

# Contextualising Idiomatic Gestures in Musical Interactions with NIMEs

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## ABSTRACT

This paper introduces various ways that idiomatic gestures emerge in performance practice with new musical instruments. It demonstrates that idiomatic gestures can play an important role in the development of personalized performance practices that can be the basis for the development of style and expression. Three detailed examples – biocontrollers, accordion-inspired instruments, and a networked intelligent controller – illustrate how a complex suite of factors throughout the design, composition and performance processes can influence the development of idiomatic gestures. We argue that the explicit consideration of idiomatic gestures throughout the life cycle of new instruments can facilitate the emergence of style and give rise to performances that can develop rich layers of meaning.

## Author Keywords

NIME, idiomatic gestures, gesture vocabulary, NIME performance

## CCS Concepts

•Applied computing → Sound and music computing; Arts and humanities; Performing arts;

## 1. INTRODUCTION

The ideal of “expression” suggests a contingent and spontaneous quality of performances with new musical instruments that is encompassed by the term *situated interaction* [13] — interactions influenced in real-time by relationships and exchanges between various actors, roles, technologies and environments, which may include musician, composer, luthier, instrument, audience, performance environment. It is significant that this in-the-moment musical interaction with the instrument provides primary information for coordinating upcoming performative actions and guiding the musician through the sound world of a particular instrument. The situated quality of musical interactions further informs *performative style*—the ways a musician adds particular variations to the characteristics of the performance through gestures that are idiomatic to the instrument and expressive of the musician’s intent [18].

This paper documents the authors’ experiences and reflective observations on the development and emergence of *idiomatic gestures* in our own performance practices with new instruments of our own design. The concept of idiomatic gesture elaborates on Vasquez et al.’s discussion of *idiomatic composition* in the context of NIME [41] with a new focus on the repertoire of physical actions involved in the performance of a new instrument and their role in conveying or fostering extramusical meaning in NIME performances. We argue that the development of idiomatic gestures is in part what enables ‘NIMEs’ to go beyond sound producing tools or demonstrations to performative (or what are commonly called “expressive”) musical instruments. Scholars and artists have long attempted to find ways to understand the complex nature of musical expression – the so-called ‘E’ in NIME [11]. Certainly one aspect of this notion of expression inheres in the gestures that emerge from the complex, personal, and embodied relationship between the performer and instrument. In this regard, understanding idiomatic uses of gestures in the context of new musical instruments can reveal a new set of design values for us to explore in our development of and interactions with NIMEs, which will shed light on the challenge of creating ‘expressive’ NIME performances.

In the following sections, we first present an overview of related work that elaborates the concept of idiomatic gestures in the context of music performance, then we discuss examples from our own NIME practices in terms of idiomatic gesture. Following that we will discuss the key features in contextualising idiomatic gestures in NIMEs and conclude our paper with future work.

## 2. STYLE AND FORM OF IDIOMATIC GESTURE IN MUSIC PERFORMANCE

Jensenius [24] highlights a variety of disparate senses of the term *gesture*, calling upon authors to clarify their intended meanings. While in NIME we often tend to associate *gesture* with actual physical movement, and correspondingly the physical characteristics of a musical instrument, there is also a long tradition of describing music in terms of compositional ‘musical’ gestures, e.g., [20]. Hatten defines human gesture as “any energetic shaping through time that may be interpreted as significant,” where significance is gauged in terms of affective, modal, or communicative meaning interpreted by an observer [21]. For the purposes of the present paper, we use the term to denote physical actions that are imbued with meaning, and given the context, we are concerned with those involved in the course of musical performance. To this we add two caveats. First, referring back to Hatten and consideration our situated perspective, we stipulate the meanings in question are not necessarily communicative or intentional; they may be contingent, emergent,



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and individualized. Second, as we shall see in the case of bio-controllers in §3, the physical actions do not need to involve large-scale motion, and can be minute or isometric.

The relationship between so-called ‘musical gestures’ and gestures that involve actual physical movement is debatable—whether metaphorical, analogical, or perceptually-rooted—but nonetheless it is noteworthy that some authors also discuss musical gestures as being idiomatic to musical styles or forms. Broyles asserts that two stylistic “streams” underlie all classical music – a sonata style and a symphonic style, which are independent of actual orchestration and are distinguishable by “idiomatic gestures” that are evident in melodic, textural and formal material [3]. He argues that even solo pieces such as Beethoven’s Piano Sonata, Op. 2, No. 1 can be stylistically symphonic due the idiomatic use of symphonic gestures. Palmer [35] employs a similar approach to the use of idiomatic closing gestures in tonal music, as means of closure that builds up some expectation on the listener about how the piece will conclude.

In traditional music performance the term ‘idiomatic style’ has been used to draw attention to the importance of the physical properties of a particular instrument on performance practice [2]. For instance, taking advantage of a figuration more idiosyncratic to violin, Neacsu [32] presents the idiomatic gesture that Beethoven wrote, which has to be played on three different strings. Violinists described this gesture as *bariolage* or *baterie*; it usually involves a repeated open-string note, with or without open strings. Similar idiomatic gestures are found in some of Beethoven’s piano works, taking the advantages of motives and motion in the composition [32]. Similarly, “double staccato” is considered as one of the playing techniques on the Paetzold flute [1]. Double staccato has been introduced as an idiomatic gesture with a very effective playing technique for situations where overblowing is used. This idiomatic gesture enables the player to select harmonic overtones with agility [8].

In contemporary research, accounting for the use of extended techniques for instrumental music, gestures in music performance have been identified in terms of high-level descriptors [28]. Further classification of gestures in music performances have been presented in multiple categories [5, 23]. As a result of a shared *ecological knowledge of gestures* [15], shared expectation of sound producing movements and concept of their affordances with design constraints in digital musical instruments have also been discussed [30, 22]. Moreover, Dahl, et al. [10] had come to analysis of movements observed in music performance as highly idiosyncratic through specific classification of gestures appearing in musical performance. While we can trace a particular interest in developing a gestural language with a focus on classifications, most of what follows in development of NIMEs similarly lacking in idiomatic gestures, lack of established set of playing techniques.

Paine [34] identifies several aspects for computer musicians to consider when developing a gestural language that can ensure *authenticity*, illustrating sound-action coupling in a more seamless manner. He emphasises the resulting notion of gestures as forms of structural evolution for music performance. Cook [9] formulates his approach to idiomatic gestures with a music composition *Pico I for Seashells and Interactive Glove* that introduces a particular idiomatic gesture for the Pico Glove instrument, moving the hand in and out of the shells that triggers note-generation algorithms. Malloch and Wanderley [31] also puts an effort in the *T-Stick* project to develop notation standards for the new musical instrument. One of the main threads in their work is to attempt to transform primary process of developing a vocabulary of gestures idiomatic to the interface.

It is there already in Choi’s [7] suggestion for formalising a component model of *gestural primitive throughput* as a design principle of new musical instruments. This model identifies performer’s movements as musical idioms, orientation towards the musical gestures. In this model, idiomatic gestures appear when performer’s movement transfers the gestural primitives into auditory signatures. Choi places the idiomatic expression at the very core concept of the styles and forms of idiomatic gestures, through essential aspects of the auditory signatures that are derived from the *instrument’s oscillations* in relation to performative movements, investigating performer’s expressive intentions. Perhaps we will agree that there is nothing new in the central idea. Musicians, composers, have always concerned themselves with the idea of expressive gestures that communicate the true performative intentions. The notion of performative intentions, has a central position in this paper. We will elaborate our discussion on idiomatic gestures presenting our three particular projects, reflecting on our own NIME practices. These projects were chosen as they provide experiential input on idiomatic gestures regarding the work itself and the work surrounding it.

### 3. IDIOMATIC GESTURES IN BIO-CONTROLLERS

If gestures are associated with the physical properties of the instrument, are there idiomatic gestures for a musical instrument or controller that has no physical embodiment? Over the years of developing interfaces that use physiological sensors to control music (so called “biocontrollers”) the answer appears to be yes. For example, from the moment that real-time bioelectric measurement of muscle tension for musical control was possible, [26], a language of biophysical gestures was created. One only has to look at the first performances of Tanaka 30 years ago using the BioMuse [39] alongside the more recent performance of Donnarumma using his Xth sense bioacoustic sensor [12] to see the commonality of gestures. As the performer stresses and strains the muscles of the arm, a language of torsion, flexion, and extension emerges. In a piece known as the *Biomuse Trio*, this language was transcribed by the authors directly into the musical score [29] using a canonical taxonomy of gestures. The idiomatic flexing and straining gestures were further combined to create multi-gestural gestures. For example, in one passage of this piece, the performer imagined shaping an object between two hands. This yielded simultaneous and coordinated flexion and extension of both hands and forearms creating a compound idiomatic gesture within the idiomatic vocabulary.

While *Biomuse Trio* mainly used gestures that are clearly idiomatic for the BioMuse, one of the discoveries of this work was gestures that are not idiomatic. For example, the concept of “arm throw” to trigger a musical event was abandoned in subsequent compositional work because in performing the gesture, it was too difficult to create a precise temporal event and the gesture was not at all idiomatic of biophysical performance.

The concept of “integral music control” opened up the possibility for completely removing physical gesture - using only physiological indicators of the performer’s emotional state as a means of creating and interacting with sound [25]. Are there idiomatic gestures for an interface that has no movement? Like the biophysical control described above, the answer is yes. While there are no gestures influenced by the physicality of the instrument (in fact, there are no physical gestures at all), there are idiomatic affective gestures. *Stem Cells*, a piece created for affective gestures, was

composed to have the performer traverse a set of emotions in order to move the piece forward [27]. For example, the piece ended with the performer slowly achieving a relaxed state which controlled a series of filters causing the complex sound structure to slowly collapse to a single tone. This emotional gesture was idiomatic in that it took advantage of the natural relief that a performer feels at the end of a performance. Other idiomatic gestures included anger for controlling complex and harsh sounds and joy for controlling the presence of staccato sonic structures.

As with *Biomuse Trio*, *Stem Cells* also discovered non-idiomatic gestures. For example, *Stem Cells* began with the performer in a relaxed state causing a single note to be played. Increasing agitation slowly increased the number of tones to create a complex tonal structure. The problem is that it is non-idiomatic to start a piece in a relaxed state. Like the difficulty of creating a precisely timed musical event with an “arm throw”, it is difficult for a performer to begin a piece in a relaxed emotional state.

#### 4. IDIOMATIC GESTURES IN ACCORDION-INSPIRED CONTROLLERS

This section contrasts the approaches and results in terms of idiomatic gestures of two of the earliest controllers associated with NIME, which were developed independently but both inspired by instruments in the acoustic accordion family: Gurevich and von Muehlen’s Accordiatron, and Cook and Leider’s SqueezeVox [19, 9]. Both were presented at the very first NIME workshop in 2001. The design of the Accordiatron (Figure 1) was motivated initially by the gestural repertoire idiomatic to the squeeze box or concertina. The designers sought to create a controller that supported gestures associated with an existing musical instrument, “natural motions associated with playing a squeeze box [concertina],” but that avoided the acoustic limitations of that instrument and also did not rely on augmentation [19]. The designers effectively attempted to abstract the original instrument down to its idiomatic gestures, and then built a new controller to support and sense those gestures.

Theoretically, this approach provided “the flexibility to apply the sensory data from these motions and buttons to any number of sonic parameters” [19]. In practice, however, although performer’s motions were constrained to the appropriate dimensions, ranges, and axes to facilitate roughly concertina-like movements, the actual specific gestures in Accordiatron performance – trajectories of motion through

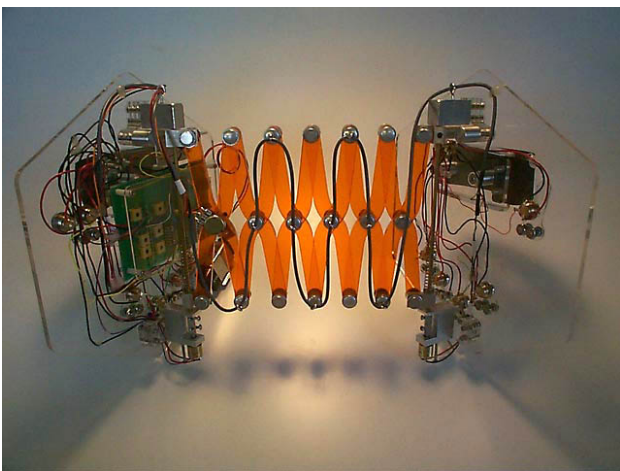


Figure 1: Gurevich and von Muehlen’s Accordiatron

time and space – were in fact determined by a far more complex set of factors than the physical properties of the instrument. In fact, Accordiatron performances do not generally involve idiomatic concertina gestures [16]. We can deduce at least two reasons why this is the case: i) the continuous sensors measuring hand movements are positional (potentiometers) and not velocity-sensitive; and ii) the mappings from sensors signals (and by extension, gestures) to sound were unrelated to those in concertina performance.

We observe that the lack of a requirement to force air through the bellows in order to activate reeds or sustain sound results in more static gestures, and furthermore the decoupling of the ‘stretch’ and ‘rotation’ controls gives rise to a new gestural vocabulary. Only in the case of a composition that employs synthesis algorithms which explicitly model an energetic input (‘ergotic’ systems in Cadoz’s terms [4]) and mapping algorithms that inferred velocity from positional input do Accordiatron gestures begin to resemble idiomatic concertina gestures.

Although also deriving from the accordion, the SqueezeVox interestingly takes a very different approach, which provides a useful contrast. Its design was initially motivated by a particular singing-voice synthesis algorithm. The accordion was seen as a “natural” interface for a physically informed synthesis model of the human voice due to the analogies of breathing and articulation. Cook described the mapping as follows: “Pitch via the keyboard, vibrato aftertouch, and a linear strip for fine pitch and vibrato are controlled with the right hand. Breathing is controlled by the bellows, and the left hand controls vowels and consonants via buttons (presets)” [9]. However, of course, the idiomatic gestures of accordion performance are not obviously related to those involved in vocal performance. Furthermore, a control interface designed for a massively polyphonic instrument is mapped onto a monophonic synthesizer. Therefore, performances with the SqueezeVox have a hybridizing or chimeric effect; it is not-quite-accordion and not-quite-voice. At times accordion-like gestures appear superimposed onto a vocal performance, and at other times the gestures are quite novel: diverging greatly from idiomatic accordion gestures in order to achieve a specific vocal effects.

#### 5. IDIOMATIC GESTURE STORAGE AND RETRIEVAL IN NOISA INSTRUMENT

NOISA, *the Network of Intelligent Sonic Agents*, is an interactive performance system with three musical instruments that are identical in their physical components but different

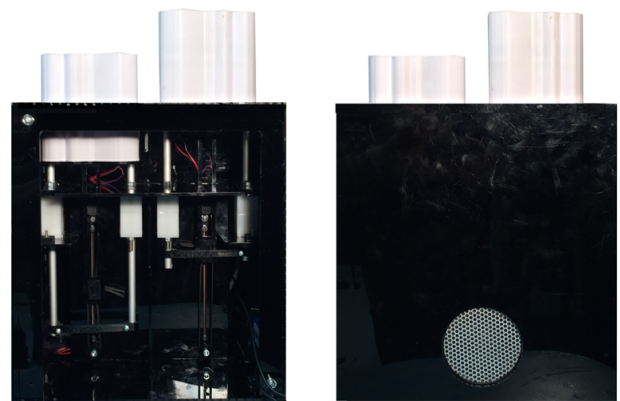


Figure 2: NOISA instrument’s physical components.

in sonic characteristics (Figure 2). The intelligent part of the interactive system estimates the musician’s engagement levels in the moment of performing music with NOISA instruments, learns a particular playing technique from the performer and decides what to do next [37, 38]. The system itself provides a musical interaction in which interaction characteristics have been reflected in music compositions, specifically to be performed with NOISA system [41]. At the same time, NOISA instruments afford unique sonic possibilities to appear, reflecting a particular playing technique, which is idiomatic to the characteristics of the instrument.

Idiomatic properties of the NOISA system firstly emerge from its intelligent behaviour that monitors the performer’s engagement as a state where the performer is connected and only paying attention to activities related to the music performance. The system provides autonomous supporting counteractions to maintain the performer’s engagement. These counteractions are specially tailored for that particular musical interaction with NOISA instruments, which associate in a seemingly musical-responses based on the complementarity of the performer and the interactive system.



Figure 3: The performance set up of the piece *3 agents + 1*

The functional affordances of the NOISA instrument involves two handles, proportional in size to human hands, of which the left-handle works as sound producer, activating the digital audio processes, and the right-handle regulates the pitch content, transforming the previous resulting signal (see Figure 2). The intervals generated as a result of the pitch shifting algorithm (right hand), simultaneously superimposed with the original signal (left hand), contribute to the richness of the instrument’s overall sound production. In relation to the functional characteristic of the instrument a gesture vocabulary is formulated by elaborating a portfolio of two second-long movements of both handles. These gestures were considered as idiomatic gestures with a focus on obtaining a wider range of expressive possibilities in music performances with NOISA instrument.

The idiomatic gesture portfolio of the NOISA instrument comprises an openness towards possible *textural* and *temporal* expansion similar to a technological implementation of the widespread composition technique of thematic development. Consideration of the possible new patterns to emerge through the gestural vocabulary resulted in writing compositions with a focus on developing dedicated repertoire for NOISA. The live performance of Vasquez’s composition *NOISA Etude#2* turned towards the music of performer’s presence and communication with NOISA instruments in the moment of playing [40]. In this composition, the major part of the music unfolds in the performer’s intended associations, of vague bodily sensations, with variations of the responsive gestures of the NOISA system. Specificity, the

variations of the counteraction gestures, shifting from low responsive to sudden clarity, is highly noted in the performance. Investigating the transformation of the second half of the score (see Figure 4) encounters the possibility of conveying the full intention of the performer through construction of conscious expectation with the musical instrument, which gives the known characteristics of the performative gestures as the essence of the instrument.

This gesture catalogue results in musically expressive outcome in another composition, *3 agents + 1* by Tahiroğlu [36]. In this composition, gestural patterns with short temporal features have been used to construct the discrete events in the piece with NOISA instrument. Figure 3 shows the live performance set up of the piece. The composition exploits what’s possible when NOISA’s idiomatic gestures communicate with the performer within a flow that is tailored to the variance and diversities of performer’s actions and responsive patterns. In the live performance of *3 agents + 1*, the idiomaticity characteristics of the gesture vocabulary emerge in the moment of playing and evolve into individual performative gestures. These idiomatic gestures incorporate the performance and become part of the distribution of decision-making, transforming their predefined vocabulary within own acoustic contexts.

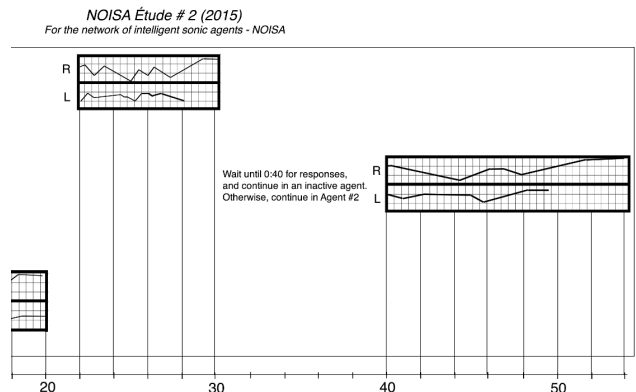


Figure 4: Second half of the score, the *Etude#2* composition

## 6. DISCUSSION

A gesture vocabulary that is idiomatic to the new musical instrument establishes a set of playing techniques for that instrument, which is in turn an essential component of a developing a performance practice. The three examples presented in this paper illustrate the complex relationships between the performers, physical properties of instruments, behaviours, mappings, and synthesis algorithms, which inform the development of idiomatic gestures. Only once such a repertoire of gestures and techniques has been established can the individual variations between performances begin to develop the potential for “expression” or style.

In this context, the idiomatic gesture that gives form to a sound-producing gesture becomes the underlying basis for the development of a performer’s style. Revisiting the definition of gesture as movement imbued with meaning, we argue that performative gestures have the potential to develop richer layers of meaning when they are rooted in, related to, or associated with gestures that are familiar in some way, whether through tradition, repetition, practice, or extra-musical reference. The development of style and expression in traditional musical performance has been accomplished through the necessary development of idiomatic gestures



informed by a similarly complex suite of forces. If NIME performances are to acquire a semblance of the richness of meanings through gesture as of those of traditional music (which, we should be clear, may not and should not always be the goal of every NIME performance), then consideration for the development of idiomatic gestures is paramount.

There is an important social dimension to idiomatic gesture as well, through the interaction of the choices, abilities, and qualities, of the various actors in the social network around a performance [17], as well through their unique relationships with the unique affordances of a particular instrument. There is an echo here, of course, with the way idiomatic compositions enhance a shared performance practice and musical experience. A central theme in our idiomatic gesture discussion is the ability to convey the full intention of the performer through building up conscious expectations with the musical instrument. Heightened attention to idiomatic gestures could further illuminate the challenges to the *situated interaction* we have with musical instruments, prompting closer collaborations between actors in the musical-social network. The idiomatic potential emerges through the relationships of these actors and these relationships maintain the critical importance of reflecting idiomatic approach in the design of new instruments. The NOISA project is a significant example to such process in which the instrument designer and composer worked together from the very early phase of the project [41].

The contrasts evident between the musical instruments Accordiatron and SqueezeVox reveal that explicit borrowing or adaptation of idiomatic gestures associated with existing musical instruments can be effective, but only to a point. Although important, neither the physical form, nor the range, orientation, and scale of motion alone are sufficient in replicating idiomatic gestures. The mappings of these features to synthesis algorithms, and of course, the nature of those algorithms themselves, are shown to be at least equally important. This is not to say that exact replication of idiomatic gestures should be a goal, nor was it for the designers of these instruments. But by examining the factors that impacted the observed divergence, and which facilitated the emergence of new gestural repertoires, we draw attention to important considerations for designers, performers and composers.

The Accordiatron was explicitly conceived as an instrument that would constrain motion to specific dimensions and trajectories. Experience in practice revealed that such constraints are not in themselves sufficient to determine idiomatic gestures. Indeed, in contrast, biocontrollers reveal an especially challenging but enlightening complementary perspective: interfaces with no specific external constraints on movement. In the absence of such physical constraints, these systems demonstrate that idiomatic gestures can be specifically *composed*, for example through reference to extramusical activities, or through induction of emotional or affective states. This suggests a counter-intuitive tipping of the balance of forces in the development of idiomatic gestures away from the physical instrument design in isolation, and toward socially- and culturally-situated forces. For example, it is interesting to ponder what combination of composer, performer, and instrument designer would choose whether to use MMG or EMG in a piece that contemplates using muscle measurement for control. Would the choice be based on the repertoire of gestures that are available within the lexicon of current performers? (A lexicon that is not identical between EMG and MMG [6].) Would the choice matter if the gestures chosen are ones that are idiomatic to both sensor systems?

The case of NOISA suggests that programming—beyond

the static physical properties of the instrument—can play a more active role in determining playing techniques and idiomatic gestures with computer-based instrument. In particular, algorithms that can learn and adapt to performers' gestures allow this process to happen in dialogue with the performer, thus widening the network of social influences.

Perhaps this socially-situated context around idiomatic gestures should not be surprising if we consider the complex interplay of cultural, musical, and technological factors that inform the wide variety of idiomatic gestures involved in the performance of traditional musical instruments. In violin performance, for example, compare the seated position with the scroll resting against the player's heel in Carnatic music [33] and the complex bowing patterns of Irish fiddling [14].

Furthermore, the *non-idiomatic* gestures revealed through experiences with biocontrollers highlight the essential situatedness of interactive performances. Gestures that might otherwise convey meaning may not be idiomatic for a particular individual, interface, sound environment, or even a moment of a composition. These various types of idiomatic gestures are not only static or dynamic representations of sound producing gestures; performer, composer, instrument designer simultaneously defines the idiomaticity and extends its usage in the performance.

## 7. CONCLUSIONS

In this paper, we have introduced the concept of idiomatic gestures with new musical instruments. The development of a repertoire of gestures that are idiomatic to a new instrument contributes to the emergence of style, expression, and extramusical meaning in performance. We argue that the explicit consideration of idiomatic gestures in a NIME can shift its reception from one with a focus on purely novelty in terms of sounds or controls toward that of a more established, performative musical instrument. The three particular projects presented demonstrate diverse ways that idiomatic gestures emerge in performance practice. The historical perspective, both in the classical era and in the NIME period, provides evidence that building an idiomatic gesture repertoire for a musical instrument is potentially crucial to the full realization of expressive possibilities.

## 8. REFERENCES

- [1] PRIME Research double staccato, articulations contrabass f. <http://www.primeresearch.ch/>. Accessed: 2017-01-16.
- [2] J. S. Bach, D. F. Tovey, and E. Wen. *The well-tempered clavier: 48 preludes and fugues*, volume 1. Courier Corporation, 2014.
- [3] M. Broyles. The two instrumental styles of classicism. *Journal of the American Musicological Society*, 36(2):210–242, 1983.
- [4] C. Cadoz. Supra-Instrumental Interactions and Gestures. *Journal of New Music Research*, 38(3):215–230, 2009.
- [5] C. Cadoz and M. M. Wanderley. Gesture-music. *Trends in Gestural Control of Music*, 13:71–94, 2000.
- [6] B. Caramiaux, M. Donnarumma, and A. Tanaka. Understanding gesture expressivity through muscle sensing. *ACM Trans. Comput.-Hum. Interact.*, 21(6):31:1–31:26, Jan. 2015.
- [7] I. Choi. A component model of gestural primitive throughput. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 201–204, Montreal, Canada, 2003.
- [8] S. Conforti and A. Güsewell. Prime gesture

- recognition. *Dissonance/Dissonanz*, (132), 2015.
- [9] P. R. Cook. Principles for designing computer music controllers. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 3–6, Seattle, WA, 2001.
- [10] S. Dahl et al. Gestures in performance. In R. I. Godøy and M. Leman, editors, *Musical Gestures: Sound, Movement, and Meaning*, pages 36–68. Routledge, 2010.
- [11] C. Dobrian and D. Koppelman. The E in NIME: Musical expression with new computer interfaces. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 277–282, Paris, France, 2006.
- [12] M. Donnarumma. Incarnated sound in music for flesh II: Defining gesture in biologically informed musical performance. *Leonardo Electronic Almanac*, 18(3), 2012.
- [13] P. Dourish. *Where the Action is: The Foundations of Embodied Interaction*. MIT press, 2004.
- [14] Fiddlevideo. Irish bowing technique. <https://youtu.be/1AMesSTGSd8>. Accessed: 2018-04-09.
- [15] R. I. Godøy. Gestural affordances of musical sound. In R. I. Godøy and M. Leman, editors, *Musical Gestures: Sound, Movement, and Meaning*, pages 103–125. Routledge, 2010.
- [16] M. Gurevich. Accordiatron: Video. [https://ccrma.stanford.edu/~gurevich/accordiatron/atron\\_video.html](https://ccrma.stanford.edu/~gurevich/accordiatron/atron_video.html). Accessed: 2018-01-27.
- [17] M. Gurevich. Discovering instruments in scores: A repertoire-driven approach to designing new interfaces for musical expression. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 163–168, Copenhagen, Denmark, 2017.
- [18] M. Gurevich, P. Stapleton, and P. Bennett. Designing for style in new musical interactions. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 213–217, Pittsburgh, PA, United States, 2009.
- [19] M. Gurevich and S. von Muehlen. The Accordiatron : A MIDI controller for interactive music. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 27–29, Seattle, WA, 2001.
- [20] R. S. Hatten. *Interpreting Musical Gestures, Topics, and Tropes: Mozart, Beethoven, Schubert*. Indiana University Press, Bloomington and Indianapolis, 2004.
- [21] R. S. Hatten. A Theory of Musical Gesture and its Application to Beethoven and Schubert. In A. Gritten and E. King, editors, *Music and Gesture*, pages 1–23. Ashgate, 2006.
- [22] D. Huron and J. Berec. Characterizing idiomatic organization in music: A theory and case study of musical affordances. *Empirical Musicology Review*, 4(3):103–122, 2009.
- [23] A. Jensenius et al. Musical gestures: concepts and methods in research. In R. I. Godøy and M. Leman, editors, *Musical Gestures: Sound, Movement, and Meaning*, pages 12–35. Routledge, 2010.
- [24] A. R. Jensenius. To gesture or not? An analysis of terminology in NIME proceedings 2001–2013. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 217–220, London, United Kingdom, 2014.
- [25] R. B. Knapp and P. R. Cook. The integral Music controller: Introducing a Direct Emotional Interface to gestural control of sound synthesis. In *Proceedings of the International Computer Music Conference*, Barcelona, Spain, 2005.
- [26] R. B. Knapp and H. S. Lusted. A bioelectric controller for computer music applications. *Computer Music Journal*, 14(1):42–47, 1990.
- [27] R. B. Knapp and E. Lyon. The measurement of performer and audience emotional state as a new means of computer music interaction: a performance case study. In *Proceedings of the International Computer Music Conference*, Huddersfield, England, 2011.
- [28] M. Leman. *Embodied Music Cognition and Mediation Technology*. Mit Press, 2008.
- [29] E. Lyon, R. B. Knapp, and G. Ouzounian. Compositional and performance mapping in computer chamber music: A case study. *Computer Music Journal*, 38(3):64–75, Sept. 2014.
- [30] T. Magnusson. Designing constraints: Composing and performing with digital musical systems. *Computer Music Journal*, 34(4):62–73, 2010.
- [31] J. Malloch and M. M. Wanderley. The t-stick : From musical interface to musical instrument. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 66–69, New York City, NY, United States, 2007.
- [32] C. Neacsu. *The Stylistic Influence of the French Violin School on the Beethoven Violin Concerto OP.61*. PhD thesis, University of Illinois, 2016.
- [33] OctavesOnline. Carnatic violin: Finger positions part-2. <https://youtu.be/LoA1M1U0rZU>. Accessed: 2018-04-09.
- [34] G. Paine. Gesture and morphology in laptop music performance. *The Oxford handbook of computer music*, pages 214–232, 2009.
- [35] C. D. Palmer. *Closure in the Music of Schoenberg*. PhD thesis, University of Alabama Libraries, 2014.
- [36] K. Tahiroğlu. 3 agents + 1: Video. <https://vimeo.com/113687370>. Accessed: 2018-04-09.
- [37] K. Tahiroğlu, T. Svedström, and V. Wikström. Noisa: A novel intelligent system facilitating smart interaction. In *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems*, pages 279–282. ACM, 2015.
- [38] K. Tahiroğlu, J. C. Vasquez, and J. Kildal. Facilitating the musician’s engagement with new musical interfaces: Counteractions in music performance. *Computer Music Journal*, 41(2):69–82, 2017.
- [39] A. Tanaka. BioMuse to bondage: Corporeal interaction in performance and exhibition. In *Intimacy Across Visceral and Digital Performance*, pages 159–169. Palgrave Macmillan, London, 2012.
- [40] J. Vasquez. Noisa etude#2: Video. <https://vimeo.com/134134739>. Accessed: 2018-04-09.
- [41] J. Vasquez, K. Tahiroğlu, and J. Kildal. Idiomatic composition practices for new musical instruments: Context, background and current applications. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 174–179, Copenhagen, Denmark, 2017.