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Touch Acoustics: Reflections On Crafting A Sonic Textile Interface

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Fig. 1. *Touch Acoustics*, textile interface

Touch Acoustics is a textile surface that responds to touch and maps it to a changing array of generated soundscapes. It interprets body movement into data, measuring pressure intensities to make sense of the duration and spread of touch signals. The surface is enriched by affordances for touch and feeling encountered through textiles, which is shaped by couplings with sonic, temporal form. It explores affinities between textiles, touch and sound in contributing multi-sensory encounters and their role in generating improvised action, expression and emotional reactions.
Reflecting on the production of *Touch Acoustics* expand craft as it incorporates computation, merging material, textural properties with temporal form and computed causality. Collaboration and expertise from an inter-disciplinary team of practitioners promote a hybrid, convergent proposition for craft, a continuously evolving, fluid space that moves between multiple domains of making.

Additional Key Words and Phrases: textile, craft, sustainable, material, tangible, sound, touch, senses

1 INTRODUCTION

My doctoral research develops enhanced textile surfaces to investigate how craft practice can contribute to the design of e-textile interfaces for embodied interaction. This was prompted by a material investigation into technology, blending its reactive, temporal properties with textiles to extend functional, behavioural and aesthetic expressions. Technological materials create opportunities for change that are determined programmatically and can be controlled through active human contact and movement.

My research has shown that combining textiles with technological materials extends their sensorial properties and suggesting new design contexts for these expressions. This paper discusses the prototype *Touch Acoustics* to reflect on artefacts as a form of design thinking [4] and an articulation of craft knowledge as well as highlighting the synergies, tensions and possibilities that arise.

Touch Acoustics is a digitally embroidered textile interface, a prototype that responds to touch and movement to produce an array of gently changing soundscapes, see Fig. 1. It explores multi-sensory modes of interaction that produce aural feedback within a tactile, movement-based interface to explore affective responses to the work. It was devised to have potentially therapeutic, regenerative effects for people with sensory processing needs.

This project was supported by WEAR Sustain, part of the EU Horizon 2020 Research & Innovation programme to investigate the sustainable development of wearable technologies, smart and electronic textiles. Design decisions promote accessible, inclusive experiences using the sense of touch to feel connected to our embodied self and the bodily, physical sensations this affords. It invites touch engagement to promote playful, exploratory experiences that move beyond hands and fingertips to encourage whole body contact.

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Touch Acoustics considers environmentally sustainable concerns in developing e-textiles and durable approaches to longevity and performance in their construction [8]. New scenarios and contexts of use are imagined and intentions developed during discussions with the team. The practice of craft supports decision-making and openness prompted through a dialogue with an expanded material palette.

2 CRAFT PRACTICE

2.1 A Material Dialogue

The development of skill around a making practice is described by Richard Sennett, the sociologist, as a 'trained practice' the result of many hours of repetitive actions with a set of chosen materials, repeated exposure and use instruments [13]. Skill development, expertise and knowledge arise from the manipulation of materials, a constant interplay between tacit knowledge and self-conscious awareness [13]. Glen Adamson positions craft around process and invokes skill as 'the most complete embodiment of craft as an active, relational concept rather than a fixed category' [2].

Fig. 2. Digital embroidery techniques

Craft is characterised by a shift from a handcrafted, personal engagement with materials to technologies that can automate aspects of the making process. As CAD/CAM technologies become more available they have revolutionised the ability to design quickly and produce artefacts, see Fig. 2, while at the same time removing the direct link the maker has with their materials and properties. The relationship between the maker, their materials and the object of their practice is altered through the introduction of automated machine production. Rachel Philpott dicusses these tensions, "these technologies offer many benefits, including the ability to create work of increased accuracy and complexity" [11].

Craft facilitates meaningful dialogue around physical and digital materials through a purposeful, making process. Craft explores how encounters with materials reveal their temporal and textural properties during the construction of exploratory artefacts. Ana Vallgarda and Tomas Sokoler define a 'material strategy' that "takes its departure in the expressive qualities and materiality of the technology" [14]. The craft focus adopted in this research builds and extends the material strategy in considering how composited materials act together, particularly in the negotiation around how function develops in tandem with the development of form [14].

Of particular interest are those properties of computational materials that can be explored during a form-giving practice in composition with physical materials, such as: 'temporality, reversibility and accumulation, computed causality and connectability' [14]. The holistic combination of materials and qualities are discussed in this paper in relation to the possibilities for felt expression that can emerge as a result of material convergences and "the potential for real surprise and creativity" [9]. Craft is a method of understanding the integration of material properties, felt sensation and behaviour as materials extend into partnerships with computational forms through purposeful action.

2.2 Material Exploration

Preliminary material exploration, in collaboration with a textile designer, experimented with creating dynamic volume and texture in textile surfaces using techniques such as tufting, felting, knotting, fringing, quilting and digital embroidery, see Fig. 3. The surfaces encourage active exploration, and are intended to stimulate heightened sensory and affective responses in people as well as their therapeutic possibilities. Textiles are adaptable, flexible surfaces that can be tailored to meet people's sensory and psychological needs in a range of different contexts. In addition textiles provide an opportunity for providing richly tactile, haptic experiences in combination with patterns, forms and colours that invite playful engagement.

Touch Acoustics invites touch through the form and feel of the volumetric, textured fur. Touching, pressing and stroking the embroidered surface feels natural and familiar, it communicates reassurance and feelings of comfort and connection. These feelings can be emphasized through the addition of sound, to immerse participants in a multisensory encounter. The piece's large size supports gestural behaviour and interaction between more than one person, stimulating shared exploration and play. Aaron et.al describe how the "sensory immediacy of tangibility, combined with real-time connectivity, allows for the sharing of experience that is essential for 'being with others' "[1].

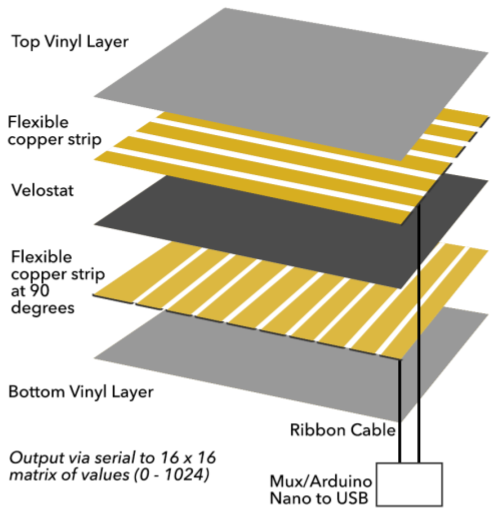
Fig. 3. Material exploration of dynamic textured surfaces.

2.3 Sensory Perception & the Touch Modality

The human sensorium is described by the cultural historian Constance Classen as the entire collection of sensory modalities and channels that enable humans to perceive the physical, biological, cultural and social world around them [3]. As a system of perception, it is entwined with felt sensation to perceive stimuli that pertain to our position in the world. Sensory channels perform an important communicative function that is "heavy with social significance" [6]. We rely on our senses to perceive and communicate information surrounding material properties during a craft practice. This perception of material attributes and our aptitude for shaping them springs from our deep, familiarity with the physical world through our embodied, situated body.

2.4 Cross-disciplinary Practice

Touch Acoustics has been designed and developed using a cross-disciplinary, collaborative process to combine expertise from a team of design and technical specialists. The team includes expertise from design researchers, textile designers, sound designers, programmers and electronics engineers. In her discussion of digital craft, Isabelle Risner [12] describes the move away from individual labour and skill in



production processes. This brings major gains and advantages to individual designer makers in leveraging distributed skills and knowledge; "negotiated collective engagement beyond the individual maker has been shown to be a likely outcome of digital technology and digital economy engagement" [12, p.250].

Fig. 4. Touch sensing surface, layers breakdown

3 HARDWARE & SOFTWARE

3.1 Custom Hardware & Processing

The touch-sensing surface was produced using materials and techniques that support scalability in the development of large-scale surfaces. The touch sensor uses Velostat, a carbon impregnated plastic that changes electrical resistance with pressure.

This is split into a grid of 16x16 sensors using vertical and horizontal copper strips; a sensor being the approximate area of Velostat where two copper strips overlap, see Fig. 4. Each sensor is sequentially powered via a resistor, giving a voltage proportional to the applied pressure. The voltage is read by an analog to digital converter and exported for processing. In Fig. 5 an Arduino Nano is connected to the sensing surface via a multiplexer, which gathers the touch data and sends it as a matrix of values via USB using the serial protocol. The touch data is aggregated and simplified using a Python script to supply the position, pressure, velocity and duration of touch events.

Fig. 5. Arduino Nano/multiplexer connected to surface

Python then sends this data to Pure Data, which generates audio output in response to the touch signal information. The touch-sensing surface is sensitive enough to be positioned underneath an existing textile layer without losing fidelity and the textile helps diffuse the large volumes of data noise from the touch contact area.

3.2 Sound Design

The team worked in collaboration with a sound designer to create procedural sound, a flexible way to construct living sound effects that change in relation to behaviour [5]. This approach opened up alternative ways to think about sound as process and new ways it could correspond to movement based, gestural touch events within the piece. The sound designer implemented a touch-tracking algorithm to control the sound output using Pure Data, a visual programming language that can be used to process and generate sound. Touch signal information such as position, speed of touch, intensity of pressure were mapped to various synthesizer modules, such as chimes and arpeggios, and their parameters modified according to constantly changing touch values.

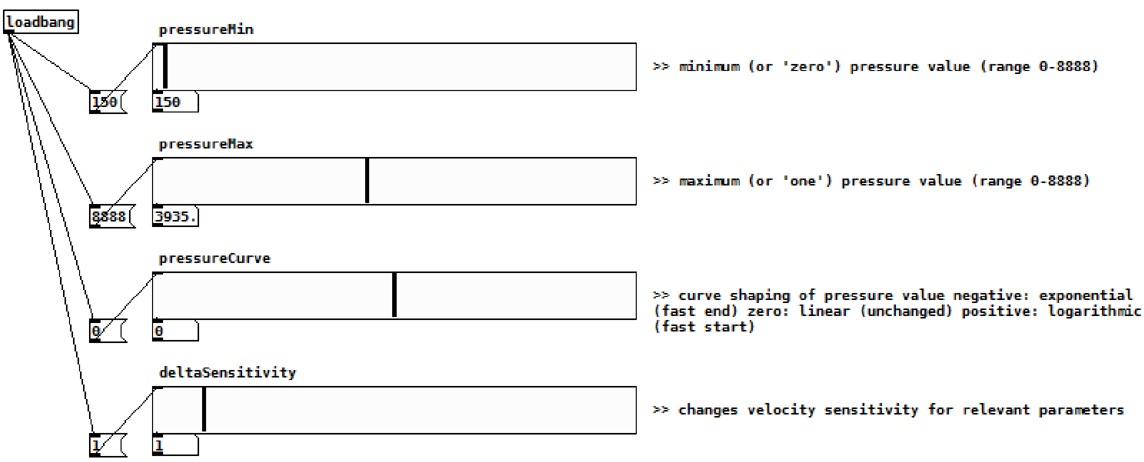


Fig. 6. Input window to control sensitivity parameters in Pure Data

For prototype purposes, the sound designer created an input window in Pure Data that allowed the team to adjust the responsiveness of the sound to correspond with our interactions with the textile surface, see Fig. 6. Pressure values can be scaled and constrained to help raise or lower touch sensitivity. Many adjustments were required to calibrate the levels of touch-sensing sensitivity to sound output. It was challenging to process the data received from the touch signals; often the algorithm was not able to detect lighter touch strokes and movements across the surface.

Other challenges involved describing the sounds that the surface would emit. Early in the process I put together a mood-board with a range of influences for the sound design. It illustrated textured surfaces and suggested volumetric, dense soundscapes with layers of orchestral, ambient tones. We emphasized the fur texture used to create the textile surface for its associative qualities of comfort, warmth and protection. Other associations were to animals and security, purring, and reassurance through touch. The intention is for the tactile, sonic and visual elements to converge, building a holistic, harmonious, multi-sensory experience that is durational, constructed in relation to movement and behavior [7].

3.3 Performance & Function

The touch-sensing surface is broken down into 5 main zones that correspond to various synthesizers, resonators and timbres that change as pressure is detected and moves across the surface. Participant movement can activate different groups of sound generators but this causes time lag and reduces the causal link between event and response. Clustering algorithms were used to detect touch events and calculate maximum pressure values. However this was less accurate for more than one hand or pressure point and more work is required to improve the accuracy of the algorithm.

Additional technical challenges surround how to translate matrices of pressure values into data sets that can be used to drive the sound generation in meaningful ways. Processing and filtering of the large data set is relatively arbitrary so the data set is aggregated into clusters to represent each touch in terms of its strength, spread and central position. However this is found to be very processor intensive & adds approximately 1 sec of lag time that results in a less responsive feel.

3.4 Environmental Sustainability

The team engaged with environmentally responsible choices around materials and processes to encourage long-term, durable performance. *Touch Acoustics* demonstrates low levels of integration between textile and technology [10], keeping them separate using a pocket behind the textile layer that contains the touch-sensing layer. Conductive materials are separated from textile materials to eliminate 'material amalgamations' [10] to easily enable recycling and reuse. Separate textile and component layers facilitate electronics removal for maintenance, which helps to reduce functional obsolescence. A modular approach to electronic, smart textiles is an essential feature in the move towards circular design goals where the reuse of components, materials and products contributes to eliminating waste. Andreas Kohler argues, "life-cycle thinking needs to be implemented concurrent to the technological development process" [8, p.51]. Where possible *Touch Acoustics* has been designed for durability, premised on ideas of openness and longevity. The design for separation approach uses layers during product construction to open up avenues for repair. Hand assembly ensures the components are accessible so they can be easily detached and replaced. We follow the 'repair don't replace' ethos and extend this for software and hardware elements as well as physical materials. Technology components commit to open source approaches for extendable, extensible and updateable processes that avoid obsolescence in long-term use.

4 RESULTS AND DISCUSSION

Much of the research undertaken in this project has focused on the challenges associated with the design and production of an artefact with less evaluation on the impact and experience of the piece. To address this gap, I am designing a series of ethnographic studies to evaluate user engagement with the work as it approaches completion. Validation of the work is recognized as a critical next step in determining the benefits of the prototype to groups and individuals, particularly in wellbeing situations for interactive, touch therapy. We are in discussion with practitioners working with disabled groups that suffer from profound and multiple learning difficulties (PMLD) and with sensory beings with differing levels of sensory processing needs. They have indicated a desire for responsive objects for whole body interaction to support wellness outcomes through playful engagements.

Sensory perception, especially the touch modality is a key influence on my approach to working with multi-sensory modes and promoting gestural, embodied user engagement. While we are still working on the technical issues discussed above, my aim is to evaluate the experience of *Touch Acoustics* to determine whether an encounter with the piece can deepen immersive feelings and contribute to emotional states that might include comfort, reassurance and relaxation. Further evaluation will help to understand whether affective, bodily responses acquire qualities of attachment and bonding through observation and interview.

5 CONCLUSIONS

It is our belief that including user groups as participants within each design stage has a critical value in the design and development process. I am developing methods and participatory frameworks that question accepted models of working and lead to more durable, inclusive practices. We recognize the need to re-evaluate working methods and aim to use workshops to involve distinct groups of people in offering feedback and speculating on future technological objects and offering use cases within their own lives.

Initial observations and explorations of *Touch Acoustics* suggest that the convergence of textural effects with sonic feedback produces playful, surprising encounters in participants. We intend to further explore the role these materials play in generating improvised action and emotional responses suggesting more personal directions for haptic and somatic engagement. This will require more coherent, intentional mappings between body actions and audio output, and this is being refined along with delays in audio responses to touch events.

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