NTNU
Norwegian University of
Science and Technology

Human Computer Interaction

NIMEs (focus on instrument design)

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31 October 2019

Learning Outcomes

— Understand the role of a *digital lutherie* or a designer of NIMEs.
— Explore the key elements of NIME instrument design from an HCI perspective.
— Discern different categories of NIMEs from an HCI design perspective (e.g. using taxonomies).
— Identify different formats of representing NIMEs.
— Be able to create diagrams of self-built NIMEs by reversed engineering methods (learning from existing diagrams).

Class Structure

— 10.15-10.40 NIME design.

— 10.40-11.20 Representing and documenting NIMEs + group activity.

— 11.20-11.40 And now all begins...

— 11.40-12.00 Survey time & Closing

NIME Design

Preparation: Reading

— Send a summary (1 page max.) of the following article:
  - Perry R. Cook. Principles for Designing Computer Music Controllers. *Proceedings of the International Conference on New Interfaces for Musical Expression*, pp. 3–6. [1]

  The summary should include: the research question, the approach used to address the research question, the main findings, and the main contribution.

Proceedings of the CHI'01 Workshop on New Interfaces for Musical Expression (NIME-01), Seattle, USA

Principles for Designing Computer Music Controllers

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ABSTRACT
This paper will present observations on the design, artistic, and human factors of creating digital music controllers. Specific projects will be presented, and a set of design principles will be supported from those examples.

Keywords
Musical control, artistic interfaces.

INTRODUCTION
Musical performance with entirely new types of computer instruments is now commonplace, as a result of the availability of inexpensive computing hardware, of new sensors for measuring physical parameters such as force and position, and of new software for real-time sound synthesis and manipulation. Musical interfaces that we construct are influenced greatly by the type of music we like, the music we set out to make, the instruments we already know how to play, and the artists we choose to work with, as well as the available sensors, computers, networks, etc. But the music we create and enable with our new instruments can be even more greatly influenced by our initial design decisions and techniques.

Through designing and constructing controllers over the last 15 years, the author has developed some principles and a (loose) philosophy. These are not assumed to be universal, but are rather a set of opinions formed as part of the process of making many musical interfaces. They relate to practical issues for the modern instrument craftsperson/hacker. Some relate to human factors, others are technical. This paper will endeavor to bring those

__Some Technological Principles__

7) **MIDI = Miracle, Industry Designed, (In)adequate**
8) **Batteries, Die (a command, not an observation)**
9) **Wires are not that bad (compared to wireless)**

__Some Other Principles__

10) **New algorithms suggest new controllers**
11) **New controllers suggest new algorithms**
12) **Existing instruments suggest new controllers**
13) **Everyday objects suggest amusing controllers**

Winds: Cook/Morrill Trumpet 1986-89 HIRN 1991
Constructed with Dexter Morrill of Colgate University, as part of an NEA grant to create an interface for trumpeter Wynton Marsalis, the Cook/Morrill trumpet controller project led to a number of new interface devices, software systems [1][2], and musical works [3]. Sensors on the valves, mouthpiece, and bell enabled fast and accurate pitch detection, and extended computer control for the trumpet player. Trumpet players lie squarely in the "**some players have spare bandwidth**" category, so attaching a few extra switches and sliders around the valves proved very successful. Figure 1 shows the interface window.

Initially it was thought that a musically interesting scheme would be to allow the brass player to use the switches to enter played notes into loops, and later trigger those loops. This proved a miserable failure, because of the mental concentration needed to keep track of which loop was where, what the loop contents were, syncing the recording, triggering, etc. Eventually a set of simple, nearly stateless

[1]
https://www.cs.princeton.edu/~prc/CHI01Web/chi01.htm

- Quick round: Favorite principle and why?
- General discussion: Pros and cons of the paper?

Oblique Strategies

Over One Hundred Worthwhile Dilemmas

A card-based method for promoting creativity by Brian Eno and Peter Schmidt

`http://stoney.sb.org/eno/oblique.html`

Digital Lutherie

- A *digital luthier* is a term coined by Jordà (2005) [2] to refer to a person who makes or remakes digital musical instruments.
- In DMIs, there is a modular distinction between the element of control (e.g. the input device or gesture controller) and the element of sound generation.
- This contrasts with acoustic musical instruments, in which both elements are coupled.

Digital Lutherie

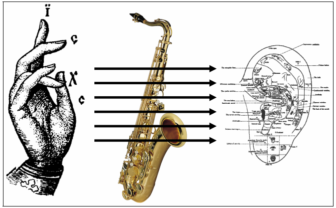


Figure 4.13. The traditional instrument microcontrol

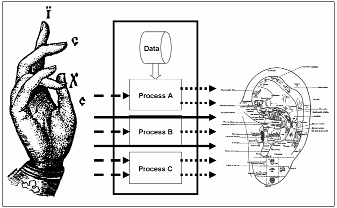


Figure 4.14. The ‘interactive instrument’ hybrid micro + macrocontrol

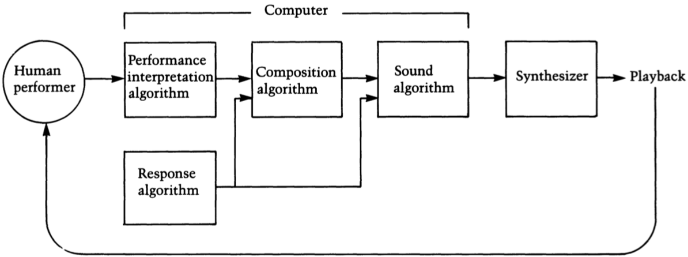
[2, p.95]

Interactive Composing Systems

The computer responds to the performer and the performer reacts to the computer, and the music takes its form through the mutually influential, interactive relationship. Joel Chadabe, 1984 [3, p.23]

Interactive Composing Systems

Fig. 2. Organization of an interactive composing system, from human performer to sound output.



Feedback loop contains information generated by computer in addition to information specified by performer.

[3, p.24]

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Designing Constraints: Composing and Performing with Digital Musical Systems

Currently, a musician working with digital technology is faced with a panoply of musical tools that can be roughly characterized by a split between ready-made music production software on the one hand, and audio-programming environments such as SuperCollider, CSound, Pure Data, Max/MSP, ChucK, or Audiomulch (to name but a few) on the other. Problems with the former lie in the conceptual and compositional constraints imposed upon users by software tools that clearly define the scope of available musical expressions. It is for this reason that many musicians, determined to fight the fossilization of music into stylistic boxes, often choose to work with programming environments that allow for more extensive experimentation. However, problems here include the practically infinite expressive scope of the environment, sometimes resulting in a creative paralysis or in the frequent symptom of a musician-turned-engineer. Consequently, a common strategy can be detected, defined here as that of *designing constraints*, where the instrument designer, the composer, or the performer (a distinction often irrelevant in these systems; see

of a clear, explicit space of gestural trajectories and musical scope. Yet, in their nature as digital systems, we find that the named concretizations are always arbitrary, dynamic, and highly transient, posing problems for the instrument's identity and historical continuity.

Affordances and Constraints

The phenomenological method of philosophical inquiry, founded by philosophers such as Husserl, Heidegger, and Merleau-Ponty, has influenced much work in HCI (e.g., Winograd and Flores 1986; Dourish 2001). A related, yet narrower, focus of the relationship between the human and the world has been studied under the terms of ecological psychology. The ecological approach to cognition was developed by psychologist James J. Gibson, who studied human perception and the environment as a dynamic system (Gibson 1979). The field of HCI has incorporated many important concepts derived from ecological psychology, such as ecological affordance

[4]

Designing Constraints

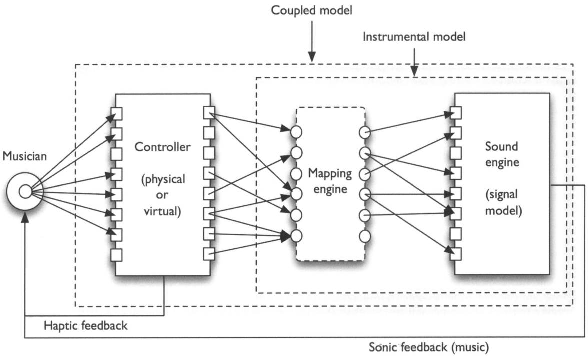
- HCI concepts: *Affordances*, *constraints* and *mapping*.
- Perceived *affordances*: the properties that the agent perceives as possible actions upon an object (Norman 1988).
- *Constraints* map out a territory of structural possibilities which can then be explored, and perhaps transformed to give another one (Boden 1990, p. 95).
- *Mapping* as designing constraints: the sound and mapping engines serve as the core of the digital musical instrument, they are its “real body”.

Designing Constraints

- Mapping should be defined as a compositional process that engenders a structure of constraints.
- Design of constraints, where the making of the instrument involves composition, or alternatively, composing involves instrument design.
- The primary character of a new NIME is defined by its constraints (affordances are provided by the hardware and software features).
- Affordances point to features that make things possible and constraints define the limits of the possible.

Designing Constraints

Figure 1. Typical model of the musical interface (Wanderley 2000; Leman 2008; Wessel and Wright 2001). Here, the split between the gestural interface (either virtual or physical) and the sound engine is bridged by the mapping engine. However, the instrumental model is defined as the core of the instrument, where constraints are programmatically defined.



[4, p.66]

CHAPTER 14

Embodied Music Interaction: Creative Design Synergies Between Music Performance and HCI

Anna Xambó

Introduction

The multidisciplinary field of sound and music computing (SMC) offers the opportunity to combine scientific, artistic, and technical skills with the aim of building new computational tools and applications for understanding, manipulating, and generating sound and music (Serra et al. 2007). Particularly within music performance, a range of novel *Digital Musical Instruments* (DMIs) (Miranda and Wanderley 2006), *Digital Musical Interactions* (DMIs) (Gurevich and Cavan Fyans 2011), and *New Interfaces for Musical Expression* (NIMEs) (Fels 2004) has been explored that share a common nature based on real-time musical interac-

[5]

Embodied Music Interaction

- We can adapt the HCI theoretical framework of embodied interaction with the aim of informing the design of DMIs.
- Meaning is co-constructed through making within a social context and is mediated by the technology used (Dourish (2001) [6]).
- Embodied interaction involves considering the role of the *body*, the *social world*, and the *physical world*, all three within a *situated context* (for *situated action* see Suchman (1987) [7]).
- Embodied interaction involves designing interfaces that require complex bodily interactions.

Embodied Music Interaction

> *A piece of jewelry is in a sense an object that is not complete in itself. Jewelry is a 'what is it?' until you relate it to the body. The body is a component in design just as air and space are. Like line, form, and color, the body is a material to work with. It is one of the basic inspirations in creating form. (Art Smith 1969)*

Embodied Music Interaction: one can say that the body is an important aspect in music technology design, just like melody, harmony, rhythm, dynamics, and timbre.

Embodied Music Interaction

- *Embodied music interaction* challenges and potentials of embodied interaction using DMIs for music performance.
- The consideration of embodied interaction in DMI design can improve rethinking of the:
  1. communication with the audience, and performers;
  2. the shareability and collaborative features, allowing for scalability of the system; and
  3. the materiality and space features, including connections between digital and physical spaces in the interface, and the space between and outside the practitioner and the musical instrument.

Embodied Music Interaction

DMI	Body	Materiality	Input Control	Sound Output	Coupling Physical-Digital	Visibility/ Feedback	Shareability	Situatedness
 Tangible	Hands, upper body	Physical objects, tabletop surface	TUIs, multitouch surface	Embedded or detached	Seamless coupling	Body-scale level (group), audio/visual/ haptic feedback	A shared interface, multiple tangible objects, multitouch interaction	Individuals or groups
 Mobile	Hands, upper body	Physical device, screen	Sensors (e.g., accelerometer, camera, gyroscope, magnetometer, mic, multitouch screen)	Embedded or detached	Seamless coupling	Hand-scale level (individual), audio/visual/ haptic feedback	Individual interface or multiple individual interfaces interconnected on a network	Individuals or groups
 Wearable	Full body	Physical wearable (e.g., textile, garment, material)	Sensors (e.g., accelerometer, biosignal, gyroscope, magnetometer, photodetector, pressure, temperature, touch)	Embedded or detached	Seamless coupling	Body-scale level (group), audio/visual/ haptic feedback	Individual interface or multiple individual interfaces interconnected on a network	Individuals or groups
 Gesture	Full body	N/A	Sensors (e.g., biosignal, IR, ultrasonic)	Detached	N/A	Body-scale level (group), audio/visual/ haptic feedback	Individual interface or multiple individual interfaces interconnected on a network	Individuals or groups
 Laptop	Hands	Physical device, screen	Sensors (e.g., camera, light, mic, touchpad), computer hardware (e.g., keyboard, mouse)	Embedded or detached	Seamless coupling	Hand-scale level (individual), audio/visual/ haptic feedback	Individual interface or multiple individual interfaces interconnected on a network	Individuals or groups

Fig. 14.3 Categories of embodied music interaction

[5, p.213]

Representing and documenting NIMEs

Videos

- Bill Buxton's SSSP
  - SSSP Overview: `https://www.youtube.com/watch?v=4DiREhbB6Nw`
  - The SSSP Interactive Performance System: `https://www.youtube.com/watch?v=cHmf36J-EEE`
- Bill Buxton videos: `https://www.billbuxton.com/buxtonVideos.html`
- Reactable basic demo #1: `https://www.youtube.com/watch?v=0h-RhyopUmc`

Graphical Representations

- Photos
- Illustrations
- Diagrams (see Unified Modeling Language (UML) e.g. behavioural diagrams, structural diagrams, and so on)
- Mindmaps :)
- and many more...

Teamwork: Classification and representation of NIMEs

— Take the same paper that you selected from the NIME Reader (https://www.springer.com/gp/book/9783319472133) where a NIME is presented. Discussion about ...
  - how is the instrument design presented in the paper: diagrams? photographs? mindmaps?
  - how is the NIME documented? are there videos? what are the characteristics of the documentation in particular the videos?

Teamwork: Summaries

— The teams summarize to the group their selected paper / NIME (5-7 minutes per group).
  - how is the instrument design presented in the paper: diagrams? photographs? mindmaps?
  - how is the NIME documented? are there videos? what are the characteristics of the documentation in particular the videos?

And now all begins...

seem to have so little to say?

I enjoy a rubber teapot as much as the next guy — *more* than the next guy — but at this late point, aren't these techie five-finger exercises becoming slightly embarrassing? If Fuseli and Piranesi had had Kai's Power Tools, humankind might never have recovered from the experience. Can it be that these old-fashioned analog geezers simply took themselves seriously in a way that modern computer graphics people somehow lack the nerve to do? Well, how come? And what should be done about that?

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Artists and the Art of the Luthier

Bill Buxton
Alias|Wavefront, Inc.
Silicon Graphics, Inc.

The old adage is, "frustration is the mother of invention." For me, it certainly is true. As a professional musician in the early 1970s, I was active in trying to do live performance using electroacoustic instruments. In one sense, the challenge was to extend the nature of "performance" beyond the ultimate creative act of pushing the "play" button on a tape recorder in the concert hall which was the status quo of the day.

I had some novel notion that computer-based "instruments" could be worthy of the name (and hence capable of improvisation, worthy of practice and sensitive to subtle nuances of the performer's skill). This brings me back to frustration and invention. For me, it was more efficient to learn digital electron-career at the University of Toronto (UofT) and Xerox PARC was relatively simple.

Well, sort of. Every once in awhile, artists resurfaced and interrupted my otherwise tranquil life as a researcher and academic. One prototypical example occurred in 1987 when Alain Fournier and I were co-directors of the UofT graphics lab. Having implemented what we thought was a significantly new airbrush into a paint program, we invited an artist from the CBC, Peter Softley, in to tell us how great we were. Tell us he did. In a few choice words (not suitable for reproduction is such an august ACM publication), he made it clear that it was obvious that neither we — nor anyone else who had implemented an airbrush — had ever seen one, much less used one. A key point, among others, was that nobody ever uses an airbrush without a frisket, or stencil, in the other hand. The one-handed wonders that we and everyone else were producing, were completely incapable of capturing the essence of the art.

The result of Peter's visit was that he took our whole lab to his studio for an airbrush lesson. What we really got was a lesson (a useful euphemism for "kick in the ass") to reaffirm the importance of involving the artist (a. k. a. user, customer — but all too often "victim") in the design process. But the reality is that despite Peter's efforts, it has taken me 10 years to be able to finally bring an airbrush to market that even begins to be worthy of the monicker.

What I knew for myself in my music system, and Peter so delicately reminded me in the domain of paint programs, was that the 10 years that this has taken are nothing special — at least when contrasted to the years that the artists themselves have invested in developing their unique skills. While the essence of artists are reflected in their work, it is rooted in skill soap, and the only time it's appropriate to draw with a bar of soap is Halloween. So where does this leave the artist the rest of the time? The issue here is one of priorities and relative economics.

Let's look at a couple more conventional "technologies." In contrast to a mouse, if I were to ask you how much does the bow of the first violinist of the New York Philharmonic cost, what would you answer? (Remember, I'm speaking about the bow, not the violin.) The answer, equally true for the first chair of almost any good symphony, is about the cost of an entire SGI workstation. Likewise, if you ask what a full set of top of the line sable water colour brushes costs, the answer is about the same as the cost of a top of the line Macintosh computer.

Now for me, I couldn't tell the difference between the bow of the top professional compared to a beginner's, any more than I could tell the difference between a good sable brush and the brush that came with the $2. 95 watercolor set that I had in grade school. But then, I'm neither a violinist nor a watercolor artist. That is not the point. Because of the huge investment in skill that these artists have made, and the potential that lies behind this skill, these artists deserve tools worthy of their investment. My claim is that, for the most part, artists have been largely short-changed by the computer industry.

In my view, it is time for this to change. The one-size-fits-all general purpose GUI that has dominated the industry is simply not worthy of the latent talent that might otherwise be manifest through the tools that we create. The tools must begin to reflect both the diversity and attention to quality that we see in more conventional media, such as the symphony orchestra or the tools found at an art college. My frustration is that it has taken so long for this to

Buxton (1997) [8]

New Interfaces for Musical Expression

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ABSTRACT
The rapid evolution of electronics, digital media, advanced materials, and other areas of technology, is opening up unprecedented opportunities for musical interface inventors and designers. The possibilities afforded by these new technologies carry with them the challenges of a complex and often confusing array of choices for musical composers and performers. New musical technologies are at least partly responsible for the current explosion of new musical forms, some of which are controversial and challenge traditional definitions of music. Alternative musical controllers, currently the leading edge of the ongoing dialogue between technology and musical culture, involve many of the issues covered at past CHI meetings. This workshop brings together interface experts interested in musical controllers and musicians and composers involved in the development of new musical interfaces.

Keywords: musical controllers, musical expression, computer and electronic music, sound synthesis, MIDI

INTRODUCTION
This workshop brings together interface experts interested in musical controllers and musicians and composers involved in the development of new musical interfaces, especially alternative controllers, to stimulate exchange with the following aims:

(1) To survey and discuss the current state of control interfaces for musical performance, identify current and promising directions of research and unsolved problems. To focus on the major practical concerns involved in the

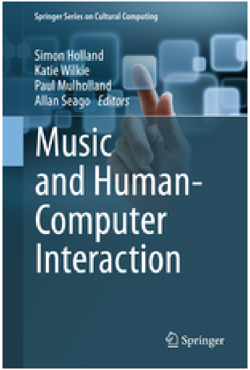
MUSICAL INTERFACES: PAST, PRESENT, FUTURE
Music has historically been a meeting point for technology and artistic expression. The design of musical instruments may well have been the first area of technology where careful and systematic interface design played an essential if not the central role. While music has always been a driving force for technological innovation, it is also true that new technologies have opened the way for new forms of musical expression and experimentation. To give a familiar example, the modern piano, and consequently the classical piano repertoire, such as Beethoven concertos, would not be possible without the great improvements in metallurgy at the turn of the 18th century. This allowed the construction of one-piece cast-iron frames that could support the 18-ton string tensions exerted by performers (Saches, 1940).

In the current era, new technologies that can benefit musical expression are appearing at an accelerating pace. The last century, especially in the 1950's and 60's, saw the rise of electronic musical sound synthesis which gave birth to a plethora of new musical forms in both popular and classical or "serious" arenas of electronic music. We can expect that the continuing progress in information technologies will stimulate composers and musicians to experiment with new means of composition and new instruments for performance.

The development of novel sensor interfaces, vision and pattern recognition, virtual and augmented reality, haptic feedback devices and the like are all opening up avenues

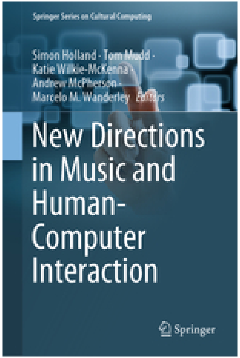
Pouprev et al. (2001) [9]

Music and HCI (2013)



Holland, S., Wilkie-McKenna, K., Mulholland, P., Seago, A. (Eds.) (2013) ([10]
Book URL: `https://www.springer.com/gb/book/9781447129899`

New Directions in Music and HCI (2019)

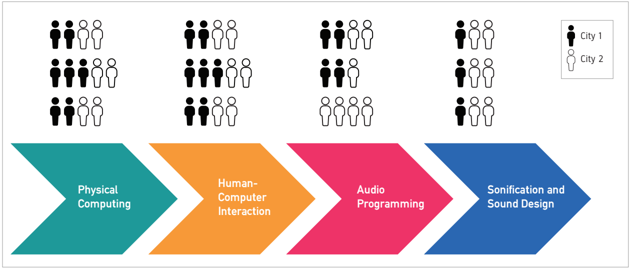


Holland, S., Mudd, T., Wilkie-McKenna, K., McPherson, A., Wanderley, M. (Eds.) ([11]
Book URL: `https://www.springer.com/gp/book/9783319920689`

Other Resources and Perspectives

- 120 Years of Electronic Music (1800–2019): `http://120years.net`
- Sarah Reid, Sara Sithi-Amnuai, and Ajay Kapur. 2018. *Women Who Build Things: Gestural Controllers, Augmented Instruments, and Musical Mechatronics*. [12]
- Anna Xambó. 2018. *Who Are the Women Authors in NIME?–Improving Gender Balance in NIME Research*. [13]
- Adnan Marquez-Borbon and Juan Pablo Martinez-Avila. 2018. *The Problem of DMI Adoption and Longevity: Envisioning a NIME Performance Pedagogy*. [14]
- Adnan Marquez-Borbon and Paul Stapleton. 2015. *Fourteen Years of NIME: The Value and Meaning of 'Community' in Interactive Music Research*. [15]

We Need More HCI!



- It is important to connect HCI more strongly with technological TBL courses related to prototyping interactive computer-based systems.
- HCI can serve as a theoretical framework and critical-thinking tool.
- This approach is helpful for shaping our future technological humanists as critical thinkers and agents of change.

Survey time & Closing

Human-Computer Interaction Day 4 - Group Assignment (post-class)

- In this assignment, you are asked to create a diagram or a set of graphical representations of how the prototype that you built for the physical computing workshop works, focusing in the performance setting. This diagram should be included in the final assignment of writing a paper about the prototype. This assignment should be submitted before **Friday 1 November 2019 17:00**.
- Assignment URL:
  `https://uio.instructure.com/courses/22318/assignments/28317`

Human-Computer Interaction - Final Assignment

— The final assignment of this course will consist in writing a short paper (2–4 pages long) about the prototype that you built in team and presented during the mini-hackathon of the Physical Computing Workshop. **Deadline: 8 November, 2019 @5pm**

- The individual part should include a link to a short video demonstrating your prototype. It is recommended to publish a blog post where the video is shortly introduced. In the paper the sections of “Reflective notes” and “Conclusion” should be individual.
- The group part should write most of the paper together. It is a plus if you create a "short" version for the MCT blog, which should summarize the main points.
- Assignment URL: `https://uio.instructure.com/courses/22318/assignments/28321`
- Category for the blog post: *HCI*, more info here: `https://github.com/MCT-master/mct-master.github.io` (README of the blog repo)

Physical Computing Workshop
Post-Questionnaire

`http://tiny.cc/pcw-postq`

Experience in the Portal

`http://tiny.cc/survey-portal`

References

[1] Perry R. Cook. “Principles for Designing Computer Music Controllers”. In: *Proceedings of the International Conference on New Interfaces for Musical Expression*. Seattle, WA, 2001, pp. 3–6.

[2] Sergi Jordà Puig. “Digital Lutherie–Crafting Musical Computers for New Musics’ Performance and Improvisation”. PhD thesis. Universitat Pompeu Fabra, 2005.

[3] Joel Chadabe. “Interactive Composing: An Overview”. In: *Computer Music Journal* 8.1 (1984), pp. 22–27.

[4] Thor Magnusson. “Designing Constraints: Composing and Performing with Digital Musical Systems”. In: *Computer Music Journal* 34.4 (2010), pp. 62–73.

[5] Anna Xambó. “Embodied Music Interaction: Creative Design Synergies between Music Performance and HCI”. In: *Digital Bodies*. Springer, 2017, pp. 207–220.

[6] Paul Dourish. *Where The Action Is: The Foundations of Embodied Interaction*. MIT press, 2004.

[7] Lucy A Suchman. *Plans and Situated Actions: The Problem of Human-Machine Communication*. Cambridge University Press, 1987.

[8] Bill Buxton. “Artists and the Art of the Luthier”. In: *SIGGRAPH Comput. Graph.* 31.1 (Feb. 1997), pp. 10–11. ISSN: 0097-8930.

[9] Ivan Poupyrev et al. “New Interfaces for Musical Expression”. In: *CHI ’01 Extended Abstracts on Human Factors in Computing Systems*. Seattle, Washington: ACM, 2001, pp. 491–492.

[10] S. Holland et al. *Music and Human-Computer Interaction*. Springer, 2013.

[11] S. Holland et al. *New Directions in Music and Human-Computer Interaction*. Springer, 2019.

[12] Sarah Reid, Sara Sithi-Amnuai, and Ajay Kapur. “Women Who Build Things: Gestural Controllers, Augmented Instruments, and Musical Mechatronics”. In: *Proceedings of the International Conference on New Interfaces for Musical Expression*. Ed. by Thomas Martin Luke Dahl Douglas Bowman. Blacksburg, Virginia, USA: Virginia Tech, 2018, pp. 178–183.

[13] Anna Xambó. “Who Are the Women Authors in NIME??Improving Gender Balance in NIME Research”. In: *Proceedings of the International Conference on New Interfaces for Musical Expression*. Ed. by Thomas Martin Luke Dahl Douglas Bowman. Blacksburg, Virginia, USA: Virginia Tech, 2018, pp. 174–177.

[14] Adnan Marquez-Borbon and Juan Pablo Martinez-Avila. “The Problem of DMI Adoption and Longevity: Envisioning a NIME Performance Pedagogy”. In: *Proceedings of the International Conference on New Interfaces for Musical Expression*. Ed. by Thomas Martin Luke Dahl Douglas Bowman. Blacksburg, Virginia, USA: Virginia Tech, 2018, pp. 190–195.

[15] Adnan Marquez-Borbon and Paul Stapleton. “Fourteen Years of NIME: The Value and Meaning of ‘Community’ in Interactive Music Research”. In: *Proceedings of the International Conference on New Interfaces for Musical Expression*. Ed. by Edgar Berdahl and Jesse Allison. Baton Rouge, Louisiana, USA: Louisiana State University, 2015, pp. 307–312.