Signal Processing as Practice: Trial-and-Error Revision of the Sensorimotor Dynamics of a Hybrid Violin

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Abstract
This paper describes the evolution of a "hybrid violin" developed and played by the author and reflects on the process of developing its sensorimotor dynamics as a salient affordance of real-time digital signal processing. The hybrid violin consists of a technical ensemble of hardware and software elements, including an acoustic violin, microphone, custom sensor glove (alto.glove), and customized ergonomic shoulder rest embedded with voice coils for haptic feedback coupled to digital audio output. Through trial-and-error revision by the designer, sensory feedforward and feedback paths are effectively symmetrized, thereby engaging the claim of the "enactive" approach to cognition as a creative practice: perception drives action and action drives perception. The hybrid violin catalyzes improvised performance insofar as it is responsive to all gesture and embeds no assumptions about expressive intention. The system allows for experimentation with violin technique by continuously and intensively tracking gestural and auditory inputs.

Author Keywords
sensors; violin; augmented violin; gesture; interaction design; sonic interaction; electronic music; live audio; improvisation; digital signal processing.

Figure 1: Alto.glove, a custom sensor glove for violin designed by the author [11].

Figure 2: Functional diagram of the alto.glove showing positions of flex sensors (lines), FSRs (dots), buttons, and IMU (dashed circle).

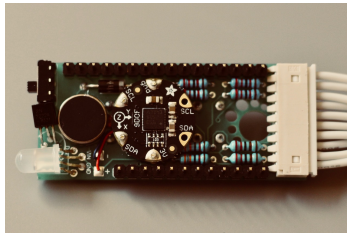

Figure 3: Alto.glove PCB interior, revealing IMU, haptic feedback motor, and other components.

CSS Concepts

• Applied computing~Media arts • Applied computing~Sound and music computing • Applied computing~Performing arts • Hardware~Tactile and hand-based interfaces • Hardware~Haptic devices

Introduction

In contrast to augmented violin approaches that make use of gestural models based on highly formalized styles of bowing [e.g., 1,7], the hybrid violin I continuously redevelop does not embed a high-level model of violinistic gesture. Instead, my approach to the computational augmentation of an acoustic violin entails an experimental method marked by continuous trial-and-error revision of the feature construction and digital signal processing. I use the term "hybrid" rather than "augmented" in order to emphasize that I make no conceptual distinction between the digitally generative and acoustic features of the violin, insofar as the instrument is co-articulated between material and computational physics.

Design Ontology

Since the meaningful features of the hybrid violin are discovered in the concrete trial-and-error process of constructing those features rather than being based on an abstract *a priori* model, the hybrid violin points to a unique form of intentionality on the part of the designer, who does not aim for a result imagined in advance of the actual material process of constructing the instrument. Instead, the designer follows an *intensive* design logic that unfolds and individuates as the instrument develops further. The hybrid violin is a "composed instrument" [8] that perturbs a classical ontology in which strict distinctions are made among canonical (*transcendental*) scores, instruments, and actualization by performers in performances.

Since the hardware of the hybrid violin has strong multimodal feedback components—primarily due to the electromechanically augmented shoulder rest that becomes both part of the instrument and the sensorium of the human performer [13]—the instrument artfully symmetrizes the action-perception feedback loop in performance. In other words, guiding the signal processing development entails the continuous construction of the actual sensorimotor dynamics of the instrument. The hybrid violin puts into practice the broad claim of the "enactive" approach to cognition espoused by Varela, Rosch, and Thompson, namely that perception drives action to the same degree that action drives perception [14]. In symmetrizing sensory feedforward and feedback paths in both the design and playing processes, the player-programmer creatively and progressively elaborates the computationally-mediated physics of the instrument.

Figure 4: A violin shoulder rest is an accessory that makes violin playing more ergonomic by lifting the instrument from the collarbone. This one has been modified with voice coils.

Figure 5: Presentation by the author of the alto.glove at the Guthman Musical Instrument Competition, Georgia Institute of Technology, March 2018.

Figure 6: Performing at the New York City Electroacoustic Improvisation Summit, CUNY City Tech, February 2019.

Figure 7: Performing at the ACM 2019 International Conference on Tangible, Embedded, and Embodied Interactions (TEI19), March 2019, Tempe.

Ethico-Aesthetic Practice

In *The Three Ecologies*, Felix Guattari writes of an "ecology of resingularization" as a process of "heterogenesis," the continuous production of novel forms of subjectivity that resist the tide of universalizing tendencies (of mass-media) [3]. The hybrid violin instantiates heterogenesis and resingularization insofar as its continuously evolving computational physics—which are modified for every performance—recondition the space of possibilities for the improvising performer who plays the instrument. Guattari emphasizes the way in which *ethico-aesthetic* as opposed to *scientific* practices resinguarlize individuals and instantiate "new universes of value" in following artistic modes of development: "the best artists don't repeat themselves, they start over and over again from scratch, uncertain with each new attempt precisely where their next experiment will take them."

The possibility of continuously reconditioning and reinventing the physics of digitally programmed musical instruments is alternatively posed in the literature as both a potential problem as well as an opportunity. For instance, Thor Magnusson writes of the implicit cultural conditioning that occurs when high-level musical percepts based on Western tonality make their way into the basic logic of the instrument and its operation. In being actualized as symbolic logic, such instruments impose "epistemic" substrates [4]. From a much different standpoint, Garth Paine uses the notion of "dynamic morphology" to include the physics of the digital instrument, for which "it must be possible for it (in accordance with the nature of interaction) to evolve into a new instrument altogether" [6]. This position emphasizes that the potential for dynamic morphological changes in the composed instrument offers a unique opportunity for composers, because of—not despite—the fact that they are able to instantiate extraordinary physics.

In my view, digital hybridization presents a need to strike a balance between defining a musical instrument's learnable kinesics in a way that follows ontogenetic experience with physical matter, and the unique affordance of the digital to allow immediate and responsive reconditioning of the gestural and sonic affordances of that instrument, especially in contexts of live improvisation. Thoughtfully designed experiential media systems [10] and multimodal interfaces can imbue digital instruments with meaningful physics. In this context, perhaps the most salient affordance of digital computation is the novel ability to skew these "pseudo-physics" [9] with the aim of creative "resingularization."

Validity or Efficacy?

The signal processing decisions that I make in continuously redefining the physics of the hybrid violin are not model-based, nor do they entail a claim to universality. In other words, I do not claim that the way I do my signal processing is the way everyone ought to do it. For this reason, signal processing entails a politico-ontological dimension, namely that the computational physics of an instrument can be *effective* without needing to make a concomitant claim to *universal validity*. At the same time, this does not mean that the refinement of the processing is in any way inferior to universalizing models. On the contrary, personal instruments are capable of being refined to an extreme degree.

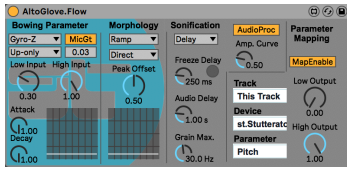

Figure 8: A Max for Live module designed by the author for rapid tuning of instrumental dynamics [12]. For any particular performance (or instrument state), multiple copies of the module are instantiated and coupled to different modes of live audio processing. The module was designed in order to facilitate a quick turnaround between encoding the hybrid violin's dynamics and playing through them in performance. This is achieved by making available a wide variety of sensor data from the glove at various orders of processing as well as "composited" features that experimentally couple different auditory and sensor inputs. The control signal can then be scaled and/or reshaped and used to modulate the amplitude of the acoustic violin signal that passes through the module into further layers of audio processing. An additional "parameter linkage" option non-linearizes the system by allowing the control signal to affect any other parameter in the system.

Another way of explicating my hybrid violin practice is as a "minor" practice. Following Gilles Deleuze and Guattari's elaboration of "minor science" in *A Thousand Plateaus* [2], Erin Manning writes of the difference between the major and the minor: "The major is a structural tendency that organizes itself according to predetermined definitions of value. The minor is a force that courses through it, unmooring its structural integrity, problematizing its normative standards" [5].

Processing Techniques

Progressive development of the hybrid violin software has yielded some recurring motifs and techniques, including temporalization of the bow (holding bow strokes activates different processes sequentially), continuous response to accentuation and amplitude dynamics (immediately responsive processing), accumulations of input dynamics generative of local periodicities (by comparing recent durations of segmented bow strokes), and "capture" processes ("autonomizing" the bow by continuing to sound and be motion responsive even when the violin itself is not being bowed).

Conclusion

As an ethico-aesthetic design practice, continuous revision of the dynamics of personal instruments articulated by symbolic code affords reflection on "minor" practices as *effective* practices that are not based on normative or *a priori* scientific models. My hybrid violin is an example of how such a practice develops in accord with a logic that is not autonomous but instead follows a creative and experimental, extemporaneous unfolding.

Video Documentation

https://vimeo.com/331471093

References

[1] Frédéric Bevilacqua, Nicolas Rasamimanana, Emmanuel Fléty, Serge Lemouton, and Florence Baschet. 2006. The Augmented Violin Project: Research, Composition and Performance Report. In *Proceedings of the Conference on New Interfaces for Musical Expression* (NIME '06), 402-406.

[2] Gilles Deleuze and Felix Guattari. 1987. *A Thousand Plateaus*. University of Minnesota Press, Minneapolis, MN.

[3] Felix Guattari. 2000. *The Three Ecologies*. The Athlone Press, London, UK.

[4] Thor Magnusson. 2009. Of Epistemic Tools: musical instruments as cognitive extensions. *Organised Sound* 14, 2: 168.

[5] Erin Manning. 2016. *The Minor Gesture*. Duke University Press, Durham, NC.

[6] Garth Paine. 2004. Gesture and Musical Interaction: Interactive Engagement Through Dynamic Morphology. In *Proceedings of the Conference on New Interfaces for Musical Expression* (NIME '04), 80-86.

[7] Margaret Schedel and Rebecca Fiebrink. 2012. A Demonstration of Bow Articulation Recognition with Wekinator and K-Bow. In *Proceedings of the International Computer Music Conference* (ICMC '12).

[8] Norbert Schnell and Marc Battier. Introducing Composed Instruments, Technical and Musicological Implications. 2002. In *Proceedings of the Conference on New Interfaces for Musical Expression* (NIME '02), 1-5.

[9] Xin Wei Sha. 2013. *Poiesis and Enchantment in Topological Matter.* MIT Press, Cambridge, MA.

[10] H. Sundaram, T. Rikakis. 2008. "Experiential media systems." *In Encyclopedia of Multimedia*, 2nd ed., Springer, New York.

[11] Seth Dominicus Thorn. 2018. Alto.glove: New Techniques for Augmented Violin. In *Proceedings of the Conference on New Interfaces for Musical Expression* (NIME '18), 334-339.

[12] Seth Dominicus Thorn. 2019. Transference: A Hybrid Computational System for Improvised Violin Performance. In *Proceedings of the ACM International Conference on Tangible, Embedded and Embodied Interaction*, 541-546.

[13] Seth Dominicus Thorn and Byron Lahey. 2019. A Haptic-Feedback Shoulder Rest for the Hybrid Violin. In *Proceedings of the International Computer Music Conference*.

[14] Francisco J. Varela, Eleanor Rosch, and Evan Thompson. 1991. *The Embodied Mind*. MIT Press, Cambridge, MA.