The Carpet Maker's Hafted Tool: A Hackable Instrument for Sonoric Textile Practice

Joseph Burgess
joseph.burgess@research.usc.edu.au
University of Sunshine Coast
CERC

Dr Toby Gifford
tgifford@usc.edu.au
University of Sunshine Coast
CERC

Alex Wixted
alexwixted@hotmail.com
Artist Blacksmith Association NSW
ABANSW

Figure 1: Pictured from left to right, V1 carpet tufting tool, V2 carpet maker's hammer, V3 Carpet Maker's Hafted Tool (CMHT)

Abstract

This paper presents the Carpet Maker's Hafted Tool (CMHT), a hackable, ESP32-based musical interface and electroacoustic instrument for sonoric textile production. The CMHT draws its conceptual inspiration from the percussive soundscape of prehistoric lithic tool production, specifically the bifaces of Box Grove (UK). Physically, the CMHT is a single-piece construction—not unlike a neck thru guitar, carved from a single block of wood which is hafted to an antique carpet-making tool. In this paper we detail an interpretative framework that supports critical engagement with the instrument's design, particularly for those seeking to adapt, extend, or recreate it using open-source resources and low-cost audio development boards. The CMHT serves as a provocation to expand the range of textile production devices in the NIME canon, promoting a paradigm of mutual implication between sonoric and textile practices, which we term *sonotextility.* Ultimately, this work models how social practices of instrument-making and open-source contribution can foster interdisciplinary collaboration.

NIME '26, June 23–26, 2026, London, UK

Keywords

NIME, ESP32, sonotextility, Tufting

1. Introduction

In this paper, we present The Carpet Maker's Hafted tool, a NIME that threads the percussive blade knapping of prehistoric industry into an ornamental and portable instrument. This paper focuses on establishing a reproducible format of electroacoustic instrument which serves to liberate an antique tufting tool into the open source community. This hafted construction is produced in the spirit of social and generative interactions which have resulted from a diverse range of collaborations with artisans and makers at Stone Giant Industries, KEPK Studio in Brisbane, and the Artist Blacksmith Association of New South Wales (ABANSW). This paper serves as a set of guidelines for other creatives who may wish to explore the intersection between textiles and music with an emphasis on reproducibility and open access.

In this endeavour we present a modular approach which can be customised to work with various devboards, DACs, and codecs. As a means of presenting a pathway towards completing this instrument we focus on the ESP32, but in essence the ingredients for this project can be distilled down

to a formidable piece of wood, an electronic processor, and the design files for reproducing the antique tufting tool.

2. Textile Tools as Instruments

While NIME research has explored the tactile and elastic affordances of textiles for musical expression, often through touch-based sensing and wearable interfaces [1], the field has yet to fully engage with textiles tools as procedural agents for composition and structured improvisation. There are several papers presenting textile-based instruments as sites for musical expression and multi-media generation and the introduction of textile tools into the NIME literature [2, 3]. However, there remains an opportunity to broaden NIME's scope by examining textile tools not only as a medium for controllers, but as a conceptual frame for structuring sound.

Manual textile tools are emerging as sites for musical expression in contemporary creative practice. Most recently within the NIME canon, The Embedded Iron v.3, Rheostat Rotary Rack and Embroidery Hoop [3] have exemplified how the role of gendered domestic textile tools can be explored as a shared act of activism. These are a collection of Embedded Acoustic Instruments which use sensors, machine learning, and ready made objects to activate Textile Rhetorics as a "living archive" installation. In this dynamic and situated performance, where textile tools are central to communicating the feminist concept of reproductive commons [2] the configuration of materials enacts the artistic intention through a choreography and the sonoric quality of the objects themselves.

3. Sonotextility

Textiles and sound have a long and intertwined history. We propose a new term — *sonotextility* — to refer to a gestalt concept describing the co-emergence of sound and textile practices in human cultural and cognitive development. Rather than treating music, proto-language, and textile production as distinct domains, sonotextility foregrounds their shared material logics: tension, rhythm, repetition, patterning, and embodied manipulation of flexible media.

Archaeological traces hint at this entanglement, for example hunting bows that function simultaneously as tools and musical instruments, their sonic affordances arising directly from the same tensile string that enables their practical use [4]. At a cognitive level, theories of early development similarly suggest that tactile intelligence scaffolded emerging lingual and musical capacities [5], and we suggest these may have been refined through practices such as weaving, knotting, and fibre manipulation, with proto-song and rhythmic vocalisation co-evolving alongside increasingly complex textile techniques. This concords with a broader description of the relationship between tactility and cognition known as Material Engagement Theory [6] – a theory of embodied cognition that posits an ontological unity between people and tools, and further relates this history of co-development to the evolution of cognition.

In line with Material Engagement Theory, sonotextility, as we propose it, refers not only to this pre-historic interrelationship between sound and textile production, but to the contemporary affordances of textile tools in musical performance, and to the embodied experience of performing with them [7]. Sonotextile devices are liberated from the schema of traditional musical instruments, where much of the orientation of articulation follows a fretboard, wind pipe, etc. Thus the structure of musical architecture has a more open framework for distinguishing and finessing these practices within a new pattern of musical expression. In exploring a theoretical description of this framework we have found resonances with Pierre Schaeffer's description of Sound Objects [8].

3.1. Old interfaces for musical expression

Pierre Schaeffer, in his Treatise on Musical Objects [8], gives a typology of musical instruments comprising three factors: the stimulating or striking mechanism, the vibrating mechanism and the resonator. In this, Schaeffer aligns with existing taxonomic descriptions of musical instruments such as the Hornbostal-Sachs system [9]. However, Schaeffer further speculated on their historical development, noting "the utensil and the musical instrument were in essence probably related"[8, p. 24]. Schaeffer was willing to wager that in reality there was no distinction between them, proposing that "the same calabash did equally well for soup and music." It is in this line of thought that we propose this paradigm of mutual implication between musical instruments and textile tools as sonotextile devices.

In "The O in NIME", Masu et al. [12] reflect on how instruments that are not "new" are implicitly devalued thus arguing that the academic framing and conference discourse largely ignores the prolongation of existing instruments. The exploration of older and repurposed devices provides ample motivation for developing these instruments with low-cost digital interfaces. This paper presents fodder for a long-term engagement between textile tools and hackable devices.

3.2. Translating signals from physicality in manual tufting

The textile joinery of hand-tufted carpet involves punching yarn through a pre-stretched primary backing fabric mounted on a frame using a low gauge needle. Tufting is neither weaving nor tapestry, it is a process of textile joinery that has a unique array of mechanical constraints that differentiate it from other textile mediums. Through the thickness of yarn and the depth of the punched tufts, the added dimensionality of "pile-height" contributes to situating tufting outside the gamut of weaving, embroidery and brocaded fabrics. Manual tufting can be done with a punch needle or hand tufting tool.

In evaluating textile tools as input devices [10] they would be considered alternative controllers, as they do not emulate or follow the control interfaces of any existing instrument. They have unique and idiosyncratic designs related to their utilitarian purposes. In addition textile tools break from traditional gestural vocabularies, as the process of textile production requires a range of movements outside the norms of other musical instruments. Through interfacing with these tools, the sequential motions of textile making provide the template for compositional structure and melodic phrasing. As a speculative compositional system, these iterations of action and rest form the basis for exploring carpet making in performance and composition.

Figure 2: An antique rug tufting tool (2025)

In the coarse gestures and repetitive process of manual tufting, one hand articulates a punch needle along a fixed rail whilst the other hand supports the device from a small handle. Together with both hands together pressure is exerted towards the flexible carpet-backing surface. The friction of the rails produces a metallic tone as the interaction of the needle and fabric create low tones, translating energy into the surface. In a Schafferean sense, the backing material acts as the vibrating mechanism, and the tufting tool the stimulating or striking mechanism, which initiates the energetic exchange [8]. In this configuration the carpet backing material serves as a large-scale highly dampened resonator, which sustains the energy exerted onto the backing materials, creating a subtle but substantial ripple effect not unlike the membrane of a timpani or drum.

In this translation of bodily energy and material practice, the fabric and metal interact. The carpet, acting as a large-scale membrane flexes. As the tool advances upward it initiates a repetitive percussive pattern with a semi-constant speed due the mechanical constraints of the manual tufting tool. As detailed in Burgess and Gifford [13], this exchange of energy is amplified and prolonged by "mounting a piezo sensor to the carpet-backing material. These audio inputs are routed to a physically modelled 'sympathetic string' using the Corpus effect in Ableton Live" which serves to harness and sustain the interactions between the vibrating mechanism and the stimulating mechanism.

3.3 Mapping across craft systems

This antique tool is accompanied by an antique yarn threading device, which consists of a round metal disk and a securely fastened wire loop. When appropriated as a playable instrument the threading tool has similar features to a jaw harp, where by striking the wire a low modulating pitch is generated. Schaefer describes "these ambivalent modulations, at the margins of music and language" [8] as the primitive models for modern synthetic music. When these signals are transduced with a piezo, it extends the affordances of the object to become a gestural sonic object. Whilst threading the hand tufting tool the threading device interacts with the hand tufting tool creating a dynamic interplay between two utilitarian objects of textile production. This interfacing of materials enables, constrains and specifies communication, flow, and interaction between entities and processes [6, p. 244].

3.4 Schaferrian Typology

Translating these material interactions into sound extends Schaeffer's typology [8] beyond simple transduction. In the CMHT, mapping redistributes and substitutes the exciter, resonator, and controller functions across a hybrid electroacoustic system. The antique tufting tool remains a primary acoustic exciter, generating the percussive texture of needle against fabric. In parallel, Hall effect sensors and contact microphones introduce a secondary, mediated excitation: gestural data triggers sampled lithic percussives without replacing the original acoustic event. A single tufting gesture thus produces three simultaneous outcomes: exciting the resonances of the carpet backing surface, a synthetic stone-based sound object, and a physical textile in progress. This plurivalent excitation — one action generating two qualitatively distinct sonic materials plus a material artifact — exemplifies how sonotextile devices can redistribute Schaeffer's tripartite model across assemblages where sound and textile production are unified.

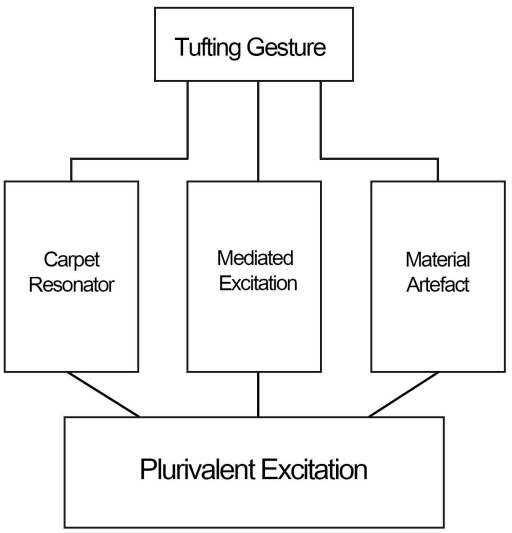

Figure 3: plurivalent excitation

4. The Carpet Maker's Hafted Tool

In the spirit of the NIME 2026 theme of community, this paper includes a re-designed antique tufting tool made in collaboration with a black smith Alex Wixted of the ABANSW. The design files and build instructions serve to extend the reach of NIME into other adjacent creative sectors. The tufting tool can be reproduced in metal and/or other materials along with 3D printable files for creating the CMHT in various materials through rapid proto typing.

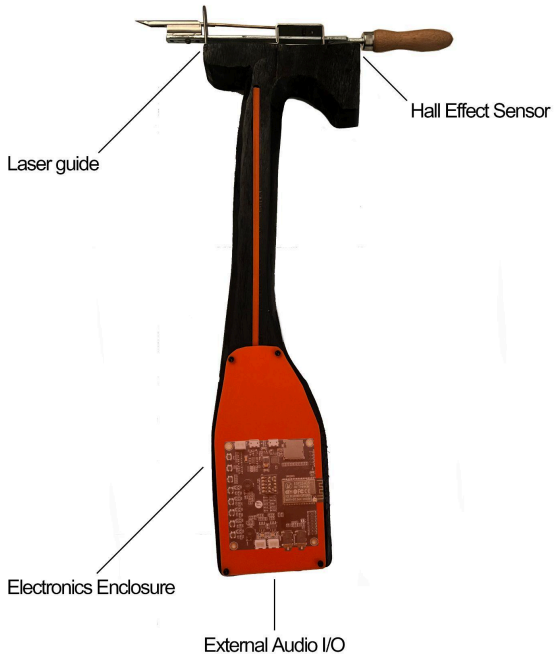

Figure 4: Carpet Maker's Hafted Tool (2026)

4.1 Instrument making

Instrument-making can be understood as a quest to assemble functional entities from disparate elements—creative outcomes emerge from "a collection of heterogeneous parts and acts that form contingent relations across time to produce an emergent whole" [11]. Building on this, we propose a methodological approach that foregrounds community as a collaborative agent within the instrument making process. By virtue of their use, textile tools operate outside the hegemonic constraints of traditional musical instruments, inviting a context-specific approach that naturally interleaves interdisciplinary perspectives.

In the case of many antique tools the handles are often poorly produced, or at times they can be nearly non functional resulting in a scenario where there is barely space for the fingers to grasp the tool. In our proposal to modify and reproduce this tool, extending the handle becomes the main driver in hacking the instrument. With this approach, the handle becomes more than just a means of holding the tool; it also serves as an electronics enclosure and resonant space for electro acoustics prototyping.

The first step was to add a crude piece of wood to the antique tufting tool with a single ziptie, to understand how the proportion and angle of the handle would affect the ergonomics involved in the embodied process of manual tufting. The V1 handle served as an in-studio test which facilitated a level of understanding about how the object could be expanded. During this stage the initial collaboration was provoked between artist and a neighbouring artisan over a conversation in a communal space. Within our model of iterative co-design, the initial prototyping involved replacing the handle and constructing a small electronics enclosure in the form of a rectangular box. This was mounted to a ready made handle used for a common hatchet. By placing the rectangular enclosure at the top of the device, it resulted in a hammer-like tool which survived only two performances. Through these iterations, this tool enabled an expansion of the performance and assisted in making the reference to stone tools more visible through the object.

4.2 Iterations of collaborative making

In the next iteration, the process began with a formidable piece of wood. It was decided to reposition the electronics enclosure at the base of the tool and elongate the handle. Throughout this process, each cut was a discussion between artist and artisan until the final form and contour of the handle was achieved. A channel was routed out to connect the electronics and the peripherals at the top of the tool.

In the current iteration the CMHT is a single-piece construction— not unlike a neck thru guitar, carved from a single block of wood which is hafted to the aforementioned antique carpet-making tool. In the following section we will outline the journey of co-design between diverse artisans and the process of bricolage making and breaking to arrive at the current iterations of the CMHT.

4.3 Electronic implementation and laser guidance

To extend the CMHT's scope of musical interaction beyond the processing of acoustic signals, a small sampler was embedded within the V2 carpet maker's hammer. An Adafruit Sound FX board, loaded with custom lithic tool making samples, was triggered via two buttons: one mounted at the top of the tool like a tactile trigger, and a second, longer level-style button positioned to be actuated by the ring and pinky fingers, which enables looping control when compressed. These performative trials offered a rapid and embodied method of exploring how sample-based workflows could accentuate the rhythms and gestures of carpet making.

In subsequent iterations, the looping functionality was refined to generate evolving rhythmic patterns that resonate with the semi-constant pulse of manual tufting—each stab of the tool echoed by a sonic fragment, each loop a stitch in an emerging audio-tactile fabric.

Alongside these sonic developments, a small low-wattage laser was mounted to the front of the device. Its inclusion served both practical and aesthetic ends: it drew a consistent voltage from the power supply to stabilise the system, while also functioning as a laser guidance system—a projected line of light that visually leads the eye, tracing the tool's trajectory through space and anchoring the performer's attention to the orientation and intent of each gesture.

4.4 Prototyping and interfacing

The CMHT has space for a variety of microcontrollers and peripherals in the electronics enclosure. Interactions between the tufting tool and microcontroller have been expanded through the use of analogue and digital hall effect sensors, piezoelectric disks, and internally mounted speakers placed directly in front of microphones. In this configuration, Analogue and digital Hall effect sensors detect magnetic fields generated by moving ferrous components—one mounted at the back plate responds to compression during tufting, triggering percussive samples of impact; another near the top senses extension and releases samples of flaked stone, granular chaff, or other brittle textures. With a combination of onboard speakers and microphones, audio I/O can be bidirectional and recursive, enabling a variety of workflows when the CMHT can become a feedback instrument.

5. Discussion

Schaeffer refers to a "margin of gratuitousness" in respect to Neanderthal Music, within which we ought to seek "the simultaneous origins of Dance, Song and Music". Manual textile making is a combination of the trifecta of these activities in traditional and industrial practices. Within this template instrument, there is an underlying recognition that the "essential relation, in a world of life, is not between matter and form but material and forces" [14, p. 377] and that in textile practice there are complimentary nodes which engage simultaneously with musical practices. The manual tools presented in this paper serve as the primary utensil [8] or signal.

Foregrounding the transversal and generative relationship between musical practices and textile production is the "basic ontological ingredients of human thought and of the embodied cultural practices that turn those ingredients into cognitive processes across the scales of time." [6, p. 248] In context of material engagement "the kind of material assemblies or enactive cognitive prostheses that enable the configuration of a dynamic alignment or tuning among brain, body, and culture."[6, p. 245] The CMTH, serves as a prosthetic extension within a musical system as a material assembly.

Figure 5: Carpet produced through sonotextilic processes (2025)

Within these "bidirectional dynamic coalitions" the use of tools as instruments and vice versa can be conceived in a similar theoretical vein to the schema of palaeolithic tool development and cultural practices in biface construction. Malaforis describes these bidirectional dynamic coalitions as the "hard-assembled (stable) or soft-assembled (reconfigurable), epistemic or pragmatic, invasive or non invasive, representational or performative, transparent or non-transparent constitutive or instrumental" all of which "can be empirically observed through diverse examples, including early Paleolithic stone tools" [6, p.245]

In this we can see how the carpet makers hafted tool exemplifies such a bidirectional dynamic coalition, affording simultaneous sound production and textile creation as a multimodal aesthetic output. An example of the textile artefact produced through this sonotextilic process can be seen in figure 5. The first threads of this were tufted in concert at NIME 2025 and completed over the course of multiple performances demonstrating one of the features of this sonotextilic compositional framework; that the persistent traces of subsequent performances interlace in a Foucauldian heterochronic weave. [15, p.6]

6. Links

CMHT Github

CMHT video demonstration

Ethical Standards

This research was conducted under the auspices of the Creative Ecologies Research Centre (CERC) at the University of the Sunshine Coast. CERC privileges ethical, respectful and reciprocal research, which benefits researcher and participant both. The timber handle was collaboratively produced with Karl Stone (Stone Giant Industry), whose contribution is acknowledged with thanks.

Acknowledgments

The authors would like to acknowledge Karl Stone of Stone Giant Industries, KEPK, and the Artist Blacksmith Association NSW (ABANSW).

References

[1] Maurin Donneaud, Cedric Honnet, and Paul Strohmeier. 2017. Designing a multi-touch etextile for music performances. In *Proceedings of New Interfaces for Musical Expression* (Copenhagen, Denmark).

[2] Jocelyn Ho. 2025. Housework Commons: Textile Rhetorics II. In *Proceedings of New Interfaces for Musical Expression* (Canberra, Australia).

[3] Jocelyn Ho, Margaret Schedel and Bryan Jacobs. 2024. Housework Commons: Rheostat Rotary Rack. In *Proceedings of New Interfaces for Musical Expression* (Utrecht, Netherlands)

[4] Bo Lawergren. 2024. The Origin of Musical Instruments and Sounds. *Anthropos*, 1988, 31-45.

[5] Dylan Van Der Schyff and Andrea Schiavio. 2017. Evolutionary Musicology Meets Embodied Cognition: Biocultural Coevolution and the Enactive Origins of Human Musicality. *Frontiers in Neuroscience* 11: 519.

[6] Lambros Malafouris. 2013. *How things shape the mind.* MIT press, Cambridge, MA.

[7] Jiaxin Zhou and Duoduo Zhang. 2023. *Stimulating Everyday Creativity: Mediating Role of New Tools in DIY Craft Ergonomics in Design,* 77, 2023.

[8] Pierre Schaeffer, Christine North, and John Dack. 2017. *Treatise on Musical Objects: An Essay across Disciplines.* University of California Press.

[9] Margaret J. Kartomi. 1990. *On concepts and classifications of musical instruments.* University of Chicago Press.

[10] David Birnbaum, Rebecca Fiebrink, Joseph Malloch and Marcelo M. Wanderley. 2017. Towards a Dimension Space for Musical Devices. *A NIME Reader: Fifteen Years of New Interfaces for Musical Expression,* 211-222.

[11] Ben Sellar. 2009. *Assemblage theory, occupational science, and the complexity of human agency.* J. of Occupational Science, 16(2), 67-74.

[12] Raul Masu, Fabio Morreale, and Alexander Refsum Jensenius. 2023. The O in NIME: Reflecting on the importance of reusing and repurposing old musical instruments. In *Proceedings of New Interfaces for Musical Expression* (Mexico City).

[13] Joseph Burgess, and Toby Gifford. 2025. Threading the Sound: The Carpet Tufting Gun as an Electroacoustic Performance Interface. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, (Canberra, Australia).

[14] Gilles Deleuze and Félix Guattari. 2004. *A Thousand Plateaus.* Translated by B. Massumi. Continuum, London, UK.

[15] Michel Foucault. 1984. *Of Other Spaces: Utopias and Heterotopia.* Architecture/Mouvement/Continuite.