while the piezo film is soft and malleable and is applied in strips surrounding the joint. [fig. 5]. The discs and film are are wired internally to charge a small battery which is housed at the waist of the garment, over the belly button. Although the amount of power generated by each element is low, between 1-5 mv per cycle, the natural continued movement of a wearer allows for the accumulation of power with a trickle flow of current.

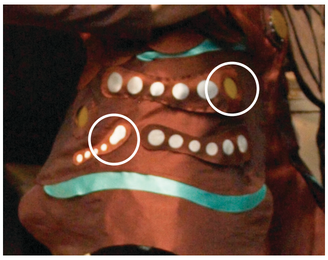

Figure 5. left circle - piezo film applied to garment along the lines of non-extension, right circle - piezo disc on hip bone to maximize mechanical strain

It is important for the piezo film to conform to the contours of the body in order to maximize bend of the material as the body moves, mazimizing energy produced. However, piezoelectric film, while soft and malleable, is not elastic in nature and cannot be mounted to areas of the body which require stretch for movement, creating a seeming contradiction in usage. Inspiration to this challenge comes from research being conducted in the Man Vehicle Lab at MIT on the BioSuit [3] a new more flexible spacesuit employing Iberall's concept of 'lines of non-extension', [2] [fig. 4] the lines along the human body which do not stretch eve when the body is moving. These lines can be followed to create a "skeleton" of strong, non-elastic material that does not inhibit movement. Patterning our piezo film along the lines of non-extension allows for maximum movement of the piezo elements without interferring or restricting the movement of the wearer.

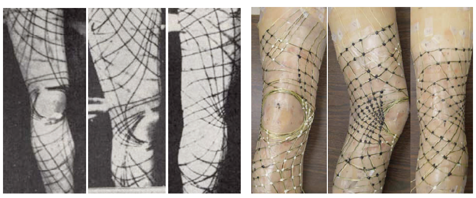

Figure 4. a) Iberall's depiction of the lines of non-extension, drawn on a mannquin b) re-creation of Iberall's lines on a full scale model with kevlar joints by MIT MVL

The patterning of Piezing was done by creating lasercut fabric segments draped directly onto a dress form. The use of a fabric blend of natural and synthetic fibers allowed the edges of the fabric pieces to seal with the lasercutting, avoiding the need for hemming the garment. The lasercut segments creating the bodice mimic the flow of the curves created with the attached piezomaterials, to create a unified aesthetic of fluid motion.

FUTURE WORK AND CONCLUSION

Piezing is currently a prototype, we are making plans for the next version to increase the overall efficiency of the energy production with greater density of piezofilm elements, new thinner lighter piezo fibers which can be sewn directly in the garment and a more thorough analysis and application of where and how to capture maximal movements of the human body. We are also envisioning a variety of aesthetics and applications, such as single joint 'sleeve' or an outfit intended to be worn specifically during exercise. We believe the ideas which Piezing elicits speaks to a larger developing idea around self-reliance, applying advances in materials combined with a more thorough understanding of the natural mappings of our bodies and bodily interactions can produce new possibilities for embedded interaction and mobility.

ACKNOWLEDGEMENTS

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