Between Garment and Prosthesis: The Design of an E-Textile Musical Interface

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Abstract

This paper presents *Noisy Flesh*, an e-textile musical interface designed to control sound through body movement in performance. Unlike traditional wearable interfaces that function as garments, this work reimagines the textile interface as a prosthetic extension that augments the performer's body. The paper discusses both the design of the interface and its sonification method, emphasising how the flexibility of e-textiles can transform bodily movement and shape interactive experiences. This work explores the potential of e-textile interfaces to challenge conventional notions of wearability and embodiment in performance.

Keywords

E-textile, Body Instrument, Wearable Interface, Musical Prosthesis

1 Introduction

E-textiles, as flexible materials, have expanded the possibilities for interaction in musical interface design, especially in wearable forms [11, 16]. Traditional designs often prioritize comfort and efficiency by integrating e-textiles into garments. In contrast, this research proposes a new approach: treating e-textiles as prosthetic interfaces that reshape the performer's body and movement. Here, interaction becomes an active negotiation rather than passive control.

Inspired by feminist textile artworks such as Lee Bul's wearable sculpture and Senga Nenegudi's performative installation [8, 12], this research explores how e-textile interfaces can represent, deform, and redefine the body alongside augmented auditory perception. The interface employs knitted stretch sensors resembling redundant body parts to encouraging the performer to explore movement as a means of sound manipulation. Movement data is sonified through audification and parameter mapping, allowing the performer to create an auditory presence that extends self-perception. Rather than offering intuitive control, the prosthetic interface promotes a process of negotiation, through which performers gradually redefine their bodily expression.

Challenging conventional notions of movement and embodiment, the e-textile prosthetic interface aligns with the concept of entangled NIME by treating the interface as an active agent in the performer's interaction.. The performing body, prosthesis interface, and the generated sound continuously inform and reshape one another, enabling embodied expression and exploration within this entangled system.

Figure 1: Extract from performance with the interface. Photography by Winston Yeung.

2 Background and Related Works

E-textiles are textiles modified to support sensing, communication, and power transmission [1]. With growing interest in novel interface design, they have been increasingly adopted for musical interaction and expression. Their flexibility makes them especially suitable for wearable computing, offering advantages over conventional materials like metal and plastic.

In musical interaction, the e-textile interface has been explored across various applications. E-embroidery interfaces were integrated as textile capacitive sensors into a jacket to function as a musical keypad [14]. FabricKeyboard [17] reimagined keyboard interaction using textile sensors, enabling diverse input gestures such as pressing, touching, sliding, hovering, and stretching. In wearable interface design, e-textiles offer a more flexible and adaptable interaction experience [16]. Stretch sensors are commonly employed in wearable applications [4]. Knit stretch sensors are often positioned around joints to capture a broad range of movement data, particularly in dance-music interaction [11, 15]. When integrated into performance garments, they support embodied interaction by dynamically responding to bodily motion.

However, compared to textiles in feminist art, the expressive potential of e-textiles for investigating themes related to gender or body in musical interfaces remains underexplored. For example, Lee Bul's wearable sculptures distort bodily proportions with grotesque, exaggerated limbs that extend into the surrounding space, demonstrating how textiles can transform the body[8] Similarly, in *R.S.V.P* Activations, Nengudi explores bodily elasticity through the tension between performer and textile, using skin-like fabric stretched to extremes to provoke both fragility and resilience [12]. These works establish a dynamic relationship in which textile and body mutually influence movement, producing a delicate but balanced tension. While such representations of bodily transformation and deformation have been noteworthy

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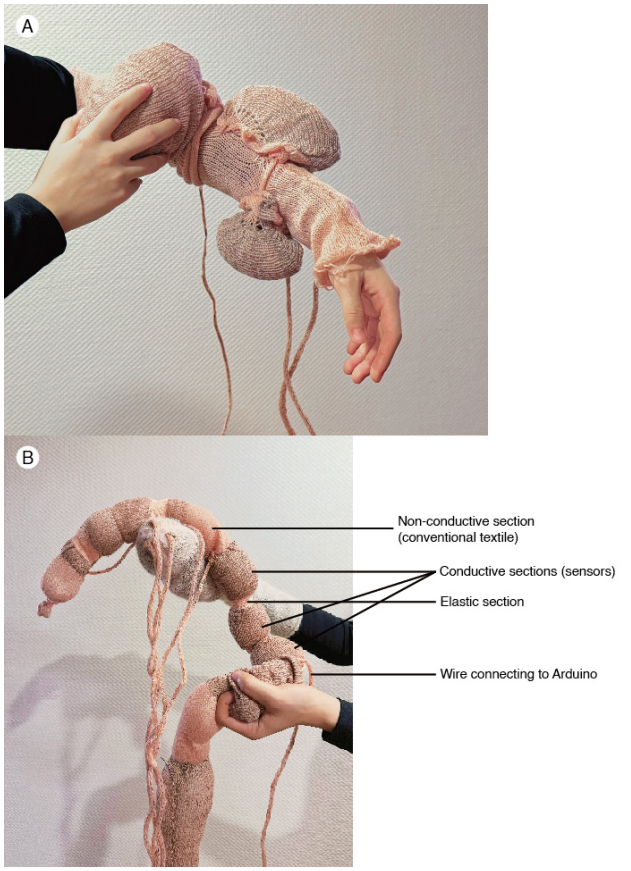

Figure 2: Individual sensors: A) tumour sensors; B) Intestinal sensors with separated conductive sections.

in textile-based art, the potential remains largely untapped in e-textile musical interfaces, which could further engage with sound as an interactive medium. Although there are projects exploring e-textile wearable instruments that have seen the potential of creating a bodily metaphor in interaction and appearance, the textile remains more decorative than interactive and has less impact on the sound output as well as the projects leaving feminist themes not fully explored [10].

This research distinguishes between e-textiles as garments and as prostheses to propose an alternative approach to movement-based musical interfaces. As garments, e-textiles serve as extensions of the body, prioritizing comfort and seamless integration with performance garments. The primary design goal is to minimize interference with movement by keeping fabric sensors flat and elastic, allowing them to conform to the body like a "second skin" [3, 11].

By contrast, the prosthetic interface is designed to actively reshape the body, encouraging the performer to negotiate control and explore exaggerated or unconventional movements. The *Visor, Ribs, and Spine* of the Prosthetic Instruments series[5] exemplify how prosthetic interfaces can impose movement constraints while simultaneously enabling new forms of interaction through sonic feedback. Drawing on the influence of feminist textile art, the e-textile prosthetic musical interface builds on this concept by integrating sound as an active feedback mechanism within a multisensory performance environment.

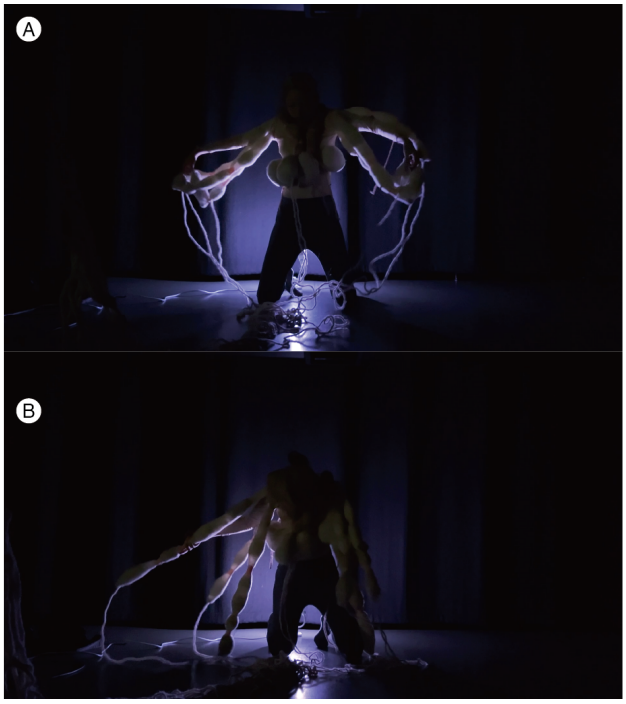

Figure 3: Extra limb sensors in two modes: A) With rings, sensors move with the arm for controlled articulation. B) Without rings, weighted sensors swing freely, causing dynamic deformations and sonic variations.

3 Design and Implementation

3.1 Conceptual definition

This research explores the design of an e-textile musical interface for controlling sound through bodily movement. The initial concept was inspired by the often-overlooked sounds of the moving body. In civilized societies, verbal communication is prioritized while sound-making through movement is typically suppressed as a marker of civility [2]. This suppression has contributed to a general unfamiliarity with the sounding body. To counter this, the project employs an e-textile prosthesis to reclaim attention to unrestrained bodily motion.

The interface is examined through a performance in which the performer wears an upper-body costume embedded with multiple e-textile sensors [9]. Designed as deformable, redundant body parts, these sensors invite the performer to generate sound through movement. The interaction and sonification design serves as a framework for investigating the prosthetic interface, focusing on how it reshapes both physical movement and sonic expression.

3.2 E-Textile interface

This wearable interface is made from knitted fabric embedded with conductive elements for sensing. Compared to other textile fabrication methods, knitting offers better stretchability, making it well-suited for deformable, movement-controlled interfaces [11]. The conductive material used in this design is 70D silver-plated thread, intertwined with regular yarn. The textile sensor is loosely knitted using a knitting machine using garter stitches. When stretched, the conductive thread compresses, forming contact points that reduce electrical resistance [13]. The deformation

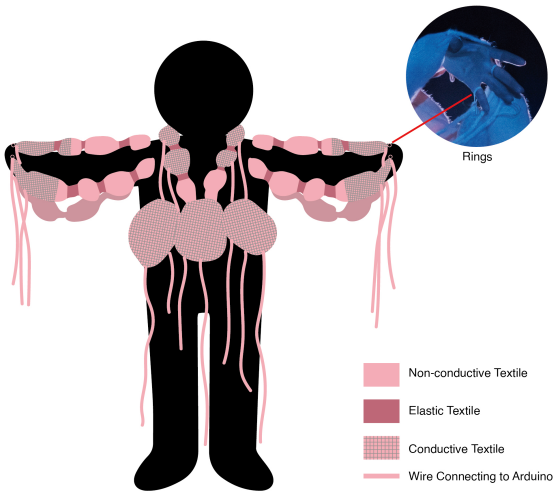

Figure 4: Design of performance costume

of each knitted stretch sensor produces fluctuations in resistance, effectively capturing movement data.

The individual textile sensors were designed to resemble redundant body parts, simulating the appearance of intestinal tracts, tumours, and extra limbs (see Figure 2). Stuffed with cotton, these sensors invite performer interaction through kneading, squeezing, and stretching. Additionally, even gentle movements can deform the sensors, producing subtle resistance variations that influence the sound output.

The performance costume integrates three types of textile sensors, each mimicking a specific bodily form, each designed for distinct interactions (see Figure 4). The "intestinal" sensor positioned around the neck consists of four conductive sections separated by non-conductive fabric. As the performer bends their neck to reach other body parts, these sensors are compressed, generating variations in data. The "tumour" sensors located around the chest are designed to press against one another. Sound is triggered when the performer applies pressure by pressing their body against the ground or other body parts. More vigorous movement causes sensor collisions, further influencing the sound output. The "extra limb" sensors attached to the arms each contain a metal ball as a weight. When the performer wears a ring at the end of each extra limb sensor (see Figure 4), the sensors move in sync with the body, producing subtle variations in data. Without the rings, the metal weights cause the sensors to swing and stretch in response to movement intensity, generating greater resistance variation. While all sensors respond to both stretching and compression, their placement on different body parts produces distinct data outputs, even for similar movements.

3.3 Sonification

This interface employs two sonification methods – audification and parameter mapping sonification – to mediate between gesture-based input and sound output (see Figure 5). Audification interprets sensor data directly as amplitude fluctuations over time, enabling an audible representation of resistance fluctuations [6]. Compared to other sonification methods, audification was chosen for its higher indexicality preserving the intrinsic characteristics of the original data [7]. The interface transmits resistance fluctuations via serial communication with Arduino Nano boards.

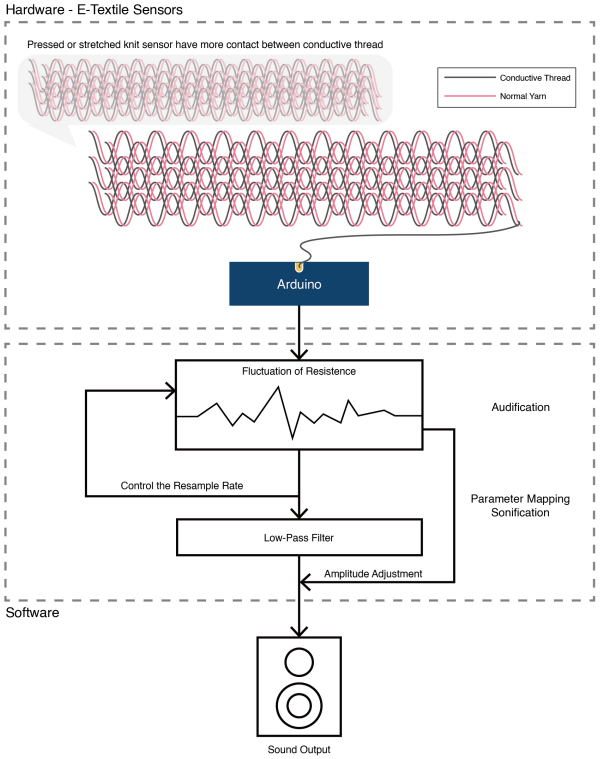

Figure 5: Diagram of the E-textile musical interface system

Since movement data typically falls within a lower frequency range, the waveform is resampled to enhance auditory perception. Variations in sensor shape and the length of conductive thread result in differing baseline resistances, producing distinct control ranges.

In addition to audification, parameter mapping sonification is used to manipulate sound characteristics. Data from the same sensor is mapped to the resampling rate, while amplitude corresponds directly to the sensor's output. These mappings reinforce a grotesque aesthetic, sonically suggesting an organic, living entity composed of redundant body parts. A low-pass filter further emphasises lower frequencies, resulting in a deep, roaring sound.

4 Discussion and Future Work

This paper introduces *Noisy Flesh*, an e-textile musical interface designed for body movement control in performance. Leveraging the inherent flexibility of textiles, e-textiles enable seamless garment integration, adaptability in form, and dynamic deformation in response to movement. Inspired by feminist textile-based artworks that investigate the body through representation, deformation, and redefinition, this project reimagines the role of e-textiles in interface design, not merely as garments but as prosthetic extensions of the body.

A prosthetic interface is proposed not as a secondary addition to the body, as in the case of garments, but as a transformative extension that reshapes bodily structure and inspires new movements through negotiated control. This e-textile interface, designed to resemble redundant body parts, challenges conventional models of movement-to-sound translation. Rather than

Figure 6: Performer folding the body to make contact, press, or rotate, for generating varied sound outputs. Photography by Winston Yeung.

offering direct, intuitive control, it invites the performer to invent movement strategies specific to the interface's unique material and spatial properties in order to achieve desired sonic outcomes. For instance, the performer may fold the body to establish contact between different body parts, such as the chest and neck sensors, and then modulate sound output by rotating or subtly shifting weight (see Figure 6). The sonification of movement constructs an auditory body, enabling the performer to perceive and engage with the extended body. Through audification, sound is derived directly from the physical state of the interface, reinforcing the perception of the e-textile extensions as 'alive' during performance. This approach aligns with the concept of a prosthetic interface, in which the extensions are not merely accessories but integral representations of augmented bodily perception.

Rather than serving as a transparent medium for bodily expression, the e-textile prosthesis interface acts as an active agent in shaping both movement and auditory experience. Through this approach, This approach reconfigures the body with deformable extensions, enabling the performer to perceive an intensified relationship.

This project aims to incorporate additional interactions and sound variations to capture different movements. The potential for further development includes modifying the shape of the interface to improve its affordance and support performers in exploring new interaction strategies. Beyond mimicking natural body parts, the design could also benefit from incorporating imaginary or bionic body parts, inspired by other creatures, thereby expanding the possibilities in aesthetic, interactional, and sonic possibilities.

Future work will involve interviews with performers to gain insights into experiences with the prosthetic interface for improving the design. Comparative analysis between the garment interface and the prosthetic interface will help identify key design principles and highlight the value of using these interfaces in performance contexts.

5 Ethical Standards

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